A SIMPLE RULE TO DETECT THE FRAGILE

A story present in the rabbinical literature (*Midrash Tehillim*), probably originating from earlier Near Eastern lore, says the following. A king, angry at his son, swore that he would crush him with a large stone. After he calmed down, he realized he was in trouble, as a king who breaks his oath is unfit to rule. His sage advisor came up with a solution. Have the stone cut into very small pebbles, and have the mischievous son pelted with them.

The difference between a thousand pebbles and a large stone of equivalent weight is a potent illustration of how fragility stems from nonlinear effects. Nonlinear? Once again, "nonlinear" means that the response is not straightforward and not a straight line, so if you double, say, the dose, you get a lot more or a lot less than double the effect—if I throw at someone's head a ten-pound stone, it will cause more than twice the harm of a five-pound stone, more than five times the harm of a two-pound stone, *etc.* It is simple: if you draw a line on a graph, with harm on the vertical axis and the size of the stone on the horizontal axis, it will be curved, not a straight line. That is a refinement of asymmetry.

Now the very simple point, in fact, that allows for a detection of fragility:

For the fragile, shocks bring higher harm as their intensity increases (up to a certain level).

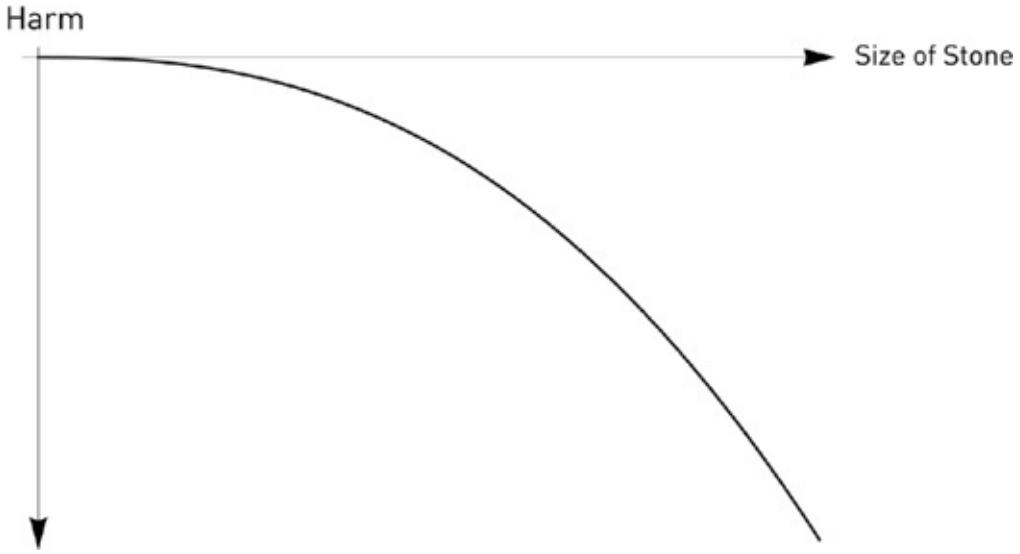

FIGURE 9. The King and His Son. The harm from the size of the stone as a function of the size of the

stone (up to a point). Every additional weight of the stone harms more than the previous one. You see nonlinearity (the harm curves inward, with a steeper and steeper vertical slope).

The example is shown in Figure 9. Let us generalize. Your car is fragile. If you drive it into the wall at 50 miles per hour, it would cause more damage than if you drove it into the same wall ten times at 5 mph. The harm at 50 mph is more than ten times the harm at 5 mph.

Other examples. Drinking seven bottles of wine (Bordeaux) in one sitting, then purified water with lemon twist for the remaining six days is more harmful than drinking one bottle of wine a day for seven days (spread out in two glasses per meal). Every additional glass of wine harms you more than the preceding one, hence your system is fragile to alcoholic consumption. Letting a porcelain cup drop on the floor from a height of one foot (about thirty centimeters) is worse than twelve times the damage from a drop from a height of one inch (two and a half centimeters).

Jumping from a height of thirty feet (ten meters) brings more than ten times the harm of jumping from a height of three feet (one meter)—actually, thirty feet seems to be the cutoff point for death from free fall.

Note that this is a simple expansion of the foundational asymmetry we saw two chapters ago, as we used Seneca's thinking as a pretext to talk about nonlinearity. Asymmetry is necessarily nonlinearity. More harm than benefits: simply, an increase in intensity brings more harm than a corresponding decrease offers benefits.

Why Is Fragility Nonlinear?

Let me explain the central argument—why fragility is generally in the nonlinear and not in the linear. That was the intuition from the porcelain cup. The answer has to do with the structure of survival probabilities: conditional on something being unharmed (or having survived), then it is more harmed by a single rock than a thousand pebbles, that is, by a single large infrequent event than by the cumulative effect of smaller shocks.

If for a human, jumping one millimeter (an impact of small force) caused an exact linear fraction of the damage of, say, jumping to the ground from thirty feet, then the person would already be dead from cumulative harm. Actually a simple computation shows that he would have expired within hours from touching objects or pacing in his living room, given the multitude of such stressors and their total effect. The fragility that comes from linearity is

immediately visible, so we rule it out because the object would be already broken. This leaves us with the following: what is fragile is something that is both unbroken and subjected to nonlinear effects—and extreme, rare events, since impacts of large size (or high speed) are rarer than ones of small size (and slow speed).

Let me rephrase this idea in connection with Black Swans and extreme events. There are a lot more ordinary events than extreme events. In the financial markets, there are at least ten thousand times more events of 0.1 percent magnitude than events of 10 percent magnitude. There are close to eight thousand microearthquakes daily on planet Earth, that is, those below 2 on the Richter scale—about three million a year. These are totally harmless, and, with three million per year, you would need them to be so. But shocks of intensity 6 and higher on the scale make the newspapers. Take objects such as porcelain cups. They get a lot of hits, a million more hits of, say, one hundredth of a pound per square inch (to take an arbitrary measure) than hits of a hundred pounds per square inch. Accordingly, we are necessarily immune to the *cumulative* effect of small deviations, or shocks of very small magnitude, which implies that these affect us disproportionally less (that is, nonlinearly less) than larger ones.

Let me reexpress my previous rule:

> *For the fragile, the cumulative effect of small shocks is smaller than the single effect of an equivalent single large shock.*

This leaves me with the principle that the fragile is what is hurt a lot more by extreme events than by a succession of intermediate ones. Finito—and there is *no other* way to be fragile.

Now let us flip the argument and consider the antifragile. Antifragility, too, is grounded in nonlinearties, nonlinear responses.

> *For the antifragile, shocks bring more benefits (equivalently, less harm) as their intensity increases (up to a point).*

A simple case—known heuristically by weight lifters. In the bodyguard-emulating story in Chapter 2, I focused only on the maximum I could do. Lifting one hundred pounds once brings more benefits than lifting fifty pounds twice, and certainly a lot more than lifting one pound a hundred times. Benefits here are in weight-lifter terms: strengthening the body, muscle mass, and bar-fight looks rather than resistance and the ability to run a marathon. The second fifty

pounds play a larger role, hence the nonlinear (that is, we will see, *convexity*) effect. Every additional pound brings more benefits, until one gets close to the limit, what weight lifters call "failure."[1]

For now, note the reach of this simple curve: it affects about just anything in sight, even medical error, government size, innovation—anything that touches uncertainty. And it helps put the "plumbing" behind the statements on size and concentration in Book II.

When to Smile and When to Frown

Nonlinearity comes in two kinds: concave (curves inward), as in the case of the king and the stone, or its opposite, convex (curves outward). And of course, mixed, with concave and convex sections.

Figures 10 and 11 show the following simplifications of nonlinearity: the convex and the concave resemble a smile and a frown, respectively.

FIGURE 10. The two types of nonlinearities, the convex (left) and the concave (right). The convex curves outward, the concave inward.

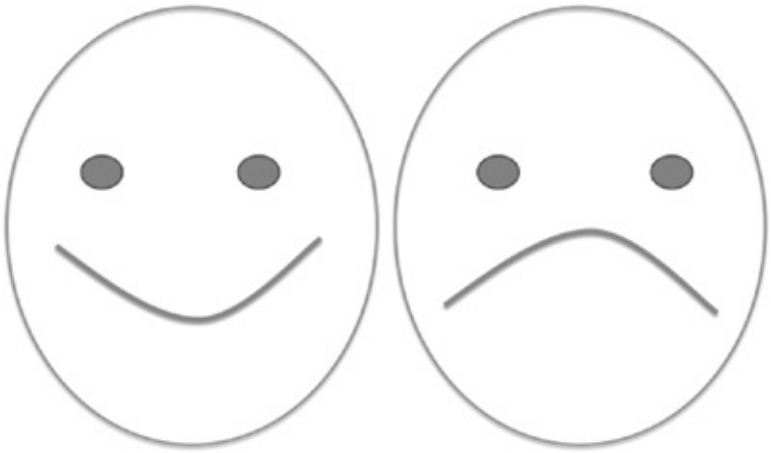

FIGURE 11. Smile! A better way to understand convexity and concavity. What curves outward looks like a smile—what curves inward makes a sad face. The convex (left) is antifragile, the concave (right) is fragile (has negative convexity effects).

I use the term "convexity effect" for both, in order to simplify the vocabulary, saying "positive convexity effects" and "negative convexity effects."

Why does asymmetry map to convexity or concavity? Simply, if for a given variation you have more upside than downside and you draw the curve, it will be convex; the opposite for the concave. Figure 12 shows the asymmetry reexpressed in terms of nonlinearities. It also shows the magical effect of mathematics that allowed us to treat steak tartare, entrepreneurship, and financial risk in the same breath: the convex graph turns into concave when one simply puts a minus sign in front of it. For instance, Fat Tony had the exact opposite payoff than, say, a bank or financial institution in a certain transaction: he made a buck whenever they lost one, and vice versa. The profits and losses are mirror images of each other at the end of the day, except that one is the minus sign times the other.

Figure 12 also shows why the convex *likes volatility*. If you earn more than you lose from fluctuations, you want a lot of fluctuations.

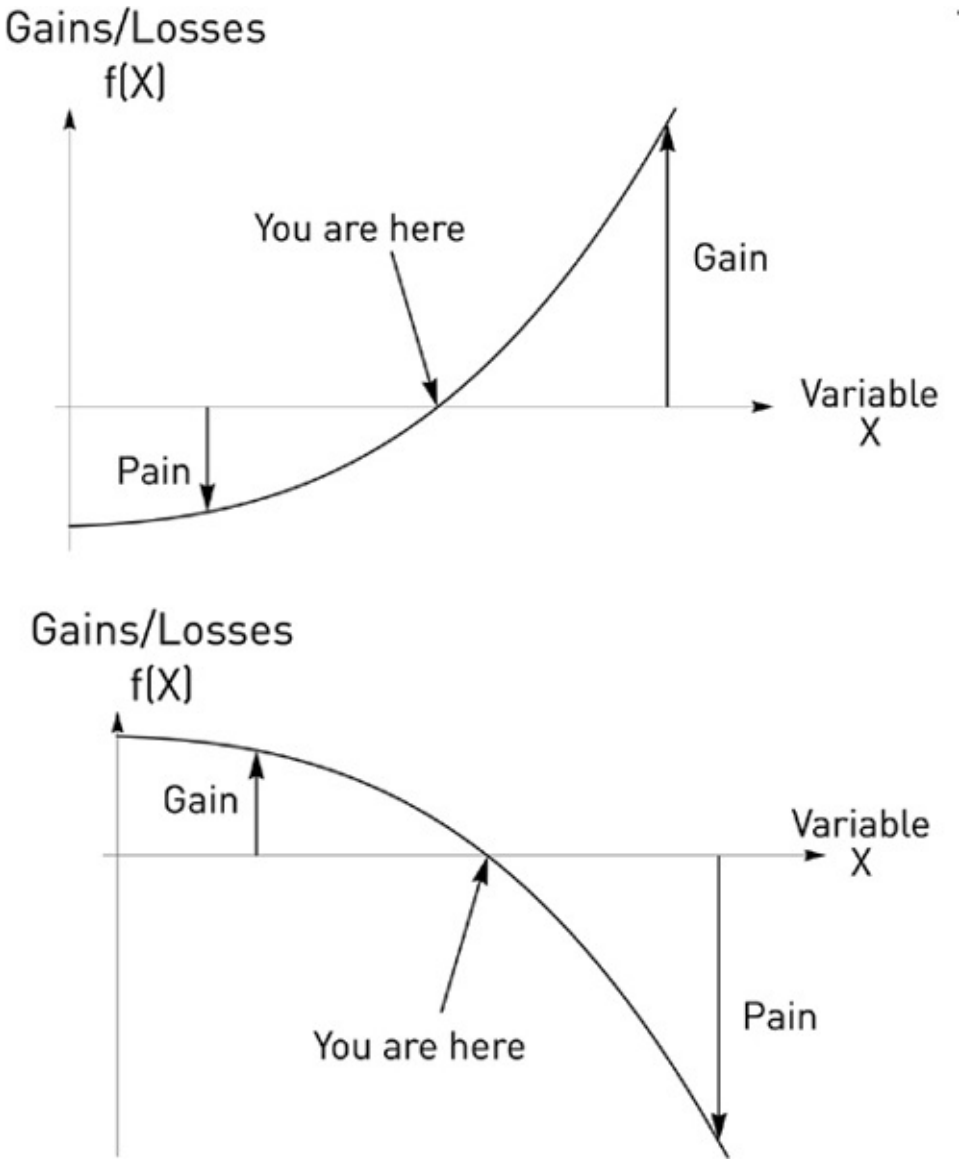

FIGURE 12. Pain More than Gain, or Gain More than Pain. Assume you start from the "You Are Here" spot. In the first case, should the variable *x* increase, i.e., move to the right on the horizontal axis, the gains (vertical axis) are larger than the losses encountered by moving left, i.e., an equivalent decrease in the variable *x*. The graph illustrates how positive asymmetry (first graph) turns into convex (inward) curving and negative asymmetry (second graph) turns into concave (outward) curving. To repeat, for a set deviation in a variable, in equivalent amounts in both directions, the convex gains more than it loses, and the reverse for the concave.

Why Is the Concave Hurt by Black Swan Events?

Now the idea that has inhabited me all my life—I never realized it could show so clearly when put in graphical form. Figure 13 illustrates the effect of harm and the unexpected. The more concave an exposure, the more harm from the

unexpected, and disproportionately so. So very large deviations have a disproportionately larger and larger effect.

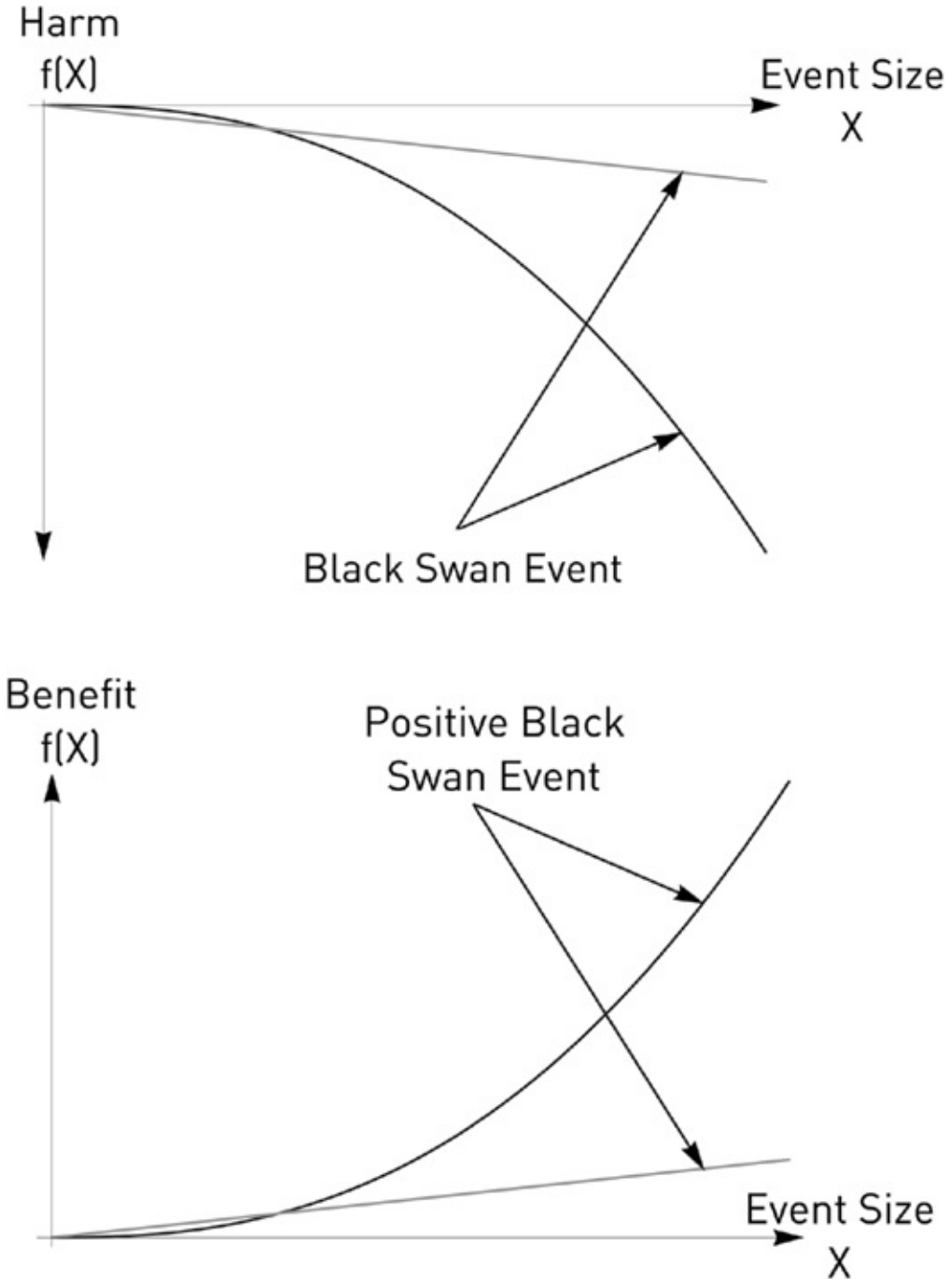

FIGURE 13. Two exposures, one linear, one nonlinear, with negative convexity—that is, concavity—in the first graph, positive convexity in the second. An unexpected event affects the nonlinear disproportionately more. The larger the event, the larger the difference.

Next, let us apply this very simple technique to the detection of fragility and

position in the Triad.

TRAFFIC IN NEW YORK

Let us apply "convexity effects" to things around us. Traffic is highly nonlinear. When I take the day flight from New York to London, and I leave my residence around five in the morning (yes, I know), it takes me around 26 minutes to reach the British Air terminal at JFK airport. At that time, New York is empty, eerily non–New York. When I leave my place at six o'clock for the later flight, there is almost no difference in travel time, although traffic is a bit denser. One can add more and more cars on the highway, with no or minimal impact on time spent in traffic.

Then, a mystery—increase the number of cars by 10 percent and watch the travel time jump by 50 percent (I am using approximate numbers). Look at the convexity effect at work: the average number of cars on the road does not matter at all for traffic speed. If you have 90,000 cars for one hour, then 110,000 cars for another hour, traffic would be much slower than if you had 100,000 cars for two hours. Note that travel time is a negative, so I count it as a cost, like an expense, and a rise is a bad thing.

So travel cost is fragile to the *volatility* of the number of cars on the highway; it does not depend so much on their average number. Every additional car increases travel time more than the previous one.

This is a hint to a central problem of the world today, that of the misunderstanding of nonlinear response by those involved in creating "efficiencies" and "optimization" of systems. For instance, European airports and railroads are stretched, seeming overly efficient. They operate at close to maximal capacity, with minimal redundancies and idle capacity, hence acceptable costs; but a small increase in congestion, say 5 percent more planes in the sky owing to a tiny backlog, can give rise to chaos in airports and cause scenes of unhappy travelers camping on floors, their only solace some bearded fellow playing French folk songs on his guitar.

We can see applications of the point across economic domains: central banks can print money; they print and print with no effect (and claim the "safety" of such a measure), then, "unexpectedly," the printing causes a jump in inflation. Many economic results are completely canceled by convexity effects—and the happy news is that we know why. Alas, the tools (and culture) of policy makers are based on the overly linear, ignoring these hidden effects. They call it "approximation." When you hear of a "second-order" effect, it means convexity

is causing the failure of approximation to represent the real story.

I have put a (very hypothetical) graph of the response of traffic to cars on the road in Figure 14. Note for now the curved shape of the graph. It curves inward.

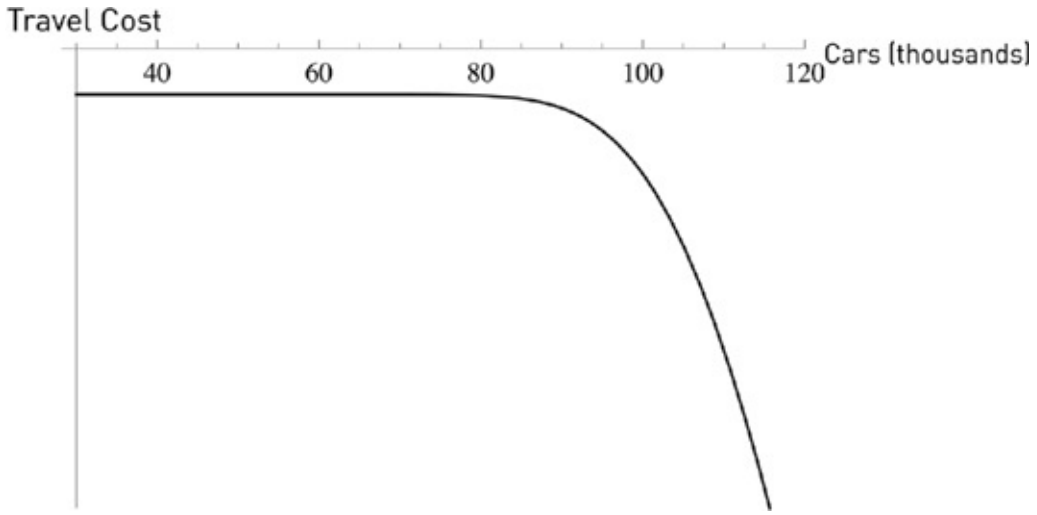

FIGURE 14. The graph shows how the author's travel time (and travel costs) to JFK depend, beyond a certain point, nonlinearly on the number of cars on the road. We show travel costs as curving inward—concave, not a good thing.

Someone Call New York City Officials

An apt illustration of how convexity effects affect an overoptimized system, along with misforecasting large deviations, is this simple story of an underestimation made by New York City officials of the effect of a line closure on traffic congestion. This error is remarkably general: a small modification with compounded results in a system that is extremely stretched, hence fragile.

One Saturday evening in November 2011, I drove to New York City to meet the philosopher Paul Boghossian for dinner in the Village—typically a forty-minute trip. Ironically, I was meeting him to talk about my book, this book, and more particularly, my ideas on redundancy in systems. I have been advocating the injection of redundancy into people's lives and had been boasting to him and others that, since my New Year's resolution of 2007, I have never been late to anything, not even by a minute (well, almost). Recall in Chapter 2 my advocacy of redundancies as an aggressive stance. Such personal discipline forces me to build buffers, and, as I carry a notebook, it allowed me to write an entire book of aphorisms. Not counting long visits to bookstores. Or I can sit in a café and read hate mail. With, of course, no stress, as I have no fear of being late. But the greatest benefit of such discipline is that it prevents me from cramming my day

with appointments (typically, appointments are neither useful nor pleasant). Actually, by another rule of personal discipline I do not make appointments (other than lectures) except the very same morning, as a date on the calendar makes me feel like a prisoner, but that's another story.

As I hit Midtown, around six o'clock, traffic stopped. Completely. By eight I had moved hardly a few blocks. So even my "redundancy buffer" failed to let me keep the so-far-unbroken resolution. Then, after relearning to operate the noisy cacophonic thing called the radio, I started figuring out what had happened: New York City had authorized a film company to use the Fifty-ninth Street Bridge, blocking part of it, assuming that it would be no problem on a Saturday. And the small traffic problem turned into mayhem, owing to the multiplicative effects. What they felt would be at the worst a few minutes' delays was multiplied by two orders of magnitude; minutes became hours. Simply, the authorities running New York City did not understand nonlinearities.

This is the central problem of efficiency: these types of errors compound, multiply, swell, with an effect that only goes in one direction—the wrong direction.

WHERE MORE IS DIFFERENT

Another intuitive way to look at convexity effects: consider the scaling property. If you double the exposure to something, do you more than double the harm it will cause? If so, then this is a situation of fragility. Otherwise, you are robust.

The point has been aptly expressed by P. W. Anderson in the title of his paper "More Is Different." And what scientists involved in complexity call "emerging properties" is the nonlinear result of adding units, as the sum becomes increasingly different from the parts. Just look at how different the large stone is from the pebbles: the latter have the same weight and the same general shape, but that's about it. Likewise, we saw in Chapter 5 that a city is not a large village; a corporation is not a larger small business. We also saw how randomness changes in nature from Mediocristan to Extremistan, how a state is not a large village, and many alterations that come from size—and speed. All these show nonlinearity in action.

A "Balanced Meal"

Another example of missing the hidden dimension, that is, variability: we are currently told by the Soviet-Harvard U.S. health authorities to eat set quantities of nutrients (total calories, protein, vitamins, etc.) every day, in some recommended amounts of each. Every food item has a "percentage daily allowance." Aside from the total lack of empirical rigor in the way these recommendations are currently derived (more on that in the medical chapters), there is another sloppiness in the edict: an insistence in the discourse on the *regularity*. Those recommending the nutritional policies fail to understand that "steadily" getting your calories and nutrients throughout the day, with "balanced" composition and metronomic regularity, does not necessarily have the same effect as consuming them unevenly or randomly, say by having a lot of proteins one day, fasting completely another, feasting the third, *etc.*

This is a denial of hormesis, the slight stressor of episodic deprivation. For a long time, nobody even bothered to try to figure out whether variability in distribution—the second-order effect—mattered as much as long-term composition. Now research is starting to catch up to such a very, very simple point. It turns out that the effect of variability in food sources and the nonlinearity in the physiological response is central to biological systems.

Consuming no protein at all on Monday and catching up on Wednesday seemingly causes a different—better—physiological response, possibly because the deprivation, as a stressor, activates some pathways that facilitate the subsequent absorption of the nutrients (or something similar). And, until a few recent (and disconnected) empirical studies, this convexity effect has been totally missed by science—though not by religions, ancestral heuristics, and traditions. And if scientists get some convexity effects (as we said about domain dependence, doctors, just like weight lifters, understand here and there nonlinearities in dose response), the notion of convexity effects itself appears to be completely missing from their language and methods.

Run, Don't Walk

Another illustration, this time a situation that benefits from variation—positive convexity effects. Take two brothers, Castor and Polydeuces, who need to travel a mile. Castor walks the mile at a leisurely pace and arrives at the destination in twenty minutes. Polydeuces spends fourteen minutes playing with his handheld device getting updates on the gossip, then runs the same mile in six minutes, arriving at the same time as Castor.

So both persons have covered the exact same distance, in exactly the same time—same average. Castor, who walked all the way, presumably will not get the same health benefits and gains in strength as Polydeuces, who sprinted. Health benefits are *convex* to speed (up to a point, of course).

The very idea of exercise is to gain from antifragility to workout stressors—as we saw, all kinds of exercise are just exploitations of convexity effects.

SMALL MAY BE UGLY, IT IS CERTAINLY LESS FRAGILE

We often hear the expression “small is beautiful.” It is potent and appealing; many ideas have been offered in its support—almost all of them anecdotal, romantic, or existential. Let us present it within our approach of *fragility* equals *concavity* equals *dislike of randomness* and see how we can measure such an effect.

How to Be Squeezed

A squeeze occurs when people have no choice but to do something, and do it right away, regardless of the costs.

Your other half is to defend a doctoral thesis in the history of German dance and you need to fly to Marburg to be present at such an important moment, meet the parents, and get formally engaged. You live in New York and manage to buy an economy ticket to Frankfurt for $400 and you are excited about how cheap it is. But you need to go through London. Upon getting to New York’s Kennedy airport, you are apprised by the airline agent that the flights to London are canceled, sorry, delays due to backlog due to weather problems, that type of thing. Something about Heathrow’s fragility. You can get a last-minute flight to Frankfurt, but now you need to pay $4,000, close to ten times the price, and hurry, as there are very few seats left. You fume, shout, curse, blame yourself, your upbringing and parents who taught you to save, then shell out the $4,000. That’s a squeeze.

Squeezes are exacerbated by size. When one is large, one becomes vulnerable to some errors, particularly horrendous squeezes. The squeezes become nonlinearly costlier as size increases.

To see how size becomes a handicap, consider the reasons one should not own an elephant as a pet, regardless of what emotional attachment you may have to the animal. Say you can afford an elephant as part of your postpromotion household budget and have one delivered to your backyard. Should there be a water shortage—hence a squeeze, since you have no choice but to shell out the money for water—you would have to pay a higher and higher price for each additional gallon of water. That’s fragility, right there, a negative convexity effect coming from getting too big. The unexpected cost, as a percentage of the total, would be monstrous. Owning, say, a cat or a dog would not bring about

such high unexpected additional costs at times of squeeze—the overruns taken as a percentage of the total costs would be very low.

In spite of what is studied in business schools concerning "economies of scale," size hurts you at times of stress; it is not a good idea to be large during difficult times. Some economists have been wondering why mergers of corporations do not appear to play out. The combined unit is now much larger, hence more powerful, and according to the theories of economies of scale, it should be more "efficient." But the numbers show, at best, no gain from such increase in size—that was already true in 1978, when Richard Roll voiced the "hubris hypothesis," finding it irrational for companies to engage in mergers given their poor historical record. Recent data, more than three decades later, still confirm both the poor record of mergers and the same hubris as managers seem to ignore the bad economic aspect of the transaction. There appears to be something about size that is harmful to corporations.

As with the idea of having elephants as pets, squeezes are much, much more expensive (relative to size) for large corporations. The gains from size are visible but the risks are hidden, and some concealed risks seem to bring frailties into the companies.

Large animals, such as elephants, boa constrictors, mammoths, and other animals of size tend to become rapidly extinct. Aside from the squeeze when resources are tight, there are mechanical considerations. Large animals are more fragile to shocks than small ones—again, stone and pebbles. Jared Diamond, always ahead of others, figured out such vulnerability in a paper called "Why Cats Have Nine Lives." If you throw a cat or a mouse from an elevation of several times their height, they will typically manage to survive. Elephants, by comparison, break limbs very easily.

Kerviel and Micro-Kerviel

Let us look at a case study from vulgar finance, a field in which participants are very good at making mistakes. On January 21, 2008, the Parisian bank Societé Générale rushed to sell in the market close to seventy billion dollars' worth of stocks, a very large amount for any single "fire sale." Markets were not very active (called "thin"), as it was Martin Luther King Day in the United States, and markets worldwide dropped precipitously, close to 10 percent, costing the company close to six billion dollars in losses just from their fire sale. The entire point of the squeeze is that they couldn't wait, and they had no option but to turn

a sale into a fire sale. For they had, over the weekend, uncovered a fraud. Jerome Kerviel, a rogue back office employee, was playing with humongous sums in the market and hiding these exposures from the main computer system. They had no choice but to sell, immediately, these stocks they didn't know they owned.

Now, to see the effect of fragility from size, look at Figure 15 showing losses as a function of quantity sold. A fire sale of $70 billion worth of stocks leads to a loss of $6 billion. But a fire sale a tenth of the size, $7 billion would result in no loss at all, as markets would absorb the quantities without panic, maybe without even noticing. So this tells us that if, instead of having one very large bank, with Monsieur Kerviel as a rogue trader, we had ten smaller banks, each with a proportional Monsieur Micro-Kerviel, and each conducted his rogue trading independently and at random times, the total losses for the ten banks would be close to nothing.

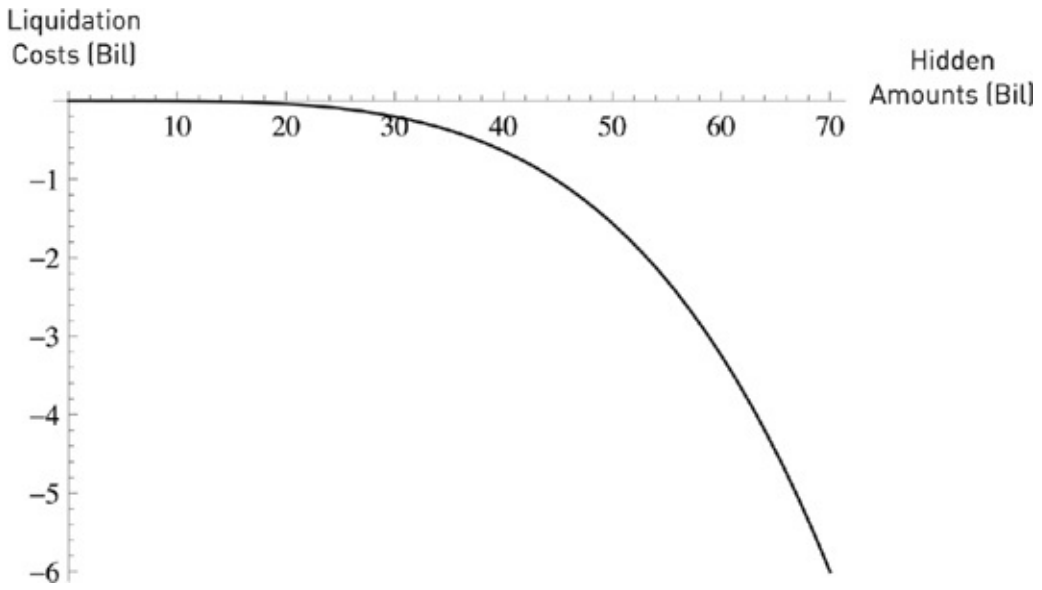

FIGURE 15. Small may be beautiful; it is certainly less fragile. The graph shows transaction costs as a function of the size of the error: they increase nonlinearly, and we can see the megafragility.

About a few weeks before the Kerviel episode, a French business school hired me to present to the board of executives of the Societé Générale meeting in Prague my ideas of Black Swan risks. In the eyes of the bankers, I was like a Jesuit preacher visiting Mecca in the middle of the annual Hajj—their "quants" and risk people hated me with passion, and I regretted not having insisted on speaking in Arabic given that they had simultaneous translation. My talk was about pseudo risk techniques à la Triffat—methods commonly used, as I said, to measure and predict events, methods that have never worked before—and how

we needed to focus on fragility and barbells. During the talk I was heckled relentlessly by Kerviel's boss and his colleague, the head of risk management. After my talk, everyone ignored me, as if I were a Martian, with a "who brought this guy here" awkward situation (I had been selected by the school, not the bank). The only person who was nice to me was the chairman, as he mistook me for someone else and had no clue about what I was discussing.

So the reader can imagine my state of mind when, shortly after my return to New York, the Kerviel trading scandal broke. It was also tantalizing that I had to keep my mouth shut (which I did, except for a few slips) for legal reasons.

Clearly, the postmortem analyses were mistaken, attributing the problem to *bad* controls by the *bad* capitalistic system, and lack of vigilance on the part of the bank. It was not. Nor was it "greed," as we commonly assume. The problem is primarily size, and the fragility that comes from size.

Always keep in mind the difference between a stone and its weight in pebbles. The Kerviel story is illustrative, so we can generalize and look at evidence across domains.

In project management, Bent Flyvbjerg has shown firm evidence that an increase in the size of projects maps to poor outcomes and higher and higher costs of delays as a proportion of the total budget. But there is a nuance: it is the size per segment of the project that matters, not the entire project—some projects can be divided into pieces, not others. Bridge and tunnel projects involve monolithic planning, as these cannot be broken up into small portions; their percentage costs overruns increase markedly with size. Same with dams. For roads, built by small segments, there is no serious size effect, as the project managers incur only small errors and can adapt to them. Small segments go one small error at the time, with no serious role for squeezes.

Another aspect of size: large corporations also end up endangering neighborhoods. I've used the following argument against large superstore chains in spite of the advertised benefits. A large super-megastore wanted to acquire an entire neighborhood near where I live, causing uproar owing to the change it would bring to the character of the neighborhood. The argument in favor was the revitalization of the area, that type of story. I fought the proposal on the following grounds: should the company go bust (and the statistical elephant in the room is that it eventually will), we would end up with a massive war zone. This is the type of argument the British advisors Rohan Silva and Steve Hilton have used in favor of small merchants, along the poetic "small is beautiful." It is completely wrong to use the calculus of benefits without including the

probability of failure.[2]

How to Exit a Movie Theater

Another example of the costs of a squeeze: Imagine how people exit a movie theater. Someone shouts “fire,” and you have a dozen persons squashed to death. So we have a fragility of the theater to size, stemming from the fact that every additional person exiting brings more and more trauma (such disproportional harm is a negative convexity effect). A thousand people exiting (or trying to exit) in one minute is not the same as the same number exiting in half an hour. Someone unfamiliar with the business who naively *optimizes* the size of the place (Heathrow airport, for example) might miss the idea that smooth functioning at regular times is different from the rough functioning at times of stress.

It so happens that contemporary economic optimized life causes us to build larger and larger theaters, but with the exact same door. They no longer make this mistake too often while building cinemas, theaters, and stadiums, but we tend to make the mistake in other domains, such as, for instance, natural resources and food supplies. Just consider that the price of wheat more than tripled in the years 2004–2007 in response to a small increase in net demand, around 1 percent.[3]

Bottlenecks are the mothers of all squeezes.

PROJECTS AND PREDICTION

Why Planes Don't Arrive Early

Let us start as usual with a transportation problem, and generalize to other areas. Travelers (typically) do not like uncertainty—especially when they are on a set schedule. Why? There is a one-way effect.

I've taken the very same London–New York flight most of my life. The flight takes about seven hours, the equivalent of a short book plus a brief polite chat with a neighbor and a meal with port wine, stilton cheese, and crackers. I recall a few instances in which I arrived early, about twenty minutes, no more. But there have been instances in which I got there more than two or three hours late, and in at least one instance it has taken me more than two days to reach my destination.

Because travel time cannot be really negative, uncertainty tends to cause delays, making arrival time increase, almost never decrease. Or it makes arrival time decrease by just minutes, but increase by hours, an obvious asymmetry. Anything unexpected, any shock, any volatility, is much more likely to extend the total flying time.

This also explains the irreversibility of time, in a way, if you consider the passage of time as an increase in disorder.

Let us now apply this concept to projects. Just as when you add uncertainty to a flight, the planes tend to land later, not earlier (and these laws of physics are so universal that they even work in Russia), when you add uncertainty to projects, they tend to cost more and take longer to complete. This applies to many, in fact almost all, projects.

The interpretation I had in the past was that a psychological bias, the underestimation of the random structure of the world, was the cause behind such underestimation—projects take longer than planned because the estimates are too optimistic. We have evidence of such bias, called overconfidence. Decision scientists and business psychologists have theorized something called the "planning fallacy," in which they try to explain the fact that projects take longer, rarely less time, using psychological factors.

But the puzzle was that such underestimation did not seem to exist in the past century or so, though we were dealing with the very same humans, endowed with the same biases. Many large-scale projects a century and a half ago were

completed on time; many of the tall buildings and monuments we see today are not just more elegant than modernistic structures but were completed within, and often ahead of, schedule. These include not just the Empire State Building (still standing in New York), but the London Crystal Palace, erected for the Great Exhibition of 1851, the hallmark of the Victorian reign, based on the inventive ideas of a gardener. The Palace, which housed the exhibition, went from concept to grand opening in just nine months. The building took the form of a massive glass house, 1,848 feet long by 454 feet wide; it was constructed from cast iron frame components and glass made almost exclusively in Birmingham and Smethwick.

The obvious is usually missed here: the Crystal Palace project did not use computers, and the parts were built not far from the source, with a small number of businesses involved in the supply chain. Further, there were no business schools at the time to teach something called "project management" and increase overconfidence. There were no consulting firms. The agency problem (which we defined as the divergence between the interest of the agent and that of his client) was not significant. In other words, it was a much more linear economy—less complex—than today. And we have more nonlinearities—asymmetries, convexities—in today's world.

Black Swan effects are necessarily increasing, as a result of complexity, interdependence between parts, globalization, and the beastly thing called "efficiency" that makes people now sail too close to the wind. Add to that consultants and business schools. One problem somewhere can halt the entire project—so the projects tend to get as weak as the weakest link in their chain (an acute negative convexity effect). The world is getting less and less predictable, and we rely more and more on technologies that have errors and interactions that are harder to estimate, let alone predict.

And the information economy is the culprit. Bent Flyvbjerg, the one of bridge and road projects mentioned earlier in this chapter, showed another result. The problem of cost overruns and delays is much more acute in the presence of information technologies (IT), as computer projects cause a large share of these cost overruns, and it is better to focus on these principally. But even outside of these IT-heavy projects, we tend to have very severe delays.

But the logic is simple: again, negative convexity effects are the main culprit, a direct and visible cause. There is an asymmetry in the way errors hit you—the same as with travel.

No psychologist who has discussed the "planning fallacy" has realized that, at

the core, it is not essentially a psychological problem, not an issue with human errors; it is inherent to the nonlinear structure of the projects. Just as time cannot be negative, a three-month project cannot be completed in zero or negative time. So, on a timeline going left to right, errors add to the right end, not the left end of it. If uncertainty were linear we would observe some projects completed extremely early (just as we would arrive sometimes very early, sometimes very late). But this is not the case.

Wars, Deficits, and Deficits

The Great War was estimated to last only a few months; by the time it was over, it had gotten France and Britain heavily in debt; they incurred at least ten times what they thought their financial costs would be, aside from all the horrors, suffering, and destruction. The same of course for the second war, which added to the U.K. debt, causing it to become heavily indebted, mostly to the United States.

In the United States the prime example remains the Iraq war, expected by George W. Bush and his friends to cost thirty to sixty billion, which so far, taking into account all the indirect costs, may have swelled to more than two trillion—indirect costs multiply, causing chains, explosive chains of interactions, all going in the same direction of more costs, not less. Complexity plus asymmetry (plus such types as George W. Bush), once again, lead to explosive errors.

The larger the military, the disproportionally larger the cost overruns.

But wars—with more than twentyfold errors—are only illustrative of the way governments underestimate explosive nonlinearities (convexity effects) and why they should not be trusted with finances or any large-scale decisions. Indeed, governments do not need wars at all to get us in trouble with deficits: the underestimation of the costs of their projects is chronic for the very same reason 98 percent of contemporary projects have overruns. They just end up spending more than they tell us. This has led me to install a governmental golden rule: no borrowing allowed, forced fiscal balance.

WHERE THE “EFFICIENT” IS NOT EFFICIENT

We can easily see the costs of fragility swelling in front of us, visible to the naked eye. Global disaster costs are today more than three times what they were in the 1980s, adjusting for inflation. The effect, noted a while ago by the visionary researcher on extreme events Daniel Zajdenweber, seems to be accelerating. The economy can get more and more “efficient,” but fragility is causing the costs of errors to be higher.

The stock exchanges have converted from “open outcry” where wild traders face each other, yelling and screaming as in a souk, then go drink together. Traders were replaced by computers, for very small visible benefits and massively large risks. While errors made by traders are confined and distributed, those made by computerized systems go wild—in August 2010, a computer error made the entire market crash (the “flash crash”); in August 2012, as this manuscript was heading to the printer, the Knight Capital Group had its computer system go wild and cause $10 million dollars of losses a minute, losing $480 million.

And naive cost-benefit analyses can be a bit harmful, an effect that of course swells with size. For instance, the French have in the past focused on nuclear energy as it seemed “clean” and cheap. And “optimal” on a computer screen. Then, after the wake-up call of the Fukushima disaster of 2011, they realized that they needed additional safety features and scrambled to add them, at any cost. In a way this is similar to the squeeze I mentioned earlier: they are forced to invest, regardless of price. Such additional expense was not part of the cost-benefit analysis that went into the initial decision and looked good on a computer screen. So when deciding on one source of fuel against another, or similar comparisons, we do not realize that model error may hit one side more than the other.

Pollution and Harm to the Planet

From this we can generate a simple ecological policy. We know that fossil fuels are harmful in a nonlinear way. The harm is necessarily concave (if a little bit of it is devoid of harm, a lot can cause climatic disturbances). While on epistemological grounds, because of opacity, we do not need to believe in anthropogenic climate change (caused by humans) in order to be ecologically

conservative, we can put these convexity effects to use in producing a risk management rule for pollution. Simply, just as with size, split your sources of pollution among many natural sources. The harm from polluting with ten different sources is smaller than the equivalent pollution from a single source.[4]

Let's look at naturelike ancestral mechanisms for regulating the concentration effects. We contemporary humans go to the stores to purchase the same items, say tuna, coffee or tea, rice, mozzarella, Cabernet wine, olive oil, and other items that appear to us as not easily substitutable. Because of sticky contemporary habits, cultural contagion, and the rigidity of factories, we are led to the excessive use of specific products. This concentration is harmful. Extreme consumption of, say, tuna, can hurt other animals, mess with the ecosystem, and lead species to extinction. And not only does the harm scale nonlinearly, but the shortages lead to disproportional rises in prices.

Ancestral humans did it differently. Jennifer Dunne, a complexity researcher who studies hunter-gatherers, examined evidence about the behavior of the Aleuts, a North American native tribe, for which we have ample data, covering five millennia. They exhibit a remarkable lack of concentration in their predatorial behavior, with a strategy of prey switching. They were not as sticky and rigid as us in their habits. Whenever they got low on a resource, they switched to another one, as if to preserve the ecosystem. So they understood convexity effects—or, rather, their habits did.

Note that globalization has had the effect of making contagions planetary—as if the entire world became a huge room with narrow exits and people rushing to the same doors, with accelerated harm. Just as about every child reads Harry Potter and joins (for now) Facebook, people when they get rich are starting to engage in the same activities and buy the same items. They drink Cabernet wine, hope to visit Venice and Florence, dream of buying a second home in the South of France, *etc.* Tourist locations are becoming unbearable: just go to Venice next July.

The Nonlinearity of Wealth

We can certainly attribute the fragilizing effect of contemporary globalization to complexity, and how connectivity and cultural contagions make gyrations in economic variables much more severe—the classic switch to Extremistan. But there is another effect: wealth. Wealth means more, and because of nonlinear scaling, more is different. We are prone to make more severe errors because we

are simply wealthier. Just as projects of one hundred million dollars are more unpredictable and more likely to incur overruns than five-million-dollar ones, simply by being richer, the world is troubled with additional unpredictability and fragility. This comes with growth—at a country level, this Highly Dreamed-of GDP Growth. Even at an individual level, wealth means more headaches; we may need to work harder at mitigating the complications arising from wealth than we do at acquiring it.

Conclusion

To conclude this chapter, fragility in any domain, from a porcelain cup to an organism, to a political system, to the size of a firm, or to delays in airports, resides in the nonlinear. Further, discovery can be seen as an antideficit. Think of the exact opposite of airplane delays or project overruns—something that benefits from uncertainty. And discovery presents the mirror image of what we saw as fragile, randomness-hating situations.

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[1] Actually there are different muscle fibers, each one responding to different sets of conditions with varied asymmetries of responses. The so-called "fast-twitch" fibers, the ones used to lift very heavy objects, are very antifragile, as they are convex to weight. And they die in the absence of intensity.

[2] A nuance: the notions of "large" and "small" are relative to a given ecology or business structure. Small for an airplane maker is different from "small" when it comes to a bakery. As with the European Union's subsidiarity principle, "small" here means the smallest possible unit for a given function or task that can operate with a certain level of efficiency.

[3] The other problem is that of misunderstanding the nonlinearity of natural resources, or anything particularly scarce and vital. Economists have the so-called law of scarcity, by which things increase in value according to the demand for them—but they ignore the consequences of nonlinearities on risk. My former thesis director, Hélyette Geman, and I are currently studying a "law of convexity" that makes commodities, particularly vital ones, even dearer than previously thought.

[4] Volatility and uncertainty are equivalent, as we saw with the table of the Disorder family. Accordingly, note that the fragile is harmed by an increase in uncertainty.

CHAPTER 19

The Philosopher’s Stone and Its Inverse

They tell you when they are going bust—Gold is sometimes a special variety of lead

And now, reader, after the Herculean effort I put into making the ideas of the last few chapters clearer to you, my turn to take it easy and express things technically, sort of. Accordingly, this chapter—a deepening of the ideas of the previous one—will be denser and should be skipped by the enlightened reader.

HOW TO DETECT WHO WILL GO BUST

Let us examine a method to detect fragility—the inverse philosopher's stone. We can illustrate it with the story of the giant government-sponsored lending firm called Fannie Mae, a corporation that collapsed leaving the United States taxpayer with hundreds of billions of dollars of losses (and, alas, still counting).

One day in 2003, Alex Berenson, a *New York Times* journalist, came into my office with the secret risk reports of Fannie Mae, given to him by a defector. It was the kind of report getting into the guts of the methodology for risk calculation that only an insider can see—Fannie Mae made its own risk calculations and disclosed what it wanted to whomever it wanted, the public or someone else. But only a defector could show us the guts to see how the risk was calculated.

We looked at the report: simply, a move upward in an economic variable led to massive losses, a move downward (in the opposite direction), to small profits. Further moves upward led to even larger additional losses and further moves downward to even smaller profits. It looked exactly like the story of the stone in Figure 9. Acceleration of harm was obvious—in fact it was monstrous. So we immediately saw that their blowup was inevitable: their exposures were severely "concave," similar to the graph of traffic in Figure 14: losses that accelerate as one deviates economic variables (I did not even need to understand which one, as fragility to one variable of this magnitude implies fragility to all other parameters). I worked with my emotions, not my brain, and I had a pang before even understanding what numbers I had been looking at. It was the mother of all fragilities and, thanks to Berenson, *The New York Times* presented my concern. A smear campaign ensued, but nothing too notable. For I had in the meantime called a few key people charlatans and they were not too excited about it.

The key is that the nonlinear is vastly more affected by extreme events—and nobody was interested in extreme events since they had a mental block against them.

I kept telling anyone who would listen to me, including random taxi drivers (well, almost), that the company Fannie Mae was "sitting on a barrel of dynamite." Of course, blowups don't happen every day (just as poorly built bridges don't collapse immediately), and people kept saying that my opinion was wrong and unfounded (using some argument that the stock was going up or something even more circular). I also inferred that other institutions, almost all

banks, were in the same situation. After checking similar institutions, and seeing that the problem was general, I realized that a total collapse of the banking system was a certainty. I was so certain I could not see straight and went back to the markets to get my revenge against the turkeys. As in the scene from *The Godfather* (III), "Just when I thought I was out, they pull me back in."

Things happened as if they were planned by destiny. Fannie Mae went bust, along with other banks. It just took a bit longer than expected, no big deal.

The stupid part of the story is that I had not seen the link between financial and general fragility—nor did I use the term "fragility." Maybe I didn't look at too many porcelain cups. However, thanks to the episode of the attic I had a measure for fragility, hence antifragility.

It all boils down to the following: figuring out if our miscalculations or misforecasts are on balance more harmful than they are beneficial, and how accelerating the damage is. Exactly as in the story of the king, in which the damage from a ten-kilogram stone is more than twice the damage from a five-kilogram one. Such accelerating damage means that a large stone would eventually kill the person. Likewise a large market deviation would eventually kill the company.

Once I figured out that fragility was directly from nonlinearity and convexity effects, and that convexity was measurable, I got all excited. The technique—detecting *acceleration* of harm—applies to anything that entails decision making under uncertainty, and risk management. While it was the most interesting in medicine and technology, the immediate demand was in economics. So I suggested to the International Monetary Fund a measure of fragility to substitute for their measures of risk that they knew didn't work. Most people in the risk business had been frustrated by the poor (rather, the random) performance of their models, but they didn't like my earlier stance: "don't use any model." They wanted something. And a risk measure was there.[1]

So here is something to use. The technique, a simple heuristic called the *fragility (and antifragility) detection heuristic*, works as follows. Let's say you want to check whether a town is overoptimized. Say you measure that when traffic increases by ten thousand cars, travel time grows by ten minutes. But if traffic increases by ten thousand more cars, travel time now extends by an extra thirty minutes. Such acceleration of traffic time shows that traffic is fragile and you have too many cars and need to reduce traffic until the acceleration becomes mild (acceleration, I repeat, is acute concavity, or negative convexity effect).

Likewise, government deficits are particularly concave to changes in

economic conditions. Every additional deviation in, say, the unemployment rate —particularly when the government has debt—makes deficits incrementally worse. And financial leverage for a company has the same effect: you need to borrow more and more to get the same effect. Just as in a Ponzi scheme.

The same with operational leverage on the part of a fragile company. Should sales increase 10 percent, then profits would increase less than they would decrease should sales drop 10 percent.

That was in a way the technique I used intuitively to declare that the Highly Respected Firm Fannie Mae was on its way to the cemetery—and it was easy to produce a rule of thumb out of it. Now with the IMF we had a simple measure with a stamp. It looks simple, too simple, so the initial reaction from "experts" was that it was "trivial" (said by people who visibly never detected these risks before—academics and quantitative analysts scorn what they can understand too easily and get ticked off by what they did not think of themselves).

According to the wonderful principle that one should use people's stupidity to have fun, I invited my friend Raphael Douady to collaborate in expressing this simple idea using the most opaque mathematical derivations, with incomprehensible theorems that would take half a day (for a professional) to understand. Raphael, Bruno Dupire, and I had been involved in an almost two-decades-long continuous conversation on how everything entailing risk—everything—can be seen with a lot more rigor and clarity from the vantage point of an option professional. Raphael and I managed to prove the link between nonlinearity, dislike of volatility, and fragility. Remarkably—as has been shown —if you can say something straightforward in a complicated manner with complex theorems, even if there is no large gain in rigor from these complicated equations, people take the idea very seriously. We got nothing but positive reactions, and we were now told that this simple detection heuristic was "intelligent" (by the same people who had found it trivial). The only problem is that mathematics is addictive.

The Idea of Positive and Negative Model Error

Now what I believe is my true specialty: error in models.

When I was in the transaction business, I used to make plenty of errors of execution. You buy one thousand units and in fact you discover the next day that you bought two thousand. If the price went up in the meantime you had a handsome profit. Otherwise you had a large loss. So these errors are in the long

run neutral in effect, since they can affect you both ways. They increase the variance, but they don't affect your business too much. There is no one-sidedness to them. And these errors can be kept under control thanks to size limits—you make a lot of small transactions, so errors remain small. And at year end, typically, the errors "wash out," as they say.

But that is not the case with most things we build, and with errors related to things that are fragile, in the presence of negative convexity effects. This class of errors has a one-way outcome, that is, negative, and tends to make planes land later, not earlier. Wars tend to get worse, not better. As we saw with traffic, variations (now called disturbances) tend to increase travel time from South Kensington to Piccadilly Circus, never shorten it. Some things, like traffic, do rarely experience the equivalent of positive disturbances.

This one-sidedness brings both underestimation of randomness and underestimation of harm, since one is more exposed to harm than benefit from error. If in the long run we get as much variation in the source of randomness one way as the other, the harm would severely outweigh the benefits.

So—and this is the key to the Triad—we can classify things by three simple distinctions: things that, in the long run, like disturbances (or errors), things that are neutral to them, and those that dislike them. By now we have seen that evolution likes disturbances. We saw that discovery likes disturbances. Some forecasts are hurt by uncertainty—and, like travel time, one needs a buffer. Airlines figured out how to do it, but not governments, when they estimate deficits.

This method is very general. I even used it with Fukushima-style computations and realized how fragile their computation of small probabilities was—in fact all small probabilities tend to be very fragile to errors, as a small change in the assumptions can make the probability rise dramatically, from one per million to one per hundred. Indeed, a ten-thousand-fold underestimation.

Finally, this method can show us where the math in economic models is bogus—which models are fragile and which ones are not. Simply do a small change in the assumptions, and look at how large the effect, and if there is acceleration of such effect. Acceleration implies—as with Fannie Mae—that someone relying on the model blows up from Black Swan effects. *Molto facile.* A detailed methodology to detect which results are bogus in economics—along with a discussion of small probabilities—is provided in the Appendix. What I can say for now is that much of what is taught in economics that has an equation, as well as econometrics, should be immediately ditched—which explains why

economics is largely a charlatanic profession. Fragilistas, *semper fragilisti*!

HOW TO LOSE A GRANDMOTHER

Next I will explain the following effect of nonlinearity: conditions under which the average—the first order effect—does not matter. As a first step before getting into the workings of the philosopher's stone.

As the saying goes:

Do not cross a river if it is on average four feet deep.

You have just been informed that your grandmother will spend the next two hours at the very desirable average temperature of seventy degrees Fahrenheit (about twenty-one degrees Celsius). Excellent, you think, since seventy degrees is the optimal temperature for grandmothers. Since you went to business school, you are a "big picture" type of person and are satisfied with the summary information.

But there is a second piece of data. Your grandmother, it turns out, will spend the first hour at zero degrees Fahrenheit (around minus eighteen Celsius), and the second hour at one hundred and forty degrees (around 60º C), for an average of the very desirable Mediterranean-style seventy degrees (21º C). So it looks as though you will most certainly end up with no grandmother, a funeral, and, possibly, an inheritance.

Clearly, temperature changes become more and more harmful as they deviate from seventy degrees. As you see, the second piece of information, the variability, turned out to be more important than the first. The notion of average is of no significance when one is fragile to variations—the dispersion in possible thermal outcomes here matters much more. Your grandmother is fragile to variations of temperature, to the volatility of the weather. Let us call that second piece of information the *second-order effect*, or, more precisely, the *convexity effect*.

Here, consider that, as much as a good simplification the notion of average can be, it can also be a Procrustean bed. The information that the average temperature is seventy degrees Fahrenheit does not simplify the situation for your grandmother. It is information squeezed into a Procrustean bed—and these are necessarily committed by scientific modelers, since a model is *by its very nature* a simplification. You just don't want the simplification to distort the situation to the point of being harmful.

Figure 16 shows the fragility of the health of the grandmother to variations. If I plot health on the vertical axis, and temperature on the horizontal one, I see a shape that curves inward—a "concave" shape, or *negative* convexity effect.

If the grandmother's response was "linear" (no curve, a straight line), then the harm of temperature below seventy degrees would be offset by the benefits of temperature above it. And the fact is that the health of the grandmother has to be capped at a maximum, otherwise she would keep improving.

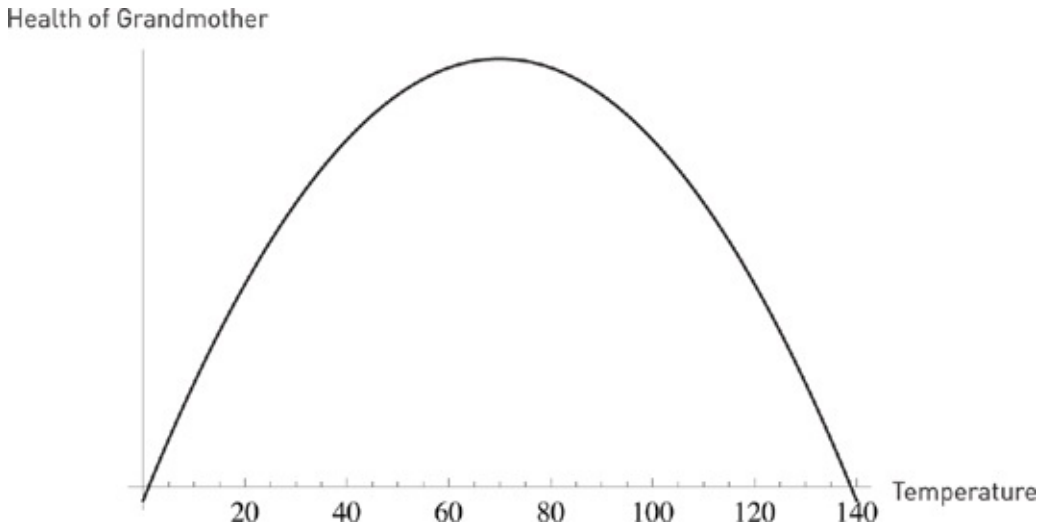

FIGURE 16. Megafragility. Health as a function of temperature curves inward. A combination of 0 and 140 degrees (F) is worse for your grandmother's health than just 70 degrees. In fact almost *any* combination averaging 70 degrees is worse than just 70 degrees.[2] The graph shows concavity or negative convexity effects—curves inward.

Take this for now as we rapidly move to the more general attributes; in the case of the grandmother's health response to temperature: (a) there is nonlinearity (the response is not a straight line, not "linear"), (b) it curves inward, too much so, and, finally, (c) the more nonlinear the response, the less relevant the average, and the more relevant the stability around such average.

NOW THE PHILOSOPHER'S STONE[3]

Much of medieval thinking went into finding the philosopher's stone. It is always good to be reminded that chemistry is the child of alchemy, much of which consisted of looking into the chemical powers of substances. The main efforts went into creating value by transforming metals into gold by the method of *transmutation*. The necessary substance was called the philosopher's stone

—*lapis philosophorum*. Many people fell for it, a list that includes such scholars as Albertus Magnus, Isaac Newton, and Roger Bacon and great thinkers who were not quite scholars, such as Paracelsus.

It is a matter of no small import that the operation of transmutation was called the *Magnus Opus*—the great(est) work. I truly believe that the operation I will discuss—based on some properties of optionality—is about as close as we can get to the philosopher's stone.

The following note would allow us to understand:

(a) The severity of the problem of conflation (mistaking the price of oil for geopolitics, or mistaking a profitable bet for good forecasting—not convexity of payoff and optionality).

(b) Why anything with optionality has a long-term advantage—and how to measure it.

(c) An additional subtle property called Jensen's inequality.

Recall from our traffic example in Chapter 18 that 90,000 cars for an hour, then 110,000 cars for the next one, for an average of 100,000, and traffic will be horrendous. On the other hand, assume we have 100,000 cars for two hours, and traffic will be smooth and time in traffic short.

The number of cars is the *something*, a variable; traffic time is the *function of something*. The behavior of the *function* is such that it is, as we said, "not the same thing." We can see here that the *function of something* becomes different from the *something* under nonlinearities.

(a) The more nonlinear, the more the *function of something* divorces itself from the *something*. If traffic were linear, then there would be no difference in traffic time between the two following situations: 90,000, then 110,000 cars on the one hand, or 100,000 cars on the other.

(b) The more volatile the *something*—the more uncertainty—the more the *function* divorces itself from the *something*. Let us consider the average number of cars again. The function (travel time) depends more on the volatility around the average. Things degrade if there is unevenness of distribution. For the same average you prefer to have 100,000 cars for both time periods; 80,000 then 120,000, would be even worse than 90,000 and 110,000.

(c) If the function is convex (antifragile), then the average of the function

of something is going to be higher than the function of the average *of something*. And the reverse when the function is concave (fragile).

As an example for (c), which is a more complicated version of the bias, assume that the function under question is the squaring function (multiply a number by itself). This is a convex function. Take a conventional die (six sides) and consider a payoff equal to the number it lands on, that is, you get paid a number equivalent to what the die shows—1 if it lands on 1, 2 if it lands on 2, up to 6 if it lands on 6. The square of the expected (average) payoff is then $(1+2+3+4+5+6 \text{ divided by } 6)^2$, equals 3.5^2, here 12.25. So the *function of the average* equals 12.25.

But the average of the function is as follows. Take the square of every payoff, $1^2+2^2+3^2+4^2+5^2+6^2$ divided by 6, that is, the average square payoff, and you can see that *the average of the function* equals 15.17.

So, since squaring is a convex function, the average of the square payoff is higher than the square of the average payoff. The difference here between 15.17 and 12.25 is what I call the hidden benefit of antifragility—here, a 24 percent "edge."

There are two biases: one elementary convexity effect, leading to mistaking the properties of the average of something (here 3.5) and those of a (convex) function of something (here 15.17), and the second, more involved, in mistaking an average of a function for the function of an average, here 15.17 for 12.25. The latter represents optionality.

Someone with a linear payoff needs to be right more than 50 percent of the time. Someone with a convex payoff, much less. The hidden benefit of antifragility is that you can guess worse than random and still end up outperforming. Here lies the power of optionality—your *function of something* is very convex, so you can be wrong and still do fine—the more uncertainty, the better.

This explains my statement that you can be dumb and antifragile and still do very well.

This hidden "convexity bias" comes from a mathematical property called Jensen's inequality. This is what the common discourse on innovation is missing. If you ignore the convexity bias, you are missing a chunk of what makes the nonlinear world go round. And it is a fact that such an idea is missing from the discourse. Sorry.[4]

Let us take the same example as before, using as the function the square root (the exact inverse of squaring, which is concave, but much less concave than the square function is convex).

The square root of the expected (average) payoff is then √(1+2+3+4+5+6 divided by 6), equals √3.5, here 1.87. The *function of the average* equals 1.87.

But the average of the function is as follows. Take the square root of every payoff, (√1+√2+√3+√4+√5+√6), divided by 6, that is, the average square root payoff, and you can see that *the average of the function* equals 1.80.

The difference is called the "negative convexity bias" (or, if you are a stickler, "concavity bias"). The hidden harm of fragility is that you need to be much, much better than random in your prediction and knowing where you are going, just to offset the negative effect.

Let me summarize the argument: if you have favorable asymmetries, or positive convexity, options being a special case, then in the long run you will do reasonably well, outperforming the average in the presence of uncertainty. The more uncertainty, the more role for optionality to kick in, and the more you will outperform. This property is very central to life.

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[1] The method does not require a good model for risk measurement. Take a ruler. You know it is wrong. It will not be able to measure the height of the child. But it can certainly tell you if he is growing. In fact the error you get about the rate of growth of the child is much, much smaller than the error you would get measuring his height. The same with a scale: no matter how defective, it will almost always be able to tell you if you are gaining weight, so stop blaming it.

Convexity is about acceleration. The remarkable thing about measuring convexity effects to detect model errors is that even if the model used for the computation is wrong, it can tell you if an entity is fragile and by how much it is fragile. As with the defective scale, we are only looking for second-order effects.

[2] I am simplifying a bit. There may be a few degrees' variation around 70 at which the grandmother might be better off than just at 70, but I skip this nuance here. In fact younger humans are antifragile to thermal variations, up to a point, benefiting from some variability, then losing such antifragility with age (or disuse, as I suspect that thermal comfort ages people and makes them fragile).

[3] I remind the reader that this section is technical and can be skipped.

[4] The grandmother does better at 70 degrees Fahrenheit than at an average of 70 degrees with one hour at 0, another at 140 degrees. The more dispersion around the average, the more harm for her. Let us see the counterintuitive effect in terms of x and function of x, $f(x)$. Let us write the health of the grandmother as $f(x)$, with x the temperature. We have a function of the average temperature, $f\{(0 + 140)/2\}$, showing the grandmother in excellent shape. But {f(o) + f(140)}/2 leaves us with a dead grandmother at $f(0)$ and a dead grandmother at $f(140)$, for an "average" of a dead grandmother. We can see an explanation of the statement

that the properties of $f(x)$ and those of x become divorced from each other when $f(x)$ is nonlinear. The average of $f(x)$ is different from f(average of x).

BOOK VI

Via Negativa

Recall that we had no name for the color blue but managed rather well without it—we stayed for a long part of our history culturally, not biologically, color blind. And before the composition of Chapter 1, we did not have a name for antifragility, yet systems have relied on it effectively in the absence of human intervention. There are many things without words, matters that we know and can act on but cannot describe directly, cannot capture in human language or within the narrow human concepts that are available to us. Almost anything around us of significance is hard to grasp linguistically—and in fact the more powerful, the more incomplete our linguistic grasp.

But if we cannot express what something is exactly, we can say something about what it is not—the indirect rather than the direct expression. The "apophatic" focuses on what cannot be said directly in words, from the Greek *apophasis* (saying no, or mentioning without mentioning). The method began as an avoidance of direct description, leading to a focus on negative description, what is called in Latin *via negativa*, the negative way, after theological traditions, particularly in the Eastern Orthodox Church. *Via negativa* does not try to express what God is—leave that to the primitive brand of contemporary thinkers and philosophasters with scientistic tendencies. It just lists what God is *not* and proceeds by the process of elimination. The idea is mostly associated with the mystical theologian Pseudo-Dionysos the Areopagite. He was some obscure Near Easterner by the name of Dionysos who wrote powerful mystical treatises and was for a long time confused with Dionysos the Areopagite, a judge in Athens who was converted by the preaching of Paul the Apostle. Hence the qualifier of "Pseudo" added to his name.

Neoplatonists were followers of Plato's ideas; they focused mainly on Plato's

forms, those abstract objects that had a distinct existence on their own. Pseudo-Dionysos was the disciple of Proclus the Neoplatonist (himself the student of Syrianus, another Syrian Neoplatonist). Proclus was known to repeat the metaphor that statues are carved by subtraction. I have often read a more recent version of the idea, with the following apocryphal pun. Michelangelo was asked by the pope about the secret of his genius, particularly how he carved the statue of David, largely considered the masterpiece of all masterpieces. His answer was: "It's simple. I just remove everything that is not David."

The reader might thus recognize the logic behind the barbell. Remember from the logic of the barbell that it is necessary to first remove fragilities.

Where Is the Charlatan?

Recall that the interventionista focuses on positive action—*doing*. Just like positive definitions, we saw that acts of commission are respected and glorified by our primitive minds and lead to, say, naive government interventions that end in disaster, followed by generalized complaints about naive government interventions, as these, it is now accepted, end in disaster, followed by more naive government interventions. Acts of omission, *not* doing something, are not considered acts and do not appear to be part of one's mission. Table 3 showed how generalized this effect can be across domains, from medicine to business.

I have used all my life a wonderfully simple heuristic: charlatans are recognizable in that they will give you positive advice, and only positive advice, exploiting our gullibility and sucker-proneness for recipes that hit you in a flash as just obvious, then evaporate later as you forget them. Just look at the "how to" books with, in their title, "Ten Steps for—" (fill in: enrichment, weight loss, making friends, innovation, getting elected, building muscles, finding a husband, running an orphanage, etc.). Yet in practice it is the negative that's used by the pros, those selected by evolution: chess grandmasters usually win by not losing; people become rich by not going bust (particularly when others do); religions are mostly about interdicts; the learning of life is about what to avoid. You reduce most of your personal risks of accident thanks to a small number of measures.

Further, being fooled by randomness is that in most circumstances fraught with a high degree of randomness, one cannot really tell if a successful person has skills, or if a person with skills will succeed—but we can pretty much predict the negative, that a person totally devoid of skills will eventually fail.

Now when it comes to knowledge, the same applies. The greatest—and most robust—contribution to knowledge consists in removing what we think is wrong —subtractive epistemology.

In life, antifragility is reached by *not* being a sucker. In *Peri mystikes theologias*, Pseudo-Dionysos did not use these exact words, nor did he discuss disconfirmation, nor did he get the idea with clarity, but in my view he figured out this subtractive epistemology and asymmetries in knowledge. I have called "Platonicity" the love of some crisp abstract forms, the theoretical forms and universals that make us blind to the mess of reality and cause Black Swan effects. Then I realized that there was an asymmetry. I truly believe in Platonic ideas when they come in reverse, like negative universals.

So the central tenet of the epistemology I advocate is as follows: we know a lot more what is wrong than what is right, or, phrased according to the fragile/robust classification, negative knowledge (what is wrong, what does not work) is more robust to error than positive knowledge (what is right, what works). So knowledge grows by subtraction much more than by addition—given that what we know today might turn out to be wrong but what we know to be wrong cannot turn out to be right, at least not easily. If I spot a black swan (not capitalized), I can be quite certain that the statement "all swans are white" is wrong. But even if I have never seen a black swan, I can never hold such a statement to be true. Rephrasing it again: since one small observation can disprove a statement, while millions can hardly confirm it, disconfirmation is more rigorous than confirmation.

This idea has been associated in our times with the philosopher Karl Popper, and I quite mistakenly thought that he was its originator (though he is at the origin of an even more potent idea on the fundamental inability to predict the course of history). The notion, in fact, is vastly more ancient, and was one of the central tenets of the skeptical-empirical school of medicine of the postclassical era in the Eastern Mediterranean. It was well known to a group of nineteenth-century French scholars who rediscovered these works. And this idea of the power of disconfirmation permeates the way we do hard science.

As you can see, we can link this to the general tableaus of positive (additive) and negative (subtractive): negative knowledge is more robust. But it is not perfect. Popper has been criticized by philosophers for his treatment of disconfirmation as hard, unequivocal, black-and-white. It is not clear-cut: it is impossible to figure out whether an experiment failed to produce the intended

results—hence "falsifying" the theory—because of the failure of the tools, because of bad luck, or because of fraud by the scientist. Say you saw a black swan. That would certainly invalidate the idea that all swans are white. But what if you had been drinking Lebanese wine, or hallucinating from spending too much time on the Web? What if it was a dark night, in which all swans look gray? Let us say that, in general, failure (and disconfirmation) are more informative than success and confirmation, which is why I claim that negative knowledge is just "more robust."

Now, before starting to write this section, I spent some time scouring Popper's complete works wondering how the great thinker, with his obsessive approach to falsification, completely missed the idea of fragility. His masterpiece, *The Poverty of Historicism*, in which he presents the limits of forecasting, shows the impossibility of an acceptable representation of the future. But he missed the point that if an incompetent surgeon is operating on a brain, one can safely predict serious damage, even the death of the patient. Yet such subtractive representation of the future is perfectly in line with his idea of disconfirmation, its logical second step. What he calls falsification of a theory should lead, in practice, to the breaking of the object of its application.

In political systems, a good mechanism is one that helps remove the bad guy; it's not about what to do or who to put in. For the bad guy can cause more harm than the collective actions of good ones. Jon Elster goes further and presents another kind of *via negativa*: A good negative is one that protects the ordinary guy from bad influences. He recently wrote a book with the telling title *Preventing Mischief* in which he bases negative action on Bentham's idea that "the art of the legislator is limited to the prevention of everything that might prevent the development of their [members of the assembly] liberty and their intelligence."

And, as expected, *via negativa* is part of classical wisdom. For the Arab scholar and religious leader Ali Bin Abi-Taleb (no relation), keeping one's distance from an ignorant person is equivalent to keeping company with a wise man.

Finally, consider this modernized version in a saying from Steve Jobs: "People think focus means saying yes to the thing you've got to focus on. But that's not what it means at all. It means saying no to the hundred other good ideas that there are. You have to pick carefully. I'm actually as proud of the things we haven't done as the things I have done. Innovation is saying no to 1,000 things."

BARBELLS, AGAIN

Subtractive knowledge is a form of barbell. Critically, it is convex. What is wrong is quite robust, what you don't know is fragile and speculative, but you do not take it seriously so you make sure it does not harm you in case it turns out to be false.

Now another application of *via negativa* lies in the less-is-more idea.

Less Is More

The less-is-more idea in decision making can be traced to Spyros Makridakis, Robyn Dawes, Dan Goldstein, and Gerd Gigerenzer, who have all found in various contexts that simpler methods for forecasting and inference can work much, much better than complicated ones. Their simple rules of thumb are not perfect, but are designed to not be perfect; adopting some intellectual humility and abandoning the aim at sophistication can yield powerful effects. The pair of Goldstein and Gigerenzer coined the notion of "fast and frugal" heuristics that make good decisions despite limited time, knowledge, and computing power.

I realized that the less-is-more heuristic fell squarely into my work in two places. First, extreme effects: there are domains in which the rare event (I repeat, good or bad) plays a disproportionate share and we tend to be blind to it, so focusing on the exploitation of such a rare event, or protection against it, changes a lot, a lot of the risky exposure. Just worry about Black Swan exposures, and life is easy.

Less is more has proved to be shockingly easy to find and apply—and "robust" to mistakes and change of minds. There may not be an easily identifiable cause for a large share of the problems, but often there is an easy solution (not to all problems, but good enough; I mean really good enough), and such a solution is immediately identifiable, sometimes with the naked eye rather than the use of complicated analyses and highly fragile, error-prone, cause-ferreting nerdiness.

Some people are aware of the *eighty/twenty* idea, based on the discovery by Vilfredo Pareto more than a century ago that 20 percent of the people in Italy owned 80 percent of the land, and vice versa. Of these 20 percent, 20 percent (that is, 4 percent) would have owned around 80 percent of the 80 percent (that is, 64 percent). We end up with less than 1 percent representing about 50 percent

of the total. These describe winner-take-all Extremistan effects. These effects are very general, from the distribution of wealth to book sales per author.

Few realize that we are moving into the far more uneven distribution of 99/1 across many things that used to be 80/20: 99 percent of Internet traffic is attributable to less than 1 percent of sites, 99 percent of book sales come from less than 1 percent of authors … and I need to stop because numbers are emotionally stirring. Almost everything contemporary has winner-take-all effects, which includes sources of harm and benefits. Accordingly, as I will show, 1 percent modification of systems can lower fragility (or increase antifragility) by about 99 percent—and all it takes is a few steps, very few steps, often at low cost, to make things better and safer.

For instance, a small number of homeless people cost the states a disproportionate share of the bills, which makes it obvious where to look for the savings. A small number of employees in a corporation cause the most problems, corrupt the general attitude—and vice versa—so getting rid of these is a great solution. A small number of customers generate a large share of the revenues. I get 95 percent of my smear postings from the same three obsessive persons, all representing the same prototypes of failure (one of whom has written, I estimate, close to one hundred thousand words in posts—he needs to write more and more and find more and more stuff to critique in my work and personality to get the same effect). When it comes to health care, Ezekiel Emanuel showed that half the population accounts for less than 3 percent of the costs, with the sickest 10 percent consuming 64 percent of the total pie. Bent Flyvbjerg (of Chapter 18) showed in his *Black Swan management* idea that the bulk of cost overruns by corporations are simply attributable to large technology projects—implying that that's what we need to focus on instead of talking and talking and writing complicated papers.

As they say in the mafia, just work on removing the pebble in your shoe.

There are some domains, like, say, real estate, in which problems and solutions are crisply summarized by a heuristic, a rule of thumb to look for the three most important properties: "location, location, and location"—much of the rest is supposed to be chickensh***t. Not quite and not always true, but it shows the central thing to worry about, as the rest takes care of itself.

Yet people want more data to "solve problems." I once testified in Congress against a project to fund a crisis forecasting project. The people involved were blind to the paradox that we have never had more data than we have now, yet have less predictability than ever. More data—such as paying attention to the

eye colors of the people around when crossing the street—can make you miss the big truck. When you cross the street, you remove data, anything but the essential threat.[1] As Paul Valéry once wrote: *que de choses il faut ignorer pour agir*—how many things one should disregard in order to act.

Convincing—and confident—disciplines, say, physics, tend to use little statistical backup, while political science and economics, which have never produced anything of note, are full of elaborate statistics and statistical "evidence" (and you know that once you remove the smoke, the evidence is not evidence). The situation in science is similar to detective novels in which the person with the largest number of alibis turns out to be the guilty one. And you do not need reams of paper full of data to destroy the megatons of papers using statistics in economics: the simple argument that Black Swans and tail events run the socioeconomic world—and these events cannot be predicted—is sufficient to invalidate their statistics.

We have further evidence of the potency of less-is-more from the following experiment. Christopher Chabris and Daniel Simons, in their book *The Invisible Gorilla*, show how people watching a video of a basketball game, when diverted with attention-absorbing details such as counting passes, can completely miss a gorilla stepping into the middle of the court.

I discovered that I had been intuitively using the less-is-more idea as an aid in decision making (contrary to the method of putting a series of pros and cons side by side on a computer screen). For instance, if you have more than one reason to do something (choose a doctor or veterinarian, hire a gardener or an employee, marry a person, go on a trip), just don't do it. It does not mean that one reason is better than two, just that by invoking more than one reason you are trying to convince yourself to do something. Obvious decisions (robust to error) *require* no more than a single reason. Likewise the French army had a heuristic to reject excuses for absenteeism for more than one reason, like death of grandmother, cold virus, and being bitten by a boar. If someone attacks a book or idea using more than one argument, you know it is not real: nobody says "he is a criminal, he killed many people, and he also has bad table manners and bad breath and is a very poor driver."

I have often followed what I call Bergson's razor: "A philosopher should be known for one single idea, not more" (I can't source it to Bergson, but the rule is good enough). The French essayist and poet Paul Valéry once asked Einstein if he carried a notebook to write down ideas. "I never have ideas" was the reply (in fact he just did not have chickens***t ideas). So, a heuristic: if someone has a

long bio, I skip him—at a conference a friend invited me to have lunch with an overachieving hotshot whose résumé "can cover more than two or three lives"; I skipped to sit at a table with the trainees and stage engineers.[2] Likewise when I am told that someone has three hundred academic papers and twenty-two honorary doctorates, but no other single compelling contribution or main idea behind it, I avoid him like the bubonic plague.

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[1] Recall that the overediting interventionist missed the main mistake in Chapter 7. The 663-page document *Financial Crisis Inquiry Report* by the Financial Crisis Inquiry Commission missed what I believe are the main reasons: fragility and absence of skin in the game. But of course they listed every possible epiphenomenon you can think of as cause.

[2] Even the Nobel, with all its ills of inducing competition in something as holy as science, is not granted for a collection of papers but rarely for more than a single, but major, contribution.

CHAPTER 20

Time and Fragility

Prophecy, like knowledge, is subtractive, not additive—The Lindy effect, or how the old prevails over the new, especially in technology, no matter what they say in California—Prophecy not a recommended and voluntary career

Antifragility implies—contrary to initial instinct—that the old is superior to the new, and much more than you think. No matter how something looks to your intellectual machinery, or how well or poorly it narrates, time will know more about its fragilities and break it when necessary. Here, I expose a contemporary disease—linked to interventionism—called *neomania,* which brings fragility but I believe may be treatable if one is patient enough.

What survives must be good at serving some (mostly hidden) purpose that time can see but our eyes and logical faculties can't capture. In this chapter we use the notion of fragility as a central driver of prediction.

Recall the foundational asymmetry: the antifragile benefits from volatility and disorder, the fragile is harmed. Well, time is the same as disorder.

FROM SIMONIDES TO JENSEN

As an exercise in the use of the distinction between fragility and antifragility, let us play prophet, with the understanding that it is not a good career choice unless you have a thick skin, a good circle of friends, little access to the Internet, a library with a good set of ancient proverbs, and, if possible, the ability to derive personal benefits from your prophecy. As shown from the track record of the prophets: before you are proven right, you will be reviled; after you are proven right, you will be hated for a while, or, what's worse, your ideas will appear to be "trivial" thanks to retrospective distortion. This makes it far more convincing to follow the Fat Tony method of focusing on shekels more than recognition. And such treatment has continued in modern times: twentieth-century intellectuals who have embraced the wrong ideas, such as Communism or even Stalinism, have remained fashionable—and their books remain on the bookstore shelves—while those who, like the political philosopher Raymond Aron, saw the problems got short shrift both before and after being acknowledged as having seen things right.

Now close your eyes and try to imagine your future surroundings in, say, five, ten, or twenty-five years. Odds are your imagination will produce *new* things in it, things we call *innovation*, *improvements*, *killer technologies*, and other inelegant and hackneyed words from the business jargon. These common concepts concerning innovation, we will see, are not just offensive aesthetically, but they are nonsense both empirically and philosophically.

Why? Odds are that your imagination will be adding things to the present world. I am sorry, but I will show in this chapter that this approach is exactly backward: the way to do it rigorously, according to the notions of fragility and antifragility, is to *take away* from the future, reduce from it, simply, things that do not belong to the coming times. *Via negativa*. What is fragile will eventually break; and, luckily, we can easily tell what is fragile. Positive Black Swans are more unpredictable than negative ones.

"Time has sharp teeth that destroy everything," declaimed the sixth-century (B.C.) poet Simonides of Ceos, perhaps starting a tradition in Western literature about the inexorable effect of time. I can trace a plethora of elegant classical expressions, from Ovid (*tempus edax rerum*—time devours everything) to the no less poetic twentieth-century Franco-Russian poetess Elsa Triolet ("time burns but leaves no ashes"). Naturally, this exercise triggered some poetic waxing, so I

am now humming a French poem put to music titled *"Avec le temps"* about how time erases things, even bad memories (though it doesn't say that it erases us as well in the process). Now, thanks to convexity effects, we can put a little bit of science in these, and produce our own taxonomy of what should be devoured the fastest by that inexorable time. The fragile will eventually break—and, luckily, we are capable of figuring out what is fragile. Even what we believe is antifragile will eventually break, but it should take much, much longer to do so (wine does well with time, but up to a point; and not if you put it in the crater of a volcano).

The verse by Simonides that started the previous paragraph continues with the stipulation "even the most solid." So Simonides had the adumbration of the idea, quite useful, that the most solid will be swallowed with more difficulty, hence last. Naturally, he did not think that something could be antifragile, hence never swallowed.

Now, I insist on the *via negativa* method of prophecy as being the only valid one: there is no other way to produce a forecast without being a turkey somewhere, particularly in the complex environment in which we live today. Now, I am not saying that new technologies will not emerge—something new will rule its day, for a while. What is currently fragile will be replaced by something else, of course. But this "something else" is unpredictable. In all likelihood, the technologies you have in your mind are not the ones that will make it, no matter your perception of their fitness and applicability—with all due respect to your imagination.

Recall that the most fragile is the predictive, what is built on the basis of predictability—in other words, those who underestimate Black Swans will eventually exit the population.

An interesting apparent paradox is that, according to these principles, longer-term predictions are more reliable than short-term ones, given that one can be quite certain that what is Black Swan–prone will be eventually swallowed by history since time augments the probability of such an event. On the other hand, typical predictions (not involving the currently fragile) degrade with time; in the presence of nonlinearities, the longer the forecast the worse its accuracy. Your error rate for a ten-year forecast of, say, the sales of a computer plant or the profits of a commodity vendor can be a thousand times that of a one-year projection.

LEARNING TO SUBTRACT

Consider the futuristic projections made throughout the past century and a half, as expressed in literary novels such as those by Jules Verne, H. G. Wells, or George Orwell, or in now forgotten narratives of the future produced by scientists or futurists. It is remarkable that the tools that seem to currently dominate the world, such as the Internet, or more mundane matters such as the wheel on the suitcase of Book IV, were completely missing from these forecasts. But it is not here that the major error lies. The problem is that almost everything that was imagined never took place, except for a few overexploited anecdotes (such as the steam engine by Hero the Alexandrian or the assault vehicle by Leonardo da Vinci). Our world looks too close to theirs, much closer to theirs than they ever imagined or wanted to imagine. And we tend to be blind to that fact—there seems to be no correcting mechanism that can make us aware of the point as we go along forecasting a highly technocratic future.

There may be a selection bias: those people who engage in producing these accounts of the future will tend to have (incurable and untreatable) *neomania*, the love of the modern for its own sake.

Tonight I will be meeting friends in a restaurant (tavernas have existed for at least twenty-five centuries). I will be walking there wearing shoes hardly different from those worn fifty-three hundred years ago by the mummified man discovered in a glacier in the Austrian Alps. At the restaurant, I will be using silverware, a Mesopotamian technology, which qualifies as a “killer application” given what it allows me to do to the leg of lamb, such as tear it apart while sparing my fingers from burns. I will be drinking wine, a liquid that has been in use for at least six millennia. The wine will be poured into glasses, an innovation claimed by my Lebanese compatriots to come from their Phoenician ancestors, and if you disagree about the source, we can say that glass objects have been sold by them as trinkets for at least twenty-nine hundred years. After the main course, I will have a somewhat younger technology, artisanal cheese, paying higher prices for those that have not changed in their preparation for several centuries.

Had someone in 1950 predicted such a minor gathering, he would have imagined something quite different. So, thank God, I will not be dressed in a shiny synthetic space-style suit, consuming nutritionally optimized pills while communicating with my dinner peers by means of screens. The dinner partners,

in turn, will be expelling airborne germs on my face, as they will not be located in remote human colonies across the galaxy. The food will be prepared using a very archaic technology (fire), with the aid of kitchen tools and implements that have not changed since the Romans (except in the quality of some of the metals used). I will be sitting on an (at least) three-thousand-year-old device commonly known as the chair (which will be, if anything, less ornate that its majestic Egyptian ancestor). And I will be not be repairing to the restaurant with the aid of a flying motorcycle. I will be walking or, if late, using a cab from a century-old technology, driven by an immigrant—immigrants were driving cabs in Paris a century ago (Russian aristocrats), same as in Berlin and Stockholm (Iraqis and Kurdish refugees), Washington, D.C. (Ethiopian postdoc students), Los Angeles (musically oriented Armenians), and New York (multinationals) today.

David Edgerton showed that in the early 2000s we produce two and a half times as many bicycles as we do cars and invest most of our technological resources in maintaining existing equipment or refining old technologies (note that this is not just a Chinese phenomenon: Western cities are aggressively trying to become bicycle-friendly). Also consider that one of the most consequential technologies seems to be the one people talk about the least: the condom. Ironically, it wants to look like less of a technology; it has been undergoing meaningful improvements, with the precise aim of being less and less noticeable.

FIGURE 17. Cooking utensils from Pompeii, hardly different from those found in today's (good) kitchens

So, the prime error is as follows. When asked to imagine the future, we have the tendency to take the present as a baseline, then produce a speculative destiny by adding new technologies and products to it and what sort of *makes sense*, given an interpolation of past developments. We also represent society according to our utopia of the moment, largely driven by our wishes—except for a few people called doomsayers, the future will be largely inhabited by our desires. So we will tend to over-technologize it and underestimate the might of the equivalent of these small wheels on suitcases that will be staring at us for the next millennia.

A word on the blindness to this over-technologizing. After I left finance, I started attending some of the fashionable conferences attended by pre-rich and post-rich technology people and the new category of technology intellectuals. I was initially exhilarated to see them wearing no ties, as, living among tie-wearing abhorrent bankers, I had developed the illusion that anyone who doesn't wear a tie was not an empty suit. But these conferences, while colorful and slick with computerized images and fancy animations, felt depressing. I knew I did not belong. It was not just their additive approach to the future (failure to subtract the fragile rather than add to destiny). It was not entirely their blindness by uncompromising neomania. It took a while for me to realize the reason: a profound lack of elegance. Technothinkers tend to have an "engineering mind"—to put it less politely, they have autistic tendencies. While they don't usually wear ties, these types tend, of course, to exhibit all the textbook characteristics of nerdiness—mostly lack of charm, interest in objects instead of persons, causing them to neglect their looks. They love precision at the expense of applicability. And they typically share an absence of literary culture.

This absence of literary culture is actually a marker of future blindness because it is usually accompanied by a denigration of history, a byproduct of unconditional neomania. Outside of the niche and isolated genre of science fiction, literature is about the past. We do not learn physics or biology from medieval textbooks, but we still read Homer, Plato, or the very modern Shakespeare. We cannot talk about sculpture without knowledge of the works of Phidias, Michelangelo, or the great Canova. These are in the past, not in the future. Just by setting foot into a museum, the aesthetically minded person is connecting with the elders. Whether overtly or not, he will tend to acquire and respect historical knowledge, even if it is to reject it. And the past—properly handled, as we will see in the next section—is a much better teacher about the properties of the future than the present. To understand the future, you do not

need technoautistic jargon, obsession with “killer apps,” these sort of things. You just need the following: some respect for the past, some curiosity about the historical record, a hunger for the wisdom of the elders, and a grasp of the notion of “heuristics,” these often unwritten rules of thumb that are so determining of survival. In other words, you will be forced to give weight to things that have been around, things that have survived.

Technology at Its Best

But technology can cancel the effect of bad technologies, by self-subtraction.

Technology is at its best when it is invisible. I am convinced that technology is of greatest benefit when it displaces the deleterious, unnatural, alienating, and, most of all, inherently fragile preceding technology. Many of the modern applications that have managed to survive today came to disrupt the deleterious effect of the philistinism of modernity, particularly the twentieth century: the large multinational bureaucratic corporation with “empty suits” at the top; the isolated family (nuclear) in a one-way relationship with the television set, even more isolated thanks to car-designed suburban society; the dominance of the state, particularly the militaristic nation-state, with border controls; the destructive dictatorship on thought and culture by the established media; the tight control on publication and dissemination of economic ideas by the charlatanic economics establishment; large corporations that tend to control their markets now threatened by the Internet; pseudorigor that has been busted by the Web; and many others. You no longer have to “press 1 for English” or wait in line for a rude operator to make bookings for your honeymoon in Cyprus. In many respects, as unnatural as it is, the Internet removed some of the even more unnatural elements around us. For instance, the absence of paperwork makes bureaucracy—something modernistic—more palatable than it was in the days of paper files. With a little bit of luck a computer virus will wipe out all records and free people from their past mistakes.

Even now, we are using technology to reverse technology. Recall my walk to the restaurant wearing shoes not too dissimilar to those worn by the ancient, preclassical person found in the Alps. The shoe industry, after spending decades “engineering” the perfect walking and running shoe, with all manner of “support” mechanisms and material for cushioning, is now selling us shoes that replicate being barefoot—they want to be so unobtrusive that their only claimed function is to protect our feet from the elements, not to dictate how we walk as

the more modernistic mission was. In a way they are selling us the calloused feet of a hunter-gatherer that we can put on, use, and then remove upon returning to civilization. It is quite exhilarating to wear these shoes when walking in nature as one wakes up to a new dimension while feeling the three dimensions of the terrain. Regular shoes feel like casts that separate us from the environment. And they don't have to be inelegant: the technology is in the sole, not the shoe, as the new soles can be both robust and very thin, thus allowing the foot to hug the ground as if one were barefoot—my best discovery is an Italian-looking moccasin made in Brazil that allows me to both run on stones and go to dinner in restaurants.

Then again, perhaps they should just sell us reinforced waterproof socks (in effect, what the Alpine fellow had), but it would not be very profitable for these firms.[1]

And the great use of the tablet computer (notably the iPad) is that it allows us to return to Babylonian and Phoenician roots of writing and take notes on a tablet (which is how it started). One can now jot down handwritten, or rather fingerwritten, notes—it is much more soothing to write longhand, instead of having to go through the agency of a keyboard. My dream would be to someday write everything longhand, as almost every writer did before modernity.

So it may be a natural property of technology to only want to be displaced by itself.

Next let me show how the future is mostly in the past.

TO AGE IN REVERSE: THE LINDY EFFECT

Time to get more technical, so a distinction is helpful at this stage. Let us separate the perishable (humans, single items) from the nonperishable, the potentially perennial. The nonperishable is anything that does not have an organic unavoidable expiration date. The perishable is typically an object, the nonperishable has an informational nature to it. A single car is perishable, but the automobile as a technology has survived about a century (and we will speculate should survive another one). Humans die, but their genes—a code—do not necessarily. The physical book is perishable—say, a specific copy of the Old Testament—but its contents are not, as they can be expressed into another physical book.

Let me express my idea in Lebanese dialect first. When you see a young and an old human, you can be confident that the younger will survive the elder. With something nonperishable, say a technology, that is not the case. We have two possibilities: either both are expected to have the same additional life expectancy (the case in which the probability distribution is called *exponential*), or the old is expected to have a longer expectancy than the young, in proportion to their relative age. In that situation, if the old is eighty and the young is ten, the elder is expected to live eight times as long as the younger one.

Click here for a larger image of this table.

TABLE 6 • DOMAINS AND COMPARISON OF LIFE EXPECTANCY WHEN WE COMPARE THE "OLD" TO THE "YOUNG"

COMPARATIVE LIFE EXPECTANCY	*DOMAIN*	*PROBABILITY DISTRIBUTION*
The young is expected to live longer than the old.	Perishable: life of humans and other animals	Gaussian (or close, from same type of family)
Both the young and the old have equivalent life expectancy.	Non-perishable informational: lifetime of species	Exponential
LINDY EFFECT. The old is expected to stay longer than the young in proportion to their age.	Non-perishable informational: life of intellectual production, lifetime of genera	Power law

Now conditional on something belonging to either category, I propose the following (building on the so-called Lindy effect in the version later developed by the great Benoît Mandelbrot):[2]

For the perishable, every additional day in its life translates into a shorter *additional life expectancy. For the nonperishable, every additional day may imply a* longer *life expectancy.*

So the longer a technology lives, the longer it can be expected to live. Let me illustrate the point (people have difficulty understanding it at the first go). Say I have for sole information about a gentleman that he is 40 years old and I want to predict how long he will live. I can look at actuarial tables and find his age-adjusted life expectancy as used by insurance companies. The table will predict that he has an extra 44 to go. Next year, when he turns 41 (or, equivalently, if applying the reasoning today to another person currently 41), he will have a little more than 43 years to go. So every year that elapses reduces his life expectancy by about a year (actually, a little less than a year, so if his life expectancy at birth is 80, his life expectancy at 80 will not be zero, but another decade or so).[3]

The opposite applies to nonperishable items. I am simplifying numbers here for clarity. If a book has been in print for forty years, I can expect it to be in print for another forty years. But, and that is the main difference, if it survives another decade, then it will be expected to be in print another fifty years. This, simply, as a rule, tells you why things that have been around for a long time are not "aging" like persons, but "aging" in reverse. Every year that passes without extinction doubles the additional life expectancy.[4] This is an indicator of some robustness. The robustness of an item is proportional to its life!

The physicist Richard Gott applied what seems to be completely different reasoning to state that whatever we observe in a randomly selected way is likely to be neither in the beginning nor in the end of its life, most likely in its middle. His argument was criticized for being rather incomplete. But by testing his argument he tested the one I just outlined above, that the expected life of an item is proportional to its past life. Gott made a list of Broadway shows on a given day, May 17, 1993, and predicted that *the longest-running ones would last longest, and vice versa*. He was proven right with 95 percent accuracy. He had, as a child, visited both the Great Pyramid (fifty-seven hundred years old), and the Berlin Wall (twelve years old), and correctly guessed that the former would outlive the latter.

The proportionality of life expectancy does not need to be tested explicitly—it is the direct result of "winner-take-all" effects in longevity.

Two mistakes are commonly made when I present this idea—people have difficulties grasping probabilistic notions, particularly when they have spent too much time on the Internet (not that they need the Internet to be confused; we are naturally probability-challenged). The first mistake is usually in the form of the presentation of the counterexample of a technology that we currently see as inefficient and dying, like, say, telephone land lines, print newspapers, and cabinets containing paper receipts for tax purposes. These arguments come with anger as many neomaniacs get offended by my point. But my argument is not about *every* technology, but about life expectancy, which is simply a probabilistically derived average. If I know that a forty-year-old has terminal pancreatic cancer, I will no longer estimate his life expectancy using unconditional insurance tables; it would be a mistake to think that he has forty-four more years to live, like others in his age group who are cancer-free. Likewise someone (a technology guru) interpreted my idea as suggesting that the World Wide Web, being currently less than about twenty years old, will *only* have another twenty to go—this is a noisy estimator that should work on average, not in every case. But in general, the older the technology, not only the longer it is expected to last, but the more certainty I can attach to such a statement.[5]

Remember the following principle: I am not saying that *all* technologies do not age, only that those technologies that were prone to aging are already dead.

The second mistake is to believe that one would be acting "young" by adopting a "young" technology, revealing both a logical error and mental bias. It leads to the inversion of the power of generational contributions, producing the illusion of the contribution of the new generations over the old—statistically, the "young" do almost nothing. This mistake has been made by many people, but most recently I saw an angry "futuristic" consultant who accuses people who don't jump into technology of "thinking old" (he is actually older than I am and, like most technomaniacs I know, looks sickly and pear-shaped and has an undefined transition between his jaw and his neck). I didn't understand why one would be acting particularly "old" by loving things historical. So by loving the classics ("older") I would be acting "older" than if I were interested in the "younger" medieval themes. This is a mistake similar to believing that one would turn into a cow by eating cow meat. It is actually a worse fallacy than the inference from eating: a technology, being informational rather than physical, does not age organically, like humans, at least not necessarily so. The wheel is not "old" in the sense of experiencing degeneracy.

This idea of “young” and “old” attached to certain crowd behavior is even more dangerous. Supposedly, if those who don’t watch prepackaged 18-minute hyped-up lectures on the Web paid attention to people in their teens and twenties, who do, and in whom supposedly the key to the future lies, they would be thinking differently. Much progress comes from the young because of their relative freedom from the system and courage to take action that older people lose as they become trapped in life. But it is precisely the young who propose ideas that are fragile, not because they are young, but because most unseasoned ideas are fragile. And, of course, someone who sells “futuristic” ideas will not make a lot of money selling the value of the past! New technology is easier to hype up.

I received an interesting letter from Paul Doolan from Zurich, who was wondering how we could teach children skills for the twenty-first century since we do not know which skills will be needed in the twenty-first century—he figured out an elegant application of the large problem that Karl Popper called the error of historicism. Effectively my answer would be to make them read the classics. The future is in the past. Actually there is an Arabic proverb to that effect: *he who does not have a past has no future*.[6]

A FEW MENTAL BIASES

Next I present an application of the *fooled by randomness* effect. Information has a nasty property: it hides failures. Many people have been drawn to, say, financial markets after hearing success stories of someone getting rich in the stock market and building a large mansion across the street—but since failures are buried and we don't hear about them, investors are led to overestimate their chances of success. The same applies to the writing of novels: we do not see the wonderful novels that are now completely out of print, we just think that because the novels that have done well are well written (whatever that means), that what is well written will do well. So we confuse the necessary and the causal: because all surviving technologies have some obvious benefits, we are led to believe that all technologies offering obvious benefits will survive. I will leave the discussion of what impenetrable property may help survival to the section on Empedocles' dog. But note here the mental bias that causes people to believe in the "power of" some technology and its ability to run the world.

Another mental bias causing the overhyping of technology comes from the fact that we notice change, not statics. The classic example, discovered by the psychologists Daniel Kahneman and Amos Tversky, applies to wealth. (The pair developed the idea that our brains like minimal effort and get trapped that way, and they pioneered a tradition of cataloging and mapping human biases with respect to perception of random outcomes and decision making under uncertainty). If you announce to someone "you lost $10,000," he will be much more upset than if you tell him "your portfolio value, which was $785,000, is now $775,000." Our brains have a predilection for shortcuts, and the variation is easier to notice (and store) than the entire record. It requires less memory storage. This psychological heuristic (often operating without our awareness), the error of variation in place of total, is quite pervasive, even with matters that are visual.

We notice what varies and changes more than what plays a large role but doesn't change. We rely more on water than on cell phones but because water does not change and cell phones do, we are prone to thinking that cell phones play a larger role than they do. Second, because the new generations are more aggressive with technology, we notice that they try more things, but we ignore that these implementations don't usually stick. Most "innovations" are failures, just as most books are flops, which should not discourage anyone from trying.

Neomania and Treadmill Effects

You are driving on the highway in your two-year-old Japanese car when you are overtaken by a vehicle of the same make, the latest version, that looks markedly different. And markedly better. Markedly better? The bumper is slightly larger and the taillights are wider. Other than these cosmetic details (and perhaps some hidden technical improvements) representing less than a few percentage points in variation, the car looks the same, but you can't tell by just looking at it. You just see the lights and feel that you are due an upgrade. And the upgrade will cost you, after you sell your car, about the third of the price of a new vehicle—all that motivated by small, mostly cosmetic variations. But switching cars is a small cost compared to switching computers—the recovery value of an old computer is so negligible.

You use an Apple Mac computer. You just bought a new version a week before. The person on the plane next to you just pulled out of his bag an older version. It has a family resemblance to yours, but looks so inferior. It is thicker and has a much less elegant screen. But you forget the days when you used to have the same model and were thrilled with it.

The same with a cell phone: you look down at those carrying older, larger models. But a few years ago you would have considered these small and slick.

So with so many technologically driven and modernistic items—skis, cars, computers, computer programs—it seems that we notice differences between versions rather than commonalities. We even rapidly tire of what we have, continuously searching for versions 2.0 and similar iterations. And after that, another "improved" reincarnation. These impulses to buy new things that will eventually lose their novelty, particularly when compared to newer things, are called *treadmill effects*. As the reader can see, they arise from the same generator of biases as the one about the salience of variations mentioned in the section before: we notice differences and become dissatisfied with some items and some classes of goods. This treadmill effect has been investigated by Danny Kahneman and his peers when they studied the psychology of what they call hedonic states. People acquire a new item, feel *more satisfied* after an initial boost, then rapidly revert to their baseline of well-being. So, when you "upgrade," you feel a boost of satisfaction with *changes* in technology. But then you get used to it and start hunting for the *new* new thing.

But it looks as though we don't incur the same treadmilling techno-dissatisfaction with classical art, older furniture—whatever we do not put in the category of the technological. You may have an oil painting and a flat-screen

television set inhabiting the same room of your house. The oil painting is an imitation of a classic Flemish scene made close to a century ago, with the dark ominous skies of Flanders, majestic trees, and an uninspiring but calmative rural scene. I am quite certain that you are not eager to upgrade the oil painting but that soon your flat-screen TV set will be donated to the local chapter of some kidney foundation.

The same with dishes—recall that we try to replicate nineteenth-century dinner customs. So there is at least one other domain in which we do not try to optimize matters.

I am initially writing these lines longhand, using a seasoned fountain pen. I do not fuss over the state of my pens. Many of them are old enough to cross decades; one of them (the best) I have had for at least thirty years. Nor do I obsess over small variations in the paper. I prefer to use Clairefontaine paper and notebooks that have hardly changed since my early childhood—if anything, they have degraded in quality.

But when it comes to transcribing my writing into electronic form, then I get worried that my Mac computer may not be the best tool for the job. I heard somewhere that the new version had a longer-lasting battery and I plan to upgrade soon, during my next impulse buying episode.

Note here is a strange inconsistency in the way we perceive items across the technological and real domains. Whenever I sit on an airplane next to some businessman reading the usual trash businessmen read on an e-reader, said businessperson will not resist disparaging my use of the book by comparing the two items. Supposedly, an e-reader is more “efficient.” It delivers the essence of the book, which said businessman assumes is information, but in a more convenient way, as he can carry a library on his device and “optimize” his time between golf outings. I have never heard anyone address the large differences between e-readers and physical books, like smell, texture, dimension (books are in three dimensions), color, ability to change pages, physicality of an object compared to a computer screen, and hidden properties causing unexplained differences in enjoyment. The focus of the discussion will be commonalities (how close to a book this wonderful device is). Yet when he compares his version of an e-reader to another e-reader, he will invariably focus on minute differences. Just as when Lebanese run into Syrians, they focus on the tiny variations in their respective Levantine dialects, but when Lebanese run into Italians, they focus on similarities.

There may be a heuristic that helps put such items in categories. First, the

electronic on-off switch. Whatever has an “off” or “on” switch that I need to turn off before I get yelled at by the flight attendant will necessarily be in one category (but not the opposite as many items without an on-off switch will be prone to neomania). For these items, I focus on variations, with attendant neomania. But consider the difference between the artisanal—the other category—and the industrial. What is artisanal has the love of the maker infused in it, and tends to satisfy—we don’t have this nagging impression of incompleteness we encounter with electronics.

It also so happens that whatever is technological happens to be fragile. Articles made by an artisan cause fewer treadmill effects. And they tend to have some antifragility—recall how my artisanal shoes take months before becoming comfortable. Items with an on-off switch tend to have no such redeeming antifragility.

But alas, some things we wish were a bit more fragile—which brings us to architecture.

ARCHITECTURE AND THE IRREVERSIBLE NEOMANIA

There is some evolutionary warfare between architects producing a compounded form of neomania. The problem with modernistic—and functional—architecture is that it is not fragile enough to break physically, so these buildings stick out just to torture our consciousness—you cannot exercise your prophetic powers by leaning on their fragility.

Urban planning, incidentally, demonstrates the central property of the so-called top-down effect: top-down is usually irreversible, so mistakes tend to stick, whereas bottom-up is gradual and incremental, with creation and destruction along the way, though presumably with a positive slope.

Further, things that grow in a natural way, whether cities or individual houses, have a fractal quality to them. Like everything alive, all organisms, like lungs, or trees, grow in some form of self-guided but tame randomness. What is fractal? Recall Mandelbrot's insight in Chapter 3: "fractal" entails both jaggedness and a form of self-similarity in things (Mandelbrot preferred "self-affinity"), such as trees spreading into branches that look like small trees, and smaller and smaller branches that look like a slightly modified, but recognizable, version of the whole. These fractals induce a certain wealth of detail based on a small number of rules of repetition of nested patterns. The fractal require some jaggedness, but one that has some method to its madness. Everything in nature is fractal, jagged, and rich in detail, though with a certain pattern. The smooth, by comparison, belongs to the class of Euclidian geometry we study in school, simplified shapes that lose this layer of wealth.

Alas, contemporary architecture is smooth, even when it tries to look whimsical. What is top-down is generally unwrinkled (that is, unfractal) and feels dead.

Sometimes modernism can take a naturalistic turn, then stop in its tracks. Gaudi's buildings in Barcelona, from around the turn of the twentieth century, are inspired by nature and rich architecture (Baroque and Moorish). I managed to visit a rent-controlled apartment there: it felt like an improved cavern with rich, jagged details. I was convinced that I had been there in a previous life. Wealth of details, ironically, leads to inner peace. Yet Gaudi's idea went nowhere, except in promoting modernism in its unnatural and naive versions: later modernistic structures are smooth and completely stripped of fractal jaggedness.

I also enjoy writing facing trees, and, if possible, wild untamed gardens with ferns. But white walls with sharp corners and Euclidian angles and crisp shapes strain me. And once they are built, there is no way to get rid of them. Almost everything built since World War II has an unnatural smoothness to it.

For some, these buildings cause even more than aesthetic harm—many Romanians are bitter about the dictator Nicolae Ceausescu's destruction of traditional villages replaced by modern high-rises. Neomania and dictatorship are an explosive combination. In France, some blame the modernistic architecture of housing projects for the immigrant riots. As the journalist Christopher Caldwell wrote about the unnatural living conditions: "Le Corbusier called houses 'machines for living.' France's housing projects, as we now know, became machines for alienation."

Jane Jacobs, the New York urban activist, took a heroic stance as a political-style resistant against neomania in architecture and urban planning, as the modernistic dream was carried by Robert Moses, who wanted to improve New York by razing tenements and installing large roads and highways, committing a greater crime against natural order than Haussmann, who, as we saw in Chapter 7, removed during the nineteenth century entire neighborhoods of Paris to make room for the "Grand Boulevards." Jacobs stood against tall buildings as they deform the experience of urban living, which is conducted at street level. Further, her bone with Robert Moses concerns the highway, as these engines for travel suck life out of the city—to her a city should be devoted to pedestrians. Again, we have the machine-organism dichotomy: to her the city is an organism, for Moses it is a machine to be improved upon. Indeed, Moses had plans to raze the West Village; it is thanks to her petitions and unremitting resistance that the neighborhood—the prettiest in Manhattan—has survived nearly intact. One might want to give Moses some credit, for not all his projects turned out to be nefarious—some might have been beneficial, such as the parks and beaches now accessible to the middle class thanks to the highways.

Recall the discussion of municipal properties—they don't translate into something larger because problems become more abstract as they scale up, and the abstract is not something human nature can manage properly. The same principle needs to apply to urban life: neighborhoods are villages, and need to remain villages.

I was recently stuck in a traffic jam in London where, one hears, the speed of traveling is equal to what it was a century and a half ago, if not slower. It took me almost two hours to cross London from one end to the other. As I was

depleting the topics of conversation with the (Polish) driver, I wondered whether Haussmann was not right, and whether London would be better off if it had its Haussmann razing neighborhoods and plowing wide arteries to facilitate circulation. Until it hit me that, in fact, if there was so much traffic in London, as compared to other cities, it was because people wanted to be there, and being there for them exceeded the costs. More than a third of the residents in London are foreign-born, and, in addition to immigrants, most high net worth individuals on the planet get their starter pied-à-terre in Central London. It could be that the absence of these large avenues and absence of a dominating state is part of its appeal. Nobody would buy a pied-à-terre in Brasilia, the perfectly top-down city built from scratch on a map.

I also checked and saw that the most expensive neighborhoods in Paris today (such as the Sixth Arrondissement or Île Saint-Louis) were the ones that had been left alone by the nineteenth-century renovators.

Finally, the best argument against teleological design is as follows. Even after they are built, buildings keep incurring mutations as if they needed to slowly evolve and be taken over by the dynamical environment: they change colors, shapes, windows—and character. In his book *How Buildings Learn*, Stewart Brand shows in pictures how buildings change through time, as if they needed to metamorphose into unrecognizable shapes—strangely buildings, when erected, do not account for the optionality of future alterations.

Wall to Wall Windows

The skepticism about architectural modernism that I am proposing is not unconditional. While most of it brings unnatural stress, some elements are a certain improvement. For instance, floor-to-ceiling windows in a rural environment expose us to nature—here again technology making itself (literally) invisible. In the past, the size of windows was dictated by thermal considerations, as insulation was not possible—heat escaped rather quickly from windows. Today's materials allow us to avoid such constraint. Further, much French architecture was a response to the tax on windows and doors installed after the Revolution, so many buildings have a very small number of windows.

Just as with the unintrusive shoes that allow us to feel the terrain, modern technology allows some of us to reverse that trend, as expressed by Oswald Spengler, which makes civilization go from plants to stone, that is, from the fractal to the Euclidian. We are now moving back from the smooth stone to the

rich fractal and natural. Benoît Mandelbrot wrote in front of a window overlooking trees: he craved fractal aesthetics so much that the alternative would have been inconceivable. Now modern technology allows us to merge with nature, and instead of a small window, an entire wall can be transparent and face lush and densely forested areas.

Metrification

One example of the neomania of states: the campaign for metrification, that is, the use of the metric system to replace "archaic" ones on grounds of efficiency —it "makes sense." The logic might be impeccable (until of course one supersedes it with a better, less naive logic, an attempt I will make here). Let us look at the wedge between rationalism and empiricism in this effort.

Warwick Cairns, a fellow similar to Jane Jacobs, has been fighting in courts to let market farmers in Britain keep selling bananas by the pound, and similar matters as they have resisted the use of the more "rational" kilogram. The idea of metrification was born out of the French Revolution, as part of the utopian mood, which includes changing the names of the winter months to *Nivôse, Pluviôse, Ventôse,* descriptive of weather, having decimal time, ten-day weeks, and similar naively rational matters. Luckily the project of changing time has failed. However, after repeated failures, the metric system was implemented there—but the old system has remained refractory in the United States and England. The French writer Edmond About, who visited Greece in 1832, a dozen years after its independence, reports how peasants struggled with the metric system as it was completely unnatural to them and stuck to Ottoman standards instead. (Likewise, the "modernization" of the Arabic alphabet from the easy-to-memorize old Semitic sequence made to sound like words, ABJAD, HAWWAZ, to the logical sequence A-B-T-TH has created a generation of Arabic speakers without the ability to recite their alphabet.)

But few realize that naturally born weights have a logic to them: we use feet, miles, pounds, inches, furlongs, stones (in Britain) because these are remarkably intuitive and we can use them with a minimal expenditure of cognitive effort—and all cultures seem to have similar measurements with some physical correspondence to the everyday. A meter does not match anything; a foot does. I can imagine the meaning of "thirty feet" with minimal effort. A mile, from the Latin *milia passum,* is a thousand paces. Likewise a stone (14 pounds) corresponds to … well, a stone. An inch (or *pouce*) corresponds to a thumb. A

furlong is the distance one can sprint before running out of breath. A pound, from *libra,* is what you can imagine holding in your hands. Recall from the story of Thales in Chapter 12 that we used *thekel* or *shekel:* these mean "weight" in Canaanite-Semitic languages, something with a physical connotation, similar to the pound. There is a certain nonrandomness to how these units came to be in an ancestral environment—and the digital system itself comes from the correspondence to the ten fingers.

As I am writing these lines, no doubt, some European Union official of the type who eats 200 grams of well-cooked meat with 200 centiliters' worth of red wine every day for dinner (the optimal quantity for his health benefits) is concocting plans to promote the "efficiency" of the metric system deep into the countryside of the member countries.

TURNING SCIENCE INTO JOURNALISM

So, we can apply criteria of fragility and robustness to the handling of information—the fragile in that context is, like technology, what does not stand the test of time. The best filtering heuristic, therefore, consists in taking into account the age of books and scientific papers. Books that are one year old are usually not worth reading (a very low probability of having the qualities for "surviving"), no matter the hype and how "earth-shattering" they may seem to be. So I follow the Lindy effect as a guide in selecting what to read: books that have been around for ten years will be around for ten more; books that have been around for two millennia should be around for quite a bit of time, and so forth. Many understand this point but do not apply it to academic work, which is, in much of its modern practice, hardly different from journalism (except for the occasional original production). Academic work, because of its attention-seeking orientation, can be easily subjected to Lindy effects: think of the hundreds of thousands of papers that are just noise, in spite of how hyped they were at the time of publication.

The problem in deciding whether a scientific result or a new "innovation" is a breakthrough, that is, the opposite of noise, is that one needs to see all aspects of the idea—and there is always some opacity that time, and only time, can dissipate. Like many people watching cancer research like a hawk, I fell for the following. There was at some point a great deal of excitement about the work of Judah Folkman, who, as we saw in Chapter 15, believed that one could cure cancer by choking the blood supply (tumors require nutrition and tend to create new blood vessels, what is called *neovascularization*). The idea looked impeccable on paper, but, about a decade and a half later, it appears that the only significant result we got was completely outside cancer, in the mitigation of macular degeneration.

Likewise, seemingly uninteresting results that go unnoticed, can, years later turn out to be breakthroughs.

So time can act as a cleanser of noise by confining to its dustbins all these overhyped works. Some organizations even turn such scientific production into a cheap spectator sport, with ranking of the "ten hottest papers" in, say, rectal oncology or some such sub-sub-specialty.

If we replace scientific results with scientists, we often get the same neomaniac hype. There is a disease to grant a prize for a promising scientist

“under forty,” a disease that is infecting economics, mathematics, finance, *etc.* Mathematics is a bit special because the value of its results can be immediately seen—so I skip the criticism. Of the fields I am familiar with, such as literature, finance, and economics, I can pretty much ascertain that the prizes given to those under forty are the best reverse indicator of value (much like the belief—well tested—by traders that companies that get hyped up for their potential and called “best” on the cover of magazines or in books such as *Good to Great* are about to underperform and one can derive an abnormal profit by shorting their stock). The worst effect of these prizes is penalizing those who don’t get them and debasing the field by turning it into an athletic competition.

Should we have a prize, it should be for “over a hundred”: it took close to one hundred and forty years to validate the contribution of one Jules Regnault, who discovered optionality and mapped it mathematically—along with what we dubbed the philosopher’s stone. His work stayed obscure all this time.

Now if you want to be convinced of my point of how noisy science can be, take any elementary textbook you read in high school or college with interest then—in any discipline. Open it to a random chapter, and see if the idea is still relevant. Odds are that it may be boring, but still relevant—or nonboring, and still relevant. It could be the famous 1215 Magna Carta (British history), Caesar’s Gallic wars (Roman history), a historical presentation of the school of Stoics (philosophy), an introduction to quantum mechanics (physics), or the genetic trees of cats and dogs (biology).

Now try to get the proceedings of a random conference about the subject matter concerned that took place five years ago. Odds are it will feel no different from a five-year-old newspaper, perhaps even less interesting. So attending breakthrough conferences might be, statistically speaking, as much a waste of time as buying a mediocre lottery ticket, one with a small payoff. The odds of the paper’s being relevant—and interesting—in five years is no better than one in ten thousand. The fragility of science!

Even the conversation of a high school teacher or that of an unsuccessful college professor is likely to be more worthwhile than the latest academic paper, less corrupted with neomania. My best conversations in philosophy have been with French lycée teachers who love the topic but are not interested in pursuing a career writing papers in it (in France they teach philosophy in the last year of high school). Amateurs in any discipline are the best, if you can connect with them. Unlike dilettantes, career professionals are to knowledge what prostitutes are to love.

Of course you may be lucky enough to hit on a jewel here and there, but in general, at best, conversation with an academic would be like the conversation of plumbers, at the worst that of a concierge bandying the worst brand of gossip: gossip about uninteresting people (other academics), small talk. True, the conversation of top scientists can sometimes be captivating, those people who aggregate knowledge and for whom cruising the subject is effortless as the entire small parts of the field come glued together. But these people are just currently too rare on this planet.

I complete this section with the following anecdote. One of my students (who was majoring in, of all subjects, economics) asked me for a rule on what to read. “As little as feasible from the last twenty years, except history books that are not about the last fifty years,” I blurted out, with irritation as I hate such questions as “what’s the best book you’ve ever read,” or “what are the ten best books,”—my “ten best books ever” change at the end of every summer. Also, I have been hyping Daniel Kahneman’s recent book, because it is largely an exposition of his research of thirty-five and forty years ago, with filtering and modernization. My recommendation seemed impractical, but, after a while, the student developed a culture in original texts such as Adam Smith, Karl Marx, and Hayek, texts he believes he will cite at the age of eighty. He told me that after his detoxification, he realized that all his peers do is read *timely* material that becomes instantly obsolete.

WHAT SHOULD BREAK

In 2010, *The Economist* magazine asked me to partake in an exercise imagining the world in 2036. As they were aware of my reticence concerning forecasters, their intention was to bring a critical "balance" and use me as a counter to the numerous imaginative forecasts, hoping for my usual angry, dismissive, and irascible philippic.

Quite surprised they were when, after a two-hour (slow) walk, I wrote a series of forecasts at one go and sent them the text. They probably thought at first that I was pulling a prank on them, or that someone got the wrong email and was impersonating me. Outlining the reasoning on fragility and asymmetry (concavity to errors), I explained that I would expect the future to be populated with wall-to-wall bookshelves, the device called the telephone, artisans, and such, using the notion that most technologies that are now twenty-five years old should be around in another twenty-five years—once again, most, not all.[7] But the fragile should disappear, or be weakened. Now, what is fragile? The large, optimized, overreliant on technology, overreliant on the so-called scientific method instead of age-tested heuristics. Corporations that are large today should be gone, as they have always been weakened by what they think is their strength: size, which is the enemy of corporations as it causes disproportionate fragility to Black Swans. City-states and small corporations are more likely to be around, even thrive. The nation-state, the currency-printing central bank, these things called economics departments, may stay nominally, but they will have their powers severely eroded. In other words, what we saw in the left column of the Triad should be gone—alas to be replaced by other fragile items.

PROPHETS AND THE PRESENT

By issuing warnings based on vulnerability—that is, subtractive prophecy—we are closer to the original role of the prophet: to warn, not necessarily to predict, and to predict calamities *if people don't listen*.

The classical role of the prophet, at least in the Levantine sense, is not to look into the future but to talk about the present. He tells people what to do, or, rather, in my opinion, the more robust what *not* to do. In the Near Eastern monotheistic traditions, Judaism, Christianity, and Islam, the major role of the prophets is the protection of monotheism from its idolatrous and pagan enemies that may bring calamities on the straying population. The prophet is someone who is in communication with the unique God, or at least can read his mind—and, what is key, issues warnings to His subjects. The Semitic *nby,* expressed as *Nevi* or *nebi* (in the original Hebrew), the same with minor differences in pronunciation in Aramaic (*nabi'y*) and Arabic (*nabi*), is principally someone connecting with God, expressing what is on God's mind—the meaning of *nab'* in Arabic is "news" (the original Semitic root in Acadian, *nabu,* meant "to call"). The initial Greek translation, *prophetes,* meant "spokesman," which is retained in Islam, as a dual role for Mohammed the Prophet is that of the Messenger (*rasoul*)—there were some small ranking differences between the roles of spokesman (*nabi*) and messenger (*rasoul*). The job of mere forecasting is rather limited to seers, or the variety of people involved in divination such as the "astrologers" so dismissed by the Koran and the Old Testament. Again, the Canaanites had been too promiscuous in their theologies and various approaches to handling the future, and the prophet is precisely someone who deals only with the One God, not with the future like a mere Baalite.

Nor has the vocation of Levantine prophet been a particularly desirable professional occupation. As I said at the beginning of the chapter, acceptance was far from guaranteed: Jesus, mentioning the fate of Elijah (who warned against Baal, then ironically had to go find solace in Sidon, where Baal was worshipped), announced that *no one becomes a prophet in his own land*. And the prophetic mission was not necessarily voluntary. Consider Jeremiah's life, laden with *jeremiads* (lamentations), as his unpleasant warnings about destruction and captivity (and their causes) did not make him particularly popular and he was the personification of the notion of "shoot the messenger" and the expression *veritas odium parit*—truth brings hatred. Jeremiah was beaten, punished, persecuted,

and the victim of numerous plots, which involved his own brothers. Apocryphal and imaginative accounts even have him stoned to death in Egypt.

Further north of the Semites, in the Greek tradition, we find the same focus on messages, warnings about the present, and the same punishment inflicted on those able to understand things others don't. For example, Cassandra gets the gift of prophecy, along with the curse of not being believed, when the temple snakes cleaned her ears so she could hear some special messages. Tiresias was made blind and transformed into a woman for revealing the secrets of the gods—but, as a consolation, Athena licked his ears so he could understand secrets in the songs of birds.

Recall the inability we saw in Chapter 2 to learn from past behavior. The problem with lack of recursion in learning—lack of second-order thinking—is as follows. If those delivering some messages deemed valuable for the long term have been persecuted in past history, one would expect that there would be a correcting mechanism, that intelligent people would end up learning from such historical experience so those delivering new messages would be greeted with the new understanding in mind. But nothing of the sort takes place.

This lack of recursive thinking applies not just to prophecy, but to other human activities as well: if you believe that what will work and do well is going to be a *new* idea that others did not think of, what we commonly call "innovation," then you would expect people to pick up on it and have a clearer eye for new ideas without too much reference to the perception of others. But they don't: something deemed "original" tends to be modeled on something that was new at the time but is no longer new, so being an Einstein for many scientists means solving a similar problem to the one Einstein solved when at the time Einstein was not solving a standard problem at all. The very idea of being an Einstein in physics is no longer original. I've detected in the area of risk management the similar error, made by scientists trying to be new in a standard way. People in risk management only consider risky things that have hurt them in the past (given their focus on "evidence"), not realizing that, in the past, before these events took place, these occurrences that hurt them severely were completely without precedent, escaping standards. And my personal efforts to make them step outside their shoes to consider these second-order considerations have failed—as have my efforts to make them aware of the notion of fragility.

EMPEDOCLES' DOG

In Aristotle's *Magna Moralia*, there is a possibly apocryphal story about Empedocles, the pre-Socratic philosopher, who was asked why a dog prefers to always sleep on the same tile. His answer was that there had to be some *likeness* between the dog and that tile. (Actually the story might be even twice as apocryphal since we don't know if *Magna Moralia* was actually written by Aristotle himself.)

Consider the match between the dog and the tile. A natural, biological, explainable or nonexplainable match, confirmed by long series of recurrent frequentation—in place of rationalism, just consider the history of it.

Which brings me to the conclusion of our exercise in prophecy.

I surmise that those human technologies such as writing and reading that have survived are like the tile to the dog, a match between natural friends, because they correspond to something deep in our nature.

Every time I hear someone trying to make a comparison between a book and an e-reader, or something ancient and a new technology, "opinions" pop up, as if reality cared about opinions and narratives. There are secrets to our world that only practice can reveal, and no opinion or analysis will ever capture in full.

This secret property is, of course, revealed through time, and, thankfully, only through time.

What Does Not Make Sense

Let's take this idea of Empedocles' dog a bit further: If something that makes no sense to you (say, religion—if you are an atheist—or some age-old habit or practice called irrational); if that something has been around for a very, very long time, then, irrational or not, you can expect it to stick around much longer, and outlive those who call for its demise.

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[1] There is anecdotal evidence from barefoot runners and users of "five finger" style athletic shoes—which includes myself—that one's feet store some memory of the terrain, remembering where they have been in the past.

[2] If something does not have a natural upper bound then the distribution of any specified event time is constrained only by fragility.

[3] The phrase originates, it seems, with a June 13, 1964, article in *The New Republic*, though the article made the mistake of applying it to perishable items. The author wrote that "the future career expectations of

a television comedian is proportional to the total amount of his past exposure on the medium." This would work for a young comedian, not an older one (comedians are, alas, perishable items). But technologies and books do not have such constraint.

[4] This is where my simplification lies: I am assuming that every year doubles the additional life expectancy. It can actually get better, increase by 2½ or more. So the Lindy effect, says, mathematically, that the nonperishable has a life expectancy that *increases* with every day it survives.

[5] Note also that the Lindy effect is invariant to the definition of the technology. You can define a technology as a "convertible car," a more general "car," a "bound book," or a broadly defined "book" (which would include electronic texts); the life expectancy will concern the item as defined.

[6] By the same Lindy effect, diseases and conditions that were not known to be diseases a hundred or so years ago are likely to be either (1) diseases of civilization, curable by *via negativa*, or (2) not diseases, just invented conditions. This applies most to psychological "conditions" and buzzwords putting people in silly buckets: "Type A," "passive aggressive," *etc*.

[7] I have had the privilege of reading a five-hundred-year-old book, an experience hardly different from that of reading a modern book. Compare such robustness to the lifespan of electronic documents: some of the computer files of my manuscripts that are less than a decade old are now irretrievable.

CHAPTER 21

Medicine, Convexity, and Opacity

What they call nonevidence—Where medicine fragilizes humans, then tries to save them—Newton's law or evidence?

The history of medicine is the story—largely documented—of the dialectic between doing and thinking—and how to make decisions under opacity. In the medieval Mediterranean, Maimonides, Avicenna, Al-Ruhawi, and the Syriac doctors such as Hunain Ibn Ishaq were at once philosophers and doctors. A doctor in the medieval Semitic world was called Al-Hakim, "the wise," or "practitioner of wisdom," a synonym for philosopher or rabbi (*hkm* is the Semitic root for "wisdom"). Even in the earlier period there was a crop of Hellenized fellows who stood in the exact middle between medicine and the practice of philosophy—the great skeptic philosopher Sextus Empiricus was himself a doctor member of the skeptical empirical school. So were Menodotus of Nicomedia and the experience-based predecessor of evidence-based medicine—on whom a bit more in a few pages. The works of these thinkers, or whatever remains extant are quite refreshing for those of us who distrust those who talk without doing.

Simple, quite simple decision rules and heuristics emerge from this chapter. *Via negativa*, of course (by removal of the unnatural): only resort to medical techniques when the health payoff is very large (say, saving a life) and visibly exceeds its potential harm, such as incontrovertibly needed surgery or lifesaving medicine (penicillin). It is the same as with government intervention. This is squarely Thalesian, not Aristotelian (that is, decision making based on payoffs, not knowledge). For in these cases medicine has positive asymmetries—

convexity effects—and the outcome will be less likely to produce fragility. Otherwise, in situations in which the benefits of a particular medicine, procedure, or nutritional or lifestyle modification appear small—say, those aiming for comfort—we have a large potential sucker problem (hence putting us on the wrong side of convexity effects). Actually, one of the unintended side benefits of the theorems that Raphael Douady and I developed in our paper mapping risk detection techniques (in Chapter 19) is an exact link between (a) nonlinearity in exposure or dose-response and (b) potential fragility or antifragility.

I also extend the problem to epistemological grounds and make rules for *what should be considered evidence:* as with whether a cup should be considered half-empty or half-full, there are situations in which we focus on *absence* of evidence, others in which we focus on evidence. In some cases one can be confirmatory, not others—it depends on the risks. Take smoking, which was, at some stage, viewed as bringing small gains in pleasure and even health (truly, people thought it was a good thing). It took decades for its harm to become visible. Yet had someone questioned it, he would have faced the canned-naive-academized and faux-expert response "do you have *evidence* that this is harmful?" (the same type of response as "is there evidence that polluting is harmful?"). As usual, the solution is simple, an extension of *via negativa* and Fat Tony's *don't-be-a-sucker* rule: the non-natural needs to prove its benefits, not the natural—according to the statistical principle outlined earlier that nature is to be considered much less of a sucker than humans. In a complex domain, only time—a long time—is evidence.

For any decision, the unknown will preponderate on one side more than the other.

The "do you have evidence" fallacy, mistaking evidence of no harm for no evidence of harm, is similar to the one of misinterpreting NED (no evidence of disease) for evidence of no disease. This is the same error as mistaking absence of evidence for evidence of absence, the one that tends to affect smart and educated people, as if education made people more confirmatory in their responses and more liable to fall into simple logical errors.

And recall that under nonlinearities, the simple statements "harmful" or "beneficial" break down: it is all in the dosage.

HOW TO ARGUE IN AN EMERGENCY ROOM

I once broke my nose … walking. For the sake of antifragility, of course. I was trying to walk on uneven surfaces, as part of my antifragility program, under the influence of Erwan Le Corre, who believes in naturalistic exercise. It was exhilarating; I felt the world was richer, more fractal, and when I contrasted this terrain with the smooth surfaces of sidewalks and corporate offices, those felt like prisons. Unfortunately, I was carrying something much less ancestral, a cellular phone, which had the insolence to ring in the middle of my walk.

In the emergency room, the doctor and staff insisted that I should "ice" my nose, meaning apply an ice-cold patch to it. In the middle of the pain, it hit me that the swelling that Mother Nature gave me was most certainly not directly caused by the trauma. It was my own body's response to the injury. It seemed to me that it was an insult to Mother Nature to override her programmed reactions unless we had a good reason to do so, backed by proper empirical testing to show that we humans can do better; the burden of evidence falls on us humans. So I mumbled to the emergency room doctor whether he had any statistical evidence of benefits from applying ice to my nose or if it resulted from a naive version of an *interventionism*.

His response was: "You have a nose the size of Cleveland and you are now interested in … numbers?" I recall developing from his blurry remarks the thought that he had no answer.

Effectively, he had no answer, because as soon as I got to a computer, I was able to confirm that there is no compelling empirical evidence in favor of the reduction of swelling. At least, not outside of the very rare cases in which the swelling would threaten the patient, which was clearly not the case. It was pure sucker-rationalism in the mind of doctors, following what made sense to boundedly intelligent humans, coupled with interventionism, this need to *do something*, this defect of thinking that we knew better, and denigration of the unobserved. This defect is not limited to our control of swelling: this confabulation plagues the entire history of medicine, along with, of course, many other fields of practice. The researchers Paul Meehl and Robin Dawes pioneered a tradition to catalog the tension between "clinical" and actuarial (that is, statistical) knowledge, and examine how many things believed to be true by professionals and clinicians aren't so and don't match empirical evidence. The problem is of course that these researchers did not have a clear idea of where the

burden of empirical evidence lies (the difference between naive or pseudo empiricism and rigorous empiricism)—the onus is on the doctors to show us why reducing fever is good, why eating breakfast before engaging in activity is healthy (there is no evidence), or why bleeding patients is the best alternative (they've stopped doing so). Sometimes I get the answer that they have no clue when they have to utter defensively "I am a doctor" or "are you a doctor?" But worst, I sometimes get some letters of support and sympathy from the alternative medicine fellows, which makes me go postal: the approach in this book is ultra-orthodox, ultra-rigorous, and ultra-scientific, certainly not in favor of alternative medicine.

The hidden costs of health care are largely in the denial of antifragility. But it may not be just medicine—what we call diseases of civilization result from the attempt by humans to make life comfortable for ourselves against our own interest, since the comfortable is what fragilizes. The rest of this chapter focuses on specific medical cases with hidden negative convexity effects (small gains, large losses)—and reframes the ideas of iatrogenics in connection with my notion of fragility and nonlinearities.

FIRST PRINCIPLE OF IATROGENICS (EMPIRICISM)

The first principle of iatrogenics is as follows: we do not need *evidence of harm* to claim that a drug or an unnatural *via positiva* procedure is dangerous. Recall my comment earlier with the turkey problem that harm is in the future, not in the narrowly defined past. In other words, empiricism is not naive empiricism.

We saw the smoking argument. Now consider the adventure of a human-invented fat, trans fat. Somehow, humans discovered how to make fat products and, as it was the great era of scientism, they were convinced they could make it *better* than nature. Not just equal; better. Chemists assumed that they could produce a fat replacement that was superior to lard or butter from so many standpoints. First, it was more convenient: synthetic products such as margarine stay soft in the refrigerator, so you can immediately spread them on a piece of bread without the usual wait while listening to the radio. Second, it was economical, as the synthetic fats were derived from vegetables. Finally, what is worst, trans fat was assumed to be healthier. Its use propagated very widely and after a few hundred million years of consumption of animal fat, people suddenly started getting scared of it (particularly something called "saturated" fat), mainly from shoddy statistical interpretations. Today trans fat is widely banned as it turned out that it kills people, as it is behind heart disease and cardiovascular problems.

For another murderous example of such sucker (and fragilizing) rationalism, consider the story of Thalidomide. It was a drug meant to reduce the nausea episodes of pregnant women. It led to birth defects. Another drug, Diethylstilbestrol, silently harmed the fetus and led to delayed gynecological cancer among daughters.

These two mistakes are quite telling because, in both cases, the benefits appeared to be obvious and immediate, though small, and the harm remained delayed for years, at least three-quarters of a generation. The next discussion will be about the burden of evidence, as you can easily imagine that someone defending these treatments would have immediately raised the objection, "Monsieur Taleb, do you have *evidence* for your statement?"

Now we can see the pattern: iatrogenics, being a cost-benefit situation, usually results from the treacherous condition in which the benefits are small, and visible—and the costs very large, delayed, and hidden. And of course, the potential costs are much worse than the cumulative gains.

For those into graphs, the appendix shows the potential risks from different angles and expresses iatrogenics as a probability distribution.

SECOND PRINCIPLE OF IATROGENICS (NONLINEARITY IN RESPONSE)

Second principle of iatrogenics: it is not linear. We should not take risks with near-healthy people; but we should take a lot, a lot more risks with those deemed in danger.[1]

Why do we need to focus treatment on more serious cases, not marginal ones? Take this example showing nonlinearity (convexity). When hypertension is mild, say marginally higher than the zone accepted as "normotensive," the chance of benefiting from a certain drug is close to 5.6 percent (only one person in eighteen benefit from the treatment). But when blood pressure is considered to be in the "high" or "severe" range, the chances of benefiting are now 26 and 72 percent, respectively (that is, one person in four and two persons out of three will benefit from the treatment). So the treatment benefits are convex to condition (the benefits rise disproportionally, in an accelerated manner). But consider that the iatrogenics should be constant for all categories! In the very ill condition, the benefits are large relative to iatrogenics; in the borderline one, they are small. This means that we need to focus on high-symptom conditions and ignore, I mean really ignore, other situations in which the patient is not very ill.

The argument here is based on the structure of conditional survival probabilities, similar to the one that we used to prove that harm needs to be nonlinear for porcelain cups. Consider that Mother Nature had to have tinkered through selection in inverse proportion to the rarity of the condition. Of the hundred and twenty thousand drugs available today, I can hardly find a *via positiva* one that makes a healthy person unconditionally "better" (and if someone shows me one, I will be skeptical of yet-unseen side effects). Once in a while we come up with drugs that enhance performance, such as, say, steroids, only to discover what people in finance have known for a while: in a "mature" market there is no free lunch anymore, and what appears as a free lunch has a hidden risk. When you think you have found a free lunch, say, steroids or trans fat, something that helps the healthy without visible downside, it is most likely that there is a concealed trap somewhere. Actually, my days in trading, it was called a "sucker's trade."

And there is a simple statistical reason that explains why we have not been able to find drugs that make us feel unconditionally better when we are well (or

unconditionally stronger, etc.): nature would have been likely to find this magic pill by itself. But consider that illness is rare, and the more ill the person the less likely nature would have found the solution by itself, in an accelerating way. A condition that is, say, three units of deviation away from the norm is more than three hundred times rarer than normal; an illness that is five units of deviation from the norm is more than a million times rarer!

The medical community has not modeled such nonlinearity of benefits to iatrogenics, and if they do so in words, I have not seen it in formalized in papers, hence into a decision-making methodology that takes probability into account (as we will see in the next section, there is little explicit use of convexity biases). Even risks seem to be linearly extrapolated, causing both underestimation and overestimation, most certainly miscalculation of degrees of harm—for instance, a paper on the effect of radiation states the following: "The standard model currently in use applies a linear scale, extrapolating cancer risk from high doses to low doses of ionizing radiation." Further, pharmaceutical companies are under financial pressures to find diseases and satisfy the security analysts. They have been scraping the bottom of the barrel, looking for disease among healthier and healthier people, lobbying for reclassifications of conditions, and fine-tuning sales tricks to get doctors to overprescribe. Now, if your blood pressure is in the upper part of the range that used to be called "normal," you are no longer "normotensive" but "pre-hypertensive," even if there are no symptoms in view. There is nothing wrong with the classification if it leads to healthier lifestyle and robust *via negativa* measures—but what is behind such classification, often, is a drive for more medication.

I am not against the function and mission of pharma, rather, its business practice: they should focus *for their own benefit* on extreme diseases, not on reclassifications or pressuring doctors to prescribe medicines. Indeed, pharma plays on the interventionism of doctors.

Another way to view it: the iatrogenics is in the patient, not in the treatment. If the patient is close to death, all speculative treatments should be encouraged—no holds barred. Conversely, if the patient is near healthy, then Mother Nature should be the doctor.

Jensen's Inequality in Medicine

The philosopher's stone explained that the volatility of an exposure can matter more than its average—the difference is the "convexity bias." If you are

antifragile (i.e., convex) to a given substance, then you are better off having it randomly distributed, rather than provided steadily.

I've found very few medical papers making use of nonlinearity by applying convexity effects to medical problems, in spite of the ubiquity of nonlinear responses in biology. (I am being generous; I actually found only one explicit use of Jensen's inequality in one single application—thanks to my friend Eric Briys—and only one that used it properly, so the response "we know that" by medical researchers when the consequence nonlinearity is explained to them is rather lame.)

Remarkably, convexity effects work in an identical way with options, innovations, anything convex. Now let us apply it … to lungs.

The next paragraph is a bit technical and can be skipped.

People with a variety of lung diseases, including acute respiratory distress syndrome, used to be put on mechanical ventilators. The belief was that constant pressure and volume were desirable—steadiness seemed a good idea. But the reaction of the patient is nonlinear to the pressure (convex over an initial range, then concave above it), and he suffers from such regularity. Further, people with very sick lungs cannot take high pressure for a long time—while they need a lot of volume. J. F. Brewster and his associates figured out that dispensing higher pressure on occasion, and low pressure at other times, allowed them to provide a lot more volume to the lungs for a given mean pressure and thus decrease patient mortality. An additional benefit is that an occasional spike in pressure helps to open up collapsed alveoli. Actually, that's how our lungs function when healthy: with variations and "noise" rather than steady airflow. Humans are antifragile to lung pressure. And this arises directly from the nonlinearity of the response since as we saw everything convex is antifragile, up to a certain dosage. Brewster's paper went through empirical validation, but this is not even necessary: you don't need empirical data to prove that one plus one equals two, or that probabilities need to add up to 100 percent.[2]

It does not look as though people who deal with nutrition have examined the difference between random calories and steady nutrition, something to which we will return in the next chapter.

Not using models of nonlinear effects such as convexity biases while "doing empirical work" is like having to catalog every apple falling from a tree and call the operation "empiricism" instead of just using Newton's equation.

BURYING THE EVIDENCE

Now some historical background. What made medicine mislead people for so long is that its successes were prominently displayed, and its mistakes literally buried—just like so many other interesting stories in the cemetery of history.

I cannot resist the following illustration of intervention bias (with negative convexity effects). In the 1940s and 1950s many children and teenagers received radiation for acne, thymus gland enlargement, tonsillitis, to remove birthmarks and treat ringworm of the scalp. In addition to the goiters and other late complications, approximately 7 percent of patients who received this radiation developed thyroid cancer two to four decades later. But let's not write off radiation, when it comes from Mother Nature. We are necessarily antifragile to some dose of radiation—at naturally found levels. It may be that small doses prevent injuries and cancers coming from larger ones, as the body develops some kind of immunity. And, talking about radiation, few wonder why, after hundreds of million of years of having our skins exposed to sun rays, we suddenly need so much protection from them—is it that our exposure is more harmful than before because of changes in the atmosphere, or populations living in an environment mismatching the pigmentation of their skin—or rather, that makers of sun protection products need to make some profits?

The Never-ending History of Turkey Situations

The list of such attempts to outsmart nature driven by naive rationalism is long—always meant to "improve" things—with continuous first-order learning, that is, banning the offending drug or medical procedure but not figuring out that we could be making the mistake again, elsewhere.

Statins. Statin drugs are meant to lower cholesterol in your blood. But there is an asymmetry, and a severe one. One needs to treat fifty high risk persons for five years to avoid a single cardiovascular event. Statins can potentially harm people who are not very sick, for whom the benefits are either minimal or totally nonexistent. We will not be able to get an evidence-based picture of the hidden harm in the short term (we need years for that—remember smoking) and, further, the arguments currently made in favor of the routine administration of these drugs often lie in a few statistical illusions or even manipulation (the experiments used by drug companies seem to play on nonlinearities and bundle

the very ill and the less ill, in addition to assuming that the metric "cholesterol" equates 100 percent with health). Statins fail in their application the first principle of iatrogenics (unseen harm); further, they certainly *do* lower cholesterol, but as a human your objective function is not to lower a certain metric to get a grade to pass a school-like test, but get in better health. Further, it is not certain whether these indicators people try to lower are causes or manifestations that correlate to a condition—just as muzzling a baby would certainly prevent him from crying but would not remove the cause of his emotions. Metric-lowering drugs are particularly vicious because of a legal complexity. The doctor has the incentive to prescribe it because should the patient have a heart attack, he would be sued for negligence; but the error in the opposite direction is not penalized at all, as side effects do not appear at all as being caused by the medicine.

The same problem of naive interpretation mixed with intervention bias applies to cancer detection: there is a marked bias in favor of treatment, even when it brings more harm, because the legal system favors intervention.

Surgery. Historians show that surgery had, for a long time, a much better track record than medicine; it was checked by the necessary rigor of visible results. Consider that, when operating on victims of very severe trauma, say, to extract a bullet or to push bowels back in their place, the iatrogenics is reduced; the downside of the operation is small compared to the benefits—hence positive convexity effects. Unlike with the usual pharmaceutical interventions, it is hard to say that Mother Nature would have done a better job. The surgeons used to be blue-collar workers, or closer to artisans than high science, so they did not feel too obligated to theorize.

The two professions of medical doctor and surgeon were kept professionally and socially separate, one was an *ars*, the other s*cientia*, hence one was a craft built around experience-driven heuristics and the other reposed on theories, nay, a general theory of humans. Surgeons were there for emergencies. In England, France, and some Italian cities, surgeons' guilds were merged with those of barbers. So the Soviet-Harvardification of surgery was for a long time constrained by the visibility of the results—you can't fool the eye. Given that for a long time people operated without anesthetics, one did not have to overly justify *doing nothing* and waiting for Nature to play her role.

But today's surgery, thanks to anesthesia, is done with a much smaller hurdle —and surgeons now need to attend medical school, albeit a less theoretical one than the Sorbonne or Bologna of the Middle Ages. By contrast, in the past,

letting blood (phlebotomy) was one of the few operations performed by surgeons without any disincentive. For instance, back surgery done in modern times to correct sciatica is often useless, minus the possible harm from the operation. Evidence shows that six years later, such an operation is, on average, equivalent to doing nothing, so we have a certain potential deficit from the back operation as every operation brings risks such as brain damage from anesthesia, medical error (the doctor harming the spinal cord), or exposure to hospital germs. Yet spinal cord surgery such as lumbar disc fusion is still practiced liberally, particularly as it is very lucrative for the doctor.[3]

Antibiotics. Every time you take an antibiotic, you help, to some degree, the mutation of germs into antibiotic-resistant strains. Add to that the toying with your immune system. You transfer the antifragility from your body to the germ. The solution, of course, is to do it only when the benefits are large. Hygiene, or excessive hygiene, has the same effect, particularly when people clean their hands with chemicals after every social exposure.

Here are some verified and potential examples of iatrogenics (in terms of larger downside outside of very ill patients, whether such downside has been verified or not)[4]: Vioxx, the anti-inflammatory medicine with delayed heart problems as side effects. Antidepressants (used beyond the necessary cases). Bariatric surgery (in place of starvation of overweight diabetic patients). Cortisone. Disinfectants, cleaning products potentially giving rise to autoimmune diseases. Hormone replacement therapy. Hysterectomies. Cesarean births beyond the strictly necessary. Ear tubes in babies as an immediate response to ear infection. Lobotomies. Iron supplementation. Whitening of rice and wheat—it was considered progress. The sunscreen creams suspected to cause harm. Hygiene (beyond a certain point, hygiene may make you fragile by denying hormesis—our own antifragility). We ingest probiotics because we don't eat enough "dirt" anymore. Lysol and other disinfectants killing so many "germs" that kids' developing immune systems are robbed of necessary workout (or robbed of the "good" friendly germs and parasites). Dental hygiene: I wonder if brushing our teeth with toothpaste full of chemical substances is not mostly to generate profits for the toothpaste industry—the brush is natural, the toothpaste might just be to counter the abnormal products we consume, such as starches, sugars and high fructose corn syrup. Speaking of which, high fructose corn syrup was the result of neomania, financed by a Nixon administration in love with technology and victim of some urge to subsidize corn farmers. Insulin injections for Type II diabetics, based on the assumption that the harm from diabetes

comes from blood sugar, not insulin resistance (or something else associated with it). Soy milk. Cow milk for people of Mediterranean and Asian descent. Heroin, the most dangerously addictive substance one can imagine, was developed as a morphine substitute for cough suppressants that did not have morphine's addictive side effects. Psychiatry, particularly child psychiatry—but I guess I don't need to convince anyone about its dangers. I stop here.

Again, my statements here are risk-management-based: if the person is very ill, there are no iatrogenics to worry about. So it is the marginal case that brings dangers.

The cases I have been discussing so far are easy to understand, but some applications are far more subtle. For instance, counter to "what makes sense" at a primitive level, there is no clear evidence that sugar-free sweetened drinks make you lose weight in accordance with the calories saved. But it took thirty years of confusing the biology of millions of people for us to start asking such questions. Somehow those recommending these drinks are under the impression, driven by the laws of physics (naive translation from thermodynamics), that the concept that we gain weight from calories is sufficient for further analysis. This would be certainly true in thermodynamics, as in a simple machine responding to energy without feedback, say, a car that burns fuel. But the reasoning does not hold in an informational dimension in which food is not just a source of energy; it conveys information about the environment (like stressors). The ingestion of food combined with one's activity brings about hormonal cascades (or something similar that conveys information), causing cravings (hence consumption of other foods) or changes in the way your body burns the energy, whether it needs to conserve fat and burn muscle, or vice versa. Complex systems have feedback loops, so what you "burn" depends on what you consume, and how you consume it.

NATURE'S OPAQUE LOGIC

At the time of this writing, the biologist Craig Venter is engaging in the creation of artificial life. He conducted experiments and stated them in a famous paper titled "Creation of a Bacterial Cell Controlled by a Chemically Synthesized Genome." I have an immense respect for Craig Venter, whom I consider one of the smartest men who ever breathed, and a "doer" in the full sense of the word, but giving fallible humans such powers is similar to giving a small child a bunch of explosives.

If I understand this well, to the creationists, this should be an insult to God; but, further, to the evolutionist, this is certainly an insult to evolution. And to the probabilist, like myself and my peers, this is an insult to human prudence, the beginning of the mother of all exposures to Black Swans.

Let me repeat the argument here in one block to make it clearer. Evolution proceeds by undirected, convex bricolage or tinkering, inherently robust, i.e., with the achievement of potential stochastic gains thanks to continuous, repetitive, small, localized mistakes. What men have done with top-down, command-and-control science has been exactly the reverse: interventions with negative convexity effects, i.e., the achievement of small certain gains through exposure to massive potential mistakes. Our record of understanding risks in complex systems (biology, economics, climate) has been pitiful, marred with retrospective distortions (we only understand the risks after the damage takes place, yet we keep making the mistake), and there is nothing to convince me that we have gotten better at risk management. In this particular case, because of the scalability of the errors, you are exposed to the wildest possible form of randomness.

Simply, humans should not be given explosive toys (like atomic bombs, financial derivatives, or tools to create life).

Guilty or Innocent

Let me phrase the last point a bit differently. If there is something in nature you don't understand, odds are it makes sense in a deeper way that is beyond your understanding. So there is a logic to natural things that is much superior to our own. Just as there is a dichotomy in law: *innocent until proven guilty* as opposed to *guilty until proven innocent*, let me express my rule as follows: what Mother

Nature does is rigorous until proven otherwise; what humans and science do is flawed until proven otherwise.

Let us close on this business of b***t "evidence." If you want to talk about the "statistically significant," nothing on the planet can be as close to "statistically significant" as nature. This is in deference to her track record and the sheer statistical significance of her massively large experience—the way she has managed to survive Black Swan events. So overriding her requires some very convincing justification on our part, rather than the reverse, as is commonly done, and it is very hard to beat her on statistical grounds—as I wrote in Chapter 7 in the discussion on procrastination, we can invoke the naturalistic fallacy when it comes to ethics, not when it comes to risk management.[5]

Let me repeat violations of logic in the name of "evidence" owing to their gravity. I am not joking: just as I face the shocking request "Do you have evidence?" when I question a given unnatural treatment, such as icing one's swollen nose, in the past, many faced the question "Do you have evidence that trans fat is harmful?" and needed to produce proofs—which they were obviously unable to do because it took decades before the harm became apparent. These questions are offered more often than not by smart people, even doctors. So when the (present) inhabitants of Mother Earth want to do something counter to nature, they are the ones that need to produce the evidence, if they can.

Everything nonstable or breakable has had ample chance to break over time. Further, the interactions between components of Mother Nature had to modulate in such a way as to keep the overall system alive. What emerges over millions of years is a wonderful combination of solidity, antifragility, and local fragility, sacrifices in one area made in order for nature to function better. We sacrifice ourselves in favor of our genes, trading our fragility for their survival. We age, but they stay young and get fitter and fitter outside us. Things break on a small scale all the time, in order to avoid large-scale generalized catastrophes.

Plead Ignorance of Biology: Phenomenology

I have explained that phenomenology is more potent than theories—and should lead to more rigorous policy making. Let me illustrate here.

I was in a gym in Barcelona next to the senior partner of a consulting firm, a profession grounded in building narratives and naive rationalization. Like many people who have lost weight, the fellow was eager to talk about it—it is easier to talk about weight loss theories than to stick to them. The fellow told me that he

did not believe in such diets as the low-carbohydrate Atkins or Dukan diet, until he was told of the mechanism of "insulin," which convinced him to embark on the regimen. He then lost thirty pounds—he had to wait for a theory before taking any action. That was in spite of the empirical evidence showing people losing one hundred pounds by avoiding carbohydrates, without changing their total food intake—just the composition! Now, being the exact opposite of the consultant, I believe that "insulin" as a cause is a fragile theory but that the phenomenology, the empirical effect, is real. Let me introduce the ideas of the postclassical school of the skeptical empiricists.

We are built to be dupes for theories. But theories come and go; experience stays. Explanations change all the time, and have changed all the time in history (because of causal opacity, the invisibility of causes) with people involved in the incremental development of ideas thinking they always had a definitive theory; experience remains constant.

As we saw in Chapter 7, what physicists call the phenomenology of the process is the empirical manifestation, without looking at how it glues to existing general theories. Take for instance the following statement, entirely evidence-based: *if you build muscle, you can eat more without getting more fat deposits in your belly* and can gorge on lamb chops without having to buy a new belt. Now in the past the theory to rationalize it was "Your metabolism is higher because muscles burn calories." Currently I tend to hear "You become more insulin-sensitive and store less fat." Insulin, shminsulin; metabolism, shmetabolism: another theory will emerge in the future and some other substance will come about, but the exact same effect will continue to prevail.

The same holds for the statement *Lifting weights increases your muscle mass*. In the past they used to say that weight lifting caused the "micro-tearing of muscles," with subsequent healing and increase in size. Today some people discuss hormonal signaling or genetic mechanisms, tomorrow they will discuss something else. But the effect has held forever and will continue to do so.

When it comes to narratives, the brain seems to be the last province of the theoretician-charlatan. Add *neurosomething* to a field, and suddenly it rises in respectability and becomes more convincing as people now have the illusion of a strong causal link—yet the brain is too complex for that; it is both the most complex part of the human anatomy and the one that seems most susceptible to sucker-causation. Christopher Chabris and Daniel Simons brought to my attention the evidence I had been looking for: whatever theory has a reference in it to brain circuitry seems more "scientific" and more convincing, even when it

is just randomized psychoneurobabble.

But this causation is highly rooted in orthodox medicine as it was traditionally built. Avicenna in his *Canon* (which in Arabic means law): "We must know the causes of health and illness if we wish to make [medicine] a *scientia*."

I am writing about health, but I do not want to rely on biology beyond the minimum required (not in the theoretical sense)—and I believe that my strength will lie there. I just want to understand as little as possible to be able to look at regularities of experience.

So the *modus operandi* in every venture is to remain as robust as possible to changes in theories (let me repeat that my deference to Mother Nature is entirely statistical and risk-management-based, i.e., again, grounded in the notion of fragility). The doctor and medical essayist James Le Fanu showed how our understanding of the biological processes was coupled with a decline of pharmaceutical discoveries, as if rationalistic theories were blinding and somehow a handicap.

In other words, we have in biology a green lumber problem!

Now, a bit of history of ancient and medieval medicine. Traditionally, medicine used to be split into three traditions: rationalists (based on preset theories, the need of global understanding of what things were made *for*), skeptical empiricists (who refused theories and were skeptical of ideas making claims about the unseen), and methodists (who taught each other some simple medical heuristics stripped of theories and found an even more practical way to be empiricists). While differences can be overplayed by the categorization, one can look at the three traditions not as entirely dogmatic approaches, but rather ones varying in their starting point, the weight of the prior beliefs: some start with theories, others with evidence.

Tensions among the three tendencies have always existed over time—and I put myself squarely in the camp attempting to vindicate the empiricists, who, as a philosophical school, were swallowed by late antiquity. I have been trying to bring alive these ideas of Aenesidemus of Knossos, Antiochus of Laodicea, Menodotus of Nicomedia, Herodotus of Tarsus, and of course Sextus Empiricus. The empiricists insisted on the "I did not know" while facing situations *not exactly seen* in the past, that is, in nearly identical conditions. The methodists did not have the same strictures against analogy, but were still careful.

The Ancients Were More Caustic

This problem of iatrogenics is not new—and doctors have been traditionally the butt of jokes.

Martial in his epigrams gives us an idea of the perceived expert problem in medicine in his time: “I thought that Diaulus was a doctor, not a caretaker—but for him it appears to be the same job” (*Nuper erat medicus, nunc est uispillo Diaulus: quod uispillo facit, fecerat et medicus*) or “I did not feel ill, Symmache; now I do (after your ministrations).” (*Non habui febrem, Symmache, nunc habeo*).

The Greek term *pharmakon* is ambiguous, as it can mean both “poison” and “cure” and has been used as a pun to warn against iatrogenics by the Arab doctor Ruhawi.

An *attribution problem* arises when the person imputes his positive results to his own skills and his failures to luck. Nicocles, as early as the fourth century B.C., asserts that doctors claimed responsibility for success and blamed failure on nature, or on some external cause. The very same idea was rediscovered by psychologists some twenty-four centuries later, and applied to stockbrokers, doctors, and managers of companies.

According to an ancient anecdote, the Emperor Hadrian continually exclaimed, as he was dying, that it was his doctors who had killed him.

Montaigne, mostly a synthesizer of classical writers, has his *Essays* replete with anecdotes: A Lacedaemonian was asked what had made him live so long; he answered, “Ignoring medicine.” Montaigne also detected the agency problem, or why the last thing a doctor needs is for you to be healthy: “No doctor derives pleasure from the health of his friends, wrote the ancient Greek satirist, no soldier from the peace of his city, etc.” *(Nul médecin ne prent plaisir à la santé de ses amis mesmes, dit l’ancien Comique Grec, ny soldat à la paix de sa ville: ainsi du reste.)*

How to Medicate Half the Population

Recall how a personal doctor can kill you.

We saw in the story of the grandmother our inability to distinguish in our logical reasoning (though not in intuitive actions) between average and other, richer properties of what we observe.

I was once attending a lunch party at the country house of a friend when someone produced a handheld blood pressure measuring tool. Tempted, I measured my arterial pressure, and it turned out to be slightly higher than

average. A doctor, who was part of the party and had a very friendly disposition, immediately pulled out a piece of paper prescribing some medication to lower it —which I later threw in the garbage can. I subsequently bought the same measuring tool and discovered that my blood pressure was much lower (hence better) than average, except once in a while, when it peaked episodically. In short, it exhibits some variability. Like everything in life.

This random variability is often mistaken for information, hence leading to intervention. Let us play a thought experiment, without making any assumption on the link between blood pressure and health. Further, assume that "normal" pressure is a certain, known number. Take a cohort of healthy persons. Suppose that because of randomness, half the time a given person's pressure will be above that number, and half the time, for the same person, the measurement will be below. So on about half the doctor's visits they will show the alarming "above normal." If the doctor automatically prescribes medication on the days the patients are above normal, then half the *normal* population will be on medication. And note that we are quite certain that their life expectancy will be reduced by unnecessary treatments. Clearly I am simplifying here; sophisticated doctors are aware of the variable nature of the measurements and do not prescribe medication when the numbers are not compelling (though it is easy to fall into the trap, and not all doctors are sophisticated). But the thought experiment can show how frequent visits to the doctor, particularly outside the cases of a life-threatening ailment or an uncomfortable condition—just like frequent access to information—can be harmful. This example also shows us the process outlined in Chapter 7 by which a personal doctor ends up killing the patient—simply by overreacting to noise.

This is more serious than you think: it seems that medicine has a hard time grasping normal variability in samples—it is hard sometimes to translate the difference between "statistically significant" and "significant" in effect. A certain disease might marginally lower your life expectancy, but it can be deemed to do so with "high statistical significance," prompting panics when in fact all these studies might be saying is they established *with a significant statistical margin* that in some cases, say, 1 percent of the cases, patients are likely to be harmed by it. Let me rephrase: the magnitude of the result, the importance of the effect, is not captured by what is called "statistical significance," something that tends to deceive specialists. We need to look in two dimensions: how much a condition, say, blood pressure a certain number of points higher than normal, is likely to affect your life expectancy; and how

significant the result is.

Why is this serious? If you think that the statistician really understands "statistical significance" in the complicated texture of real life (the "large world," as opposed to the "small world" of textbooks), some surprises. Kahneman and Tversky showed that statisticians themselves made practical mistakes in real life in violation of their teachings, forgetting that they were statisticians (thinking, I remind the reader, requires effort). My colleague Daniel Goldstein and I did some research on "quants," professionals of quantitative finance, and realized that the overwhelming majority did not understand the practical effect of elementary notions such as "variance" or "standard deviation," concepts they used in about every one of their equations. A recent powerful study by Emre Soyer and Robin Hogarth showed that many professionals and experts in the field of econometrics supplying pompous numbers such as "regression" and "correlation" made egregious mistakes translating into practice the numbers they were producing themselves—they get the equation right but make severe translation mistakes when expressing it into reality. In all cases they underestimate randomness and underestimate the uncertainty in the results. And we are talking about errors of interpretation *made by the statisticians,* not by the users of statistics such as social scientists and doctors.

Alas, all these biases lead to action, almost never inaction.

In addition, we now know that the craze against fats and the "fat free" slogans result from an elementary mistake in interpreting the results of a regression: when two variables are jointly responsible for an effect (here, carbohydrates and fat), sometimes one of them shows sole responsibility. Many fell into the error of attributing problems under joint consumption of fat and carbohydrates to fat rather than carbohydrates. Further, the great statistician and debunker of statistical misinterpretation David Freedman showed (very convincingly) with a coauthor that the link everyone is obsessing about between salt and blood pressure has no statistical basis. It may exist for some hypertensive people, but it is more likely the exception than the rule.

The "Rigor of Mathematics" in Medicine

For those of us who laugh at the charlatanism hidden behind fictional mathematics in social science, one may wonder why this did not happen to medicine.

And indeed the cemetery of bad ideas (and hidden ideas) shows that

mathematics fooled us there. There have been many forgotten attempts to mathematize medicine. There was a period during which medicine derived its explanatory models from the physical sciences. Giovanni Borelli, in *De motu animalium*, compared the body to a machine consisting of animal levers—hence we could apply the rules of linear physics.

Let me repeat: I am not against rationalized learned discourse, provided it is not fragile to error; I am first and last a decision maker hybrid and will never separate the philosopher-probabilist from the decision maker, so I am that joint person all the time, in the morning when I drink the ancient liquid called coffee, at noon when I eat with my friends, and at night when I go to bed clutching a book. What I am against is *naive* rationalized, pseudolearned discourse, with green lumber problems—one that focuses solely on the known and *ignores the unknown*. Nor am I against the use of mathematics when it comes to gauging the importance of the unknown—this is the robust application of mathematics. Actually the arguments in this chapter and the next are all based on the mathematics of probability—but it is not a rationalistic use of mathematics and much of it allows the detection of blatant inconsistencies between statements about severity of disease and intensity of treatment. On the other hand, the use of mathematics in social science is like interventionism. Those who practice it professionally tend to use it everywhere except where it can be useful.

The only condition for such brand of more sophisticated rationalism: to believe and act as if one does not have the full story—to be sophisticated you need to accept that you are not so.

Next

This chapter has introduced the idea of convexity effects and burden of evidence into medicine and into the assessment of risk of iatrogenics. Next, let us look at more applications of convexity effects and discuss *via negativa* as a rigorous approach to life.

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[1] A technical comment. This is a straightforward result of convexity effects on the probability distribution of outcomes. By the "inverse barbell effect," when the gains are small to iatrogenics, uncertainty harms the situation. But by the "barbell effect," when the gains are large in relation to potential side effects, uncertainty tends to be helpful. An explanation with ample graphs is provided in the Appendix.

[2] In other words, the response for, say, 50 percent of a certain dose during one period, followed by 150 percent of the dose in a subsequent period in convex cases, is superior to 100 percent of the dose in

both periods. We do not need much empiricism to estimate the convexity bias: by theorem, such bias is a necessary result of convexity.

[3] Stuart McGill, an evidence-based scientist who specializes in back conditions, describes the self-healing process as follows: the sciatic nerve, when trapped in too narrow a cavity, causing the common back problem that is thought (by doctors) to be curable only by (lucrative) surgery, produces acid substances that cut through the bone and, over time, carves itself a larger passage. The body does a better job than surgeons.

[4] The core point in this chapter and the next is nonlinearity as it links to fragility, and how to make use of it in medical decision making, not specific medical treatments and errors. These examples are just illustrative of things we look at without considering concave responses.

[5] A common mistake is to argue that the human body is not perfectly adapted, as if the point had consequences for decision making. This is not the point here; the idea is that nature is computationally more able than humans (and has proven to be so), not that it is perfect. Just look at it as the master of high-dimensional trial and error.

CHAPTER 22

To Live Long, but Not Too Long

Wednesdays and Fridays, plus Lent—How to live forever, according to Nietzsche or others—Or why, when you think about it, not to live longer

LIFE EXPECTANCY AND CONVEXITY

Whenever you question some aspects of medicine—or unconditional technological "progress"—you are invariably and promptly provided the sophistry that "we tend to live longer" than past generations. Note that some make the even sillier argument that a propensity to natural things implies favoring a return to a day of "brutish and short" lives, not realizing it is the exact same argument as saying that eating fresh, noncanned foods implies rejecting civilization, the rule of law, and humanism. So there are a lot of nuances in this life expectancy argument.

Life expectancy has increased (conditional on no nuclear war) because of the combination of many factors: sanitation, penicillin, a drop in crime, life-saving surgery, and of course, *some* medical practitioners operating in severe life-threatening situations. If we live longer, it is thanks to medicine's benefits in cases that are lethal, in which the condition is severe—hence low iatrogenics, as we saw, the convex cases. So it is a serious error to infer that if we live longer because of medicine, that all medical treatments make us live longer.

Further, to account for the effect of "progress," we need to deduct of course, from the gains in medical treatment, the costs of the diseases of civilization (primitive societies are largely free of cardiovascular disease, cancer, dental cavities, economic theories, lounge music, and other modern ailments); advances in lung cancer treatment need to be offset by the effect of smoking. From the research papers, one can estimate that medical practice may have contributed a small number of years to the increase, but again, this depends greatly on the gravity of the disease (cancer doctors certainly provide a positive contribution in advanced—and curable—cases, while interventionistic personal doctors, patently, provide a negative one). We need to take into account the unfortunate fact that iatrogenics, hence medicine, reduces life expectancy in a set—and easy to map—number of cases, the concave ones. We have a few pieces of data from the small number of hospital strikes during which only a small number of operations are conducted (for the most urgent cases), and elective surgery is postponed. Depending on whose side in the debate you join, life expectancy either increases in these cases or, at the least, does not seem to drop. Further, which is significant, many of the elective surgeries are subsequently canceled upon the return to normalcy—evidence of the denigration of Mother Nature's work by *some* doctors.

Another fooled-by-randomness-style mistake is to think that because life expectancy at birth used to be thirty until the last century, that people lived *just* thirty years. The distribution was massively skewed, with the bulk of the deaths coming from birth and childhood mortality. Conditional life expectancy was high—just consider that ancestral men tended to die of trauma.[1] Perhaps legal enforcement contributed more than doctors to the increase in length of life—so the gains in life expectancy are more societal than from the result of scientific advance.

As a case study, consider mammograms. It has been shown that administering them to women over forty on an annual basis does not lead to an increase in life expectancy (at best; it could even lead to a decrease). While female mortality from breast cancer decreases for the cohort subjected to mammograms, the death *from other causes* increases markedly. We can spot here simple measurable iatrogenics. The doctor, seeing the tumor, cannot avoid doing something harmful, like surgery followed by radiation, chemotherapy, or both—that is, more harmful than the tumor. There is a break-even point that is easily crossed by panicked doctors and patients: treating *the tumor that will not kill you* shortens your life—chemotherapy is toxic. We have built up so much paranoia against cancer, looking at the chain backward, an error of logic called *affirming the consequent*. If all of those dying prematurely from cancer had a malignant tumor, that does not mean that all malignant tumors lead to death from cancer. Most equally intelligent persons do not infer from the fact that all Cretans are liars that all liars are Cretan, or from the condition that all bankers are corrupt that all corrupt people are bankers. Only in extreme cases does nature allow us to make such violations of logic (called *modus ponens*) in order to help us survive. Overreaction is beneficial in an ancestral environment.[2]

Misunderstanding of the problems with mammograms has led to overreactions on the part of politicians (another reason to have a society immune from the stupidity of lawmakers by decentralization of important decisions). One politician of the primitive kind, Hillary Clinton, went so far as to claim that critics of the usefulness of mammograms were killing women.

We can generalize the mammogram problem to unconditional laboratory tests, finding deviations from the norm, and acting to “cure” them.

Subtraction Adds to Your Life

Now I speculate the following, having looked closely at data with my friend

Spyros Makridakis, a statistician and decision scientist who we introduced a few chapters ago as the first to find flaws in statistical forecasting methods. We estimated that cutting medical expenditures by a certain amount (while limiting the cuts to elective surgeries and treatments) would extend people's lives in most rich countries, especially the United States. Why? Simple basic convexity analysis; a simple examination of conditional iatrogenics: the error of treating the mildly ill puts them in a concave position. And it looks as if we know very well how to do this. Just raise the hurdle of medical intervention in favor of cases that are most severe, for which the iatrogenics effect is very small. It may even be better to increase expenditures on these and reduce the one on elective ones.

In other words, reason backward, starting from the iatrogenics to the cure, rather than the other way around. Whenever possible, replace the doctor with human antifragility. But otherwise don't be shy with aggressive treatments.

Another application of *via negativa:* spend less, live longer is a subtractive strategy. We saw that iatrogenics comes from the intervention bias, *via positiva*, the propensity to want to *do something*, causing all the problems we've discussed. But let's do some *via negativa* here: removing things can be quite a potent (and, empirically, a more rigorous) action.

Why? Subtraction of a substance not seasoned by our evolutionary history reduces the possibility of Black Swans while leaving one open to improvements. Should the improvements occur, we can be pretty comfortable that they are as free of unseen side effects as one can get.

So there are many hidden jewels in *via negativa* applied to medicine. For instance, telling people *not* to smoke seems to be the greatest medical contribution of the last sixty years. Druin Burch, in *Taking the Medicine*, writes: "The harmful effects of smoking are roughly equivalent to the combined good ones of *every* medical intervention developed since the war.… Getting rid of smoking provides more benefit than being able to cure people of every possible type of cancer."

As usual, the ancients. As Ennius wrote, "The good is mostly in the absence of bad"; *Nimium boni est, cui nihil est mali.*

Likewise, happiness is best dealt with as a negative concept; the same nonlinearity applies. Modern happiness researchers (who usually look quite unhappy), often psychologists turned economists (or vice versa), do not use nonlinearities and convexity effects when they lecture us about happiness as if we knew what it was and whether that's what we should be after. Instead, they

should be lecturing us about unhappiness (I speculate that just as those who lecture on happiness look unhappy, those who lecture on unhappiness would look happy); the “pursuit of happiness” is not equivalent to the “avoidance of unhappiness.” Each of us certainly knows not only what makes us unhappy (for instance, copy editors, commuting, bad odors, pain, the sight of a certain magazine in a waiting room, etc.), but what to do about it.

Let us probe the wisdom of the ages. “Sometimes scantiness of nourishment restores the system,” wrote Plotinus—and the ancients believed in purges (one manifestation of which was the oft-harmful, though often beneficial, routine of bloodletting). The regimen of the Salerno School of Medicine: joyful mood, rest, and scant nourishment. *Si tibi deficiant medici, medici tibi fiant haec tria: mens laeta, requies, moderata diaeta.*

There is a seemingly apocryphal (but nevertheless interesting) story about Pomponius Atticus, famous for being Cicero’s relative and epistolary recipient. Being ill, incurably ill, he tried to put an end to both his life and his suffering by abstinence, and only succeeded in ending the latter, as, according to Montaigne, his health was restored. But I am citing the story in spite of its apocryphal nature simply because, from a scientific perspective, it seems that the only way we may manage to extend people’s lives is through caloric restriction—which seems to cure many ailments in humans and extend lives in laboratory animals. But, as we will see in the next section, such restriction does not need to be permanent—just an occasional (but painful) fast might do.

We know we can cure many cases of diabetes by putting people on a very strict starvation-style diet, shocking their system—in fact the mechanism had to have been known heuristically for a long time since there are institutes and sanatoria for curative starvation in Siberia.

It has been shown that many people benefit from the removal of products that did not exist in their ancestral habitat: sugars and other carbohydrates in unnatural format, wheat products (those with celiac disease, but almost all of us are somewhat ill-adapted to this new addition to the human diet), milk and other cow products (for those of non–Northern European origin who did not develop lactose tolerance), sodas (both diet and regular), wine (for those of Asian origin who do not have the history of exposure), vitamin pills, food supplements, the family doctor, headache medicine and other painkillers. Reliance on painkillers encourages people to avoid addressing the cause of the headache with trial and error, which can be sleep deprivation, tension in the neck, or bad stressors—it

allows them to keep destroying themselves in a Procrustean-bed-style life. But one does not have to go far, just start removing the medications that your doctor gave you, or, preferably, remove your doctor—as Oliver Wendell Holmes Sr. put it, “if all the medications were dumped in the sea, it would be better for mankind but worse for the fishes.” My father, an oncologist (who also did research in anthropology) raised me under that maxim (alas, while not completely following it in practice; he cited it enough, though).

I, for my part, resist eating fruits not found in the ancient Eastern Mediterranean (I use “I” here in order to show that I am not narrowly generalizing to the rest of humanity). I avoid any fruit that does not have an ancient Greek or Hebrew name, such as mangoes, papayas, even oranges. Oranges seem to be the postmedieval equivalent of candy; they did not exist in the ancient Mediterranean. Apparently, the Portuguese found a sweet citrus tree in Goa or elsewhere and started breeding it for sweeter and sweeter fruits, like a modern confectionary company. Even the apples we see in the stores are to be regarded with some suspicion: original apples were devoid of sweet taste and fruit corporations bred them for maximal sweetness—the mountain apples of my childhood were acid, bitter, crunchy, and much smaller than the shiny variety in U.S. stores said to keep the doctor away.

As to liquid, my rule is drink no liquid that is not at least a thousand years old—so its fitness has been tested. I drink just wine, water, and coffee. No soft drinks. Perhaps the most possibly deceitfully noxious drink is the orange juice we make poor innocent people imbibe at the breakfast table while, thanks to marketing, we convince them it is “healthy.” (Aside from the point that the citrus our ancestors ingested was not sweet, they never ingested carbohydrates without large, very large quantities of fiber. Eating an orange or an apple is not biologically equivalent to drinking orange or apple juice.) From such examples, I derived the rule that what is called “healthy” is generally unhealthy, just as “social” networks are antisocial, and the “knowledge”-based economy is typically ignorant.

I would add that, in my own experience, a considerable jump in my personal health has been achieved by removing offensive irritants: the morning newspapers (the mere mention of the names of the fragilista journalists Thomas Friedman or Paul Krugman can lead to explosive bouts of unrequited anger on my part), the boss, the daily commute, air-conditioning (though not heating), television, emails from documentary filmmakers, economic forecasts, news about the stock market, gym “strength training” machines, and many more.[3]

The Iatrogenics of Money

To understand the outright denial of antifragility in the way we seek wealth, consider that construction laborers seem happier with a ham and cheese baguette than businessmen with a Michelin three-star meal. Food tastes so much better after exertion. The Romans had a strange relation to wealth: anything that "softens" or "mollifies" was seen negatively. Their reputation for decadence is a bit overdone—history likes the lurid; they disliked comfort and understood its side effects. The same with the Semites, split between desert tribes and city dwellers, with city dwellers harboring a certain cross-generational nostalgia for their roots and their original culture; so there is the culture of the desert, full of poetry, chivalry, contemplation, rough episodes, and frugality, plotted against the cities' comfort, which is associated with physical and moral decay, gossip, and decadence. The city dweller repairs to the desert for purification, as Christ did for forty days in the Judean desert, or Saint Mark in the Egyptian desert, starting a tradition of such asceticism. There was at some point an epidemic of monasticism in the Levant, perhaps the most impressive being Saint Simeon, who spent forty years on top of a column in Northern Syria. The Arabs kept the tradition, shedding possessions to go to silent, barren, empty spaces. And of course, with mandatory fasting, on which a bit later.

Note that medical iatrogenics is the result of wealth and sophistication rather than poverty and artlessness, and of course the product of partial knowledge rather than ignorance. So this idea of shedding possessions to go to the desert can be quite potent as a *via negativa*–style subtractive strategy. Few have considered that money has its own iatrogenics, and that separating some people from their fortune would simplify their lives and bring great benefits in the form of healthy stressors. So being poorer might not be completely devoid of benefits if one does it right. We need modern civilization for many things, such as the legal system and emergency room surgery. But just imagine how by the subtractive perspective, *via negativa*, we can be better off by getting tougher: no sunscreen, no sunglasses if you have brown eyes, no air-conditioning, no orange juice (just water), no smooth surfaces, no soft drinks, no complicated pills, no loud music, no elevator, no juicer, no … I stop.

When I see pictures of my friend the godfather of the Paleo ancestral lifestyle, Art De Vany, who is extremely fit in his seventies (much more than most people thirty years younger than him), and those of the pear-shaped billionaires Rupert Murdoch or Warren Buffett or others in the same age group, I am invariably hit with the following idea. If true wealth consists in worriless sleeping, clear

conscience, reciprocal gratitude, absence of envy, good appetite, muscle strength, physical energy, frequent laughs, no meals alone, no gym class, some physical labor (or hobby), good bowel movements, no meeting rooms, and periodic surprises, then it is largely subtractive (elimination of iatrogenics).

Religion and Naive Interventionism

Religion has invisible purposes beyond what the literal-minded scientistic-scientifiers identify—one of which is to protect us from scientism, that is, them. We can see in the corpus of inscriptions (on graves) accounts of people erecting fountains or even temples to their favorite gods after these succeeded where doctors failed. Indeed we rarely look at religion's benefits in limiting the intervention bias and its iatrogenics: *in a large set of circumstances (marginal disease), anything that takes you away from the doctor and allows you to do nothing (hence gives nature a chance to do its work) will be beneficial*. So going to church (or the temple of Apollo) for mild cases—say, those devoid of trauma, like a mild discomfort, not injuries from a car accident, those situations in which the risk of iatrogenics exceeds the benefit of cure, to repeat it again, the cases with negative convexity—will certainly help. We have so many inscriptions on temples of the type *Apollo saved me, my doctors tried to kill me*—typically the patient has bequeathed his fortune to the temple.

And it seems to me that human nature does, deep down, know when to resort to the solace of religion, and when to switch to science.[4]

IF IT'S WEDNESDAY, I MUST BE VEGAN

Sometimes, for a conference dinner, the organizers send me a form asking me if I have dietary requirements. Some do so close to six months in advance. In the past, my usual answer had been that I avoid eating cats, dogs, rats, and humans (especially economists). Today, after my personal evolution, I truly need to figure out the day of the week to know if I will be vegan then or capable of eating those thick monstrous steaks. How? Just by looking at the Greek Orthodox calendar and its required fasts. This confuses the usual categorizing business-reader-TED-conference modern version of the naive fellow who cannot place me in the "Paleo camp" or the "vegan camp." (The "Paleo" people are carnivores who try to replicate the supposed ancestral high-meat, high-animal-fat diet of hunter-gatherers; vegans are people who eat no animal product, not even butter). We will see further down why it is a naive rationalistic mistake to be in either category (except for religious or spiritual reasons) except episodically.

I believe in the heuristics of religion and blindly accommodate its rules (as an Orthodox Christian, I can cheat once in a while, as it is part of the game). Among other things the role of religion is to tame the iatrogenics of abundance —fasting makes you lose your sense of entitlement. But there are more subtle aspects.

Convexity Effects and Random Nutrition

Recall from the lung ventilator discussion this practical consequence of Jensen's inequality: irregularity has its benefits in some areas; regularity has its detriments. Where Jensen's inequality applies, irregularity might be medicine.

Perhaps what we mostly need to remove is a few meals at random, or at least avoid steadiness in food consumption. The error of missing nonlinearities is found in two places, in the mixture and in the frequency of food intake.

The problem with the mixture is as follows. We humans are said to be omnivorous, compared to more specialized mammals, such as cows and elephants (who eat salads) and lions (who eat prey, generally salad-eating prey). But such ability to be omnivorous had to come in response to more variegated environments with unplanned, haphazard, and, what is key, serial availability of sources—specialization is the response to a very stable habitat free of abrupt changes, redundancy of pathways the response to a more variegated one.

Diversification of function had to come in response to variety. And a variety of a certain structure.

Note a subtlety in the way we are built: the cow and other herbivores are subjected to much less randomness than the lion in their food intake; they eat steadily but need to work extremely hard in order to metabolize all these nutrients, spending several hours a day just eating. Not to count the boredom of standing there eating salads. The lion, on the other hand, needs to rely on more luck; it succeeds in a small percentage of the kills, less than 20 percent, but when it eats, it gets in a quick and easy way all these nutrients produced thanks to very hard and boring work by the prey. So take the following principles derived from the random structure of the environment: when we are herbivores, we eat steadily; but when we are predators we eat more randomly. Hence our proteins need to be consumed randomly for statistical reasons.

So if you agree that we need "balanced" nutrition of a certain combination, it is wrong to immediately assume that we need such balance *at every meal* rather than serially so. Assuming that we need on average certain quantities of the various nutrients that have been identified, say a certain quantity of carbohydrates, proteins, and fats.[5] There is a big difference between getting them together, at every meal, with the classical steak, salad, followed by fresh fruits, or having them separately, serially.

Why? Because deprivation is a stressor—and we know what stressors do when allowed adequate recovery. Convexity effects at work here again: getting three times the daily dose of protein in one day and nothing the next two is certainly not biologically equivalent to "steady" moderate consumption if our metabolic reactions are nonlinear. It should have some benefits—at least this is how we are designed to be.

I speculate; in fact I more than speculate: I am convinced (an inevitable result of nonlinearity) that we are antifragile to randomness in food delivery and composition—at least over a certain range, or number of days.

And one blatant denial of convexity bias is the theory about the benefits of the so-called Cretan (or Mediterranean) diet that triggered a change in the eating habits of the U.S. enlightened class, away from steak and potatoes in favor of grilled fish with salad and feta cheese. It happened as follows. Someone looked at the longevity of Cretans, cataloged what they ate, then inferred—naively—that they lived longer because of the types of food they consumed. It could be true, but the second-order effect (the variations in intake) could be dominant, something that went unnoticed by mechanistic researchers. Indeed, it took a

while to notice the following: the Greek Orthodox church has, depending on the severity of the local culture, almost two hundred days of fasting per year; and these are harrowing fasts.

Yes, harrowing fasts, as I am feeling it right now. For I am writing these lines during Orthodox Lent, a forty-day period in which almost no animal product can be consumed, no sweets, and, for some sticklers, no olive oil. As there are several gradations, I try to stick to a semistrict level, and life is not very easy, as is meant to be. I just spent a long weekend in Amioun, my ancestral village in Northern Lebanon, in the Greek Orthodox area called the Koura valley. There traditional "ruse" foods are perfected, with great imagination: Levantine kibbeh made with herbs and beans in place of meat, meatballs made of matzoh-style small brown balls in a lentil soup. Remarkably, while fish is banned, most days, shellfish is allowed, probably as it was not considered a luxury item. The compensation for the absence of some nutrients from my daily diet will take place in lumps. I will make up my deprivation of what researchers (for now) call protein with fish on days when it is allowed, and of course I will ravenously eat lamb on Easter Day, then consume disproportionally high quantities of fatty red meat for a while thereafter. I dream of the red steak served in Fat Tony–patronized restaurants in unapologetically monstrous portions.

And there is this antifragility to the stressor of the fast, as it makes the wanted food taste better and can produce euphoria in one's system. Breaking a fast feels like the exact opposite of a hangover.[6]

How to Eat Yourself

I wonder how people can accept that the stressors of exercise are good for you, but do not transfer to the point that food deprivation can have the same effect. But scientists are in the process of discovering the effects of episodic deprivation of some, or all, foods. Somehow, evidence shows, we get sharper and fitter in response to the stress of the constraint.

We can look at biological studies not to generalize or use in the rationalistic sense, but to verify the existence of a human response to hunger: that biological mechanisms are activated by food deprivation. And we have experiments on cohorts showing the positive effect of hunger—or deprivation of a food group—on the human body. Researchers rationalize now with the mechanism of *autophagy* (eating oneself): when deprived of external sources, the theories are that your cells start eating themselves, or breaking down proteins and

recombining amino acids to provide material for building other cells. It is assumed by some researchers (for now) that the "vacuum cleaner" effect of autophagy is the key to longevity—though my ideas of the natural are impervious to their theories: as I will show further down, occasional starvation produces some health benefits and that's that.

The response to hunger, our antifragility, has been underestimated. We've been telling people to eat a good meal for breakfast so they can face the travails of the day. And it is not a new theory by empirically blind modern-day nutritionists—for instance I was struck by a dialogue in Stendhal's monumental novel *Le rouge et le noir* in which the protagonist, Julien Sorel, is told "the work for the day will be long and rough, so let us *fortify* ourselves with a breakfast" (which in the French of the period was called "the first lunch"). Indeed, the idea of breakfast as a main meal with cereals and other such materials has been progressively shown to be harming humans—I wonder why it took so long before anyone realized that such an unnatural idea needs to be tested; further, the tests show that harm, or, at least, no benefits are derived from breakfast unless one has worked for it beforehand.

Let us remember that we are not designed to be receiving foods from the delivery person. In nature, we had to expend some energy to eat. Lions hunt to eat, they don't eat their meal then hunt for pleasure. Giving people food before they expend energy would certainly confuse their signaling process. And we have ample evidence that intermittently (and only intermittently) depriving organisms of food has been shown to engender beneficial effects on many functions—Valter Longo, for instance, noted that prisoners in concentration camps got less sick in the first phase of food restriction, then broke down later. He tried the result experimentally and found out that mice, in the initial phases of starvation, can withstand high doses of chemotherapy without visible side effects. Scientists use the narrative that starvation causes the expression of a gene coding a protein called SIRT, SIRT1, or sirtuin, which brings longevity and other effects. The antifragility of humans manifests itself in the response with up-regulation of some genes in response to hunger.

So once again, religions with ritual fasts have more answers than assumed by those who look at them too literally. In fact what these ritual fasts do is try to bring nonlinearities in consumption to match biological properties. The Appendix shows graphically the standard dose responses in biology: a little bit of anything seems to harbor positive convexity effects (whether beneficial or harmful); add to it and the effect weakens. Clearly at the upper end, the dose has

no additional effect since one reaches saturation.

Walk-Deprived

Another source of harm from naive rationalism. Just as for a long time people tried to shorten their sleep, as it seemed useless to our earthling logic, many people think that walking is useless, so they use mechanical transportation (car, bicycle, etc.) and get their exercise working out at the gym. And when they walk, they do this ignominious "power walk," sometimes with weights on their arms. They do not realize that for reasons still opaque to them, walking effortlessly, at a pace below the stress level, can have some benefits—or, as I speculate, is necessary for humans, perhaps as necessary as sleep, which at some point modernity could not rationalize and tried to reduce. Now it may or may not be true that walking effortlessly is as necessary as sleep, but since all my ancestors until the advent of the automobile spent much of their time walking around (and sleeping), I try to just follow the logic, even before some medical journal catches up to the idea and produces what referees of medical journals call "evidence."

I Want to Live Forever

All I hear is how to live longer, richer, and, of course, more laden with electronic gadgets. We are not the first generation to believe that the worst possible thing to befall us is death. But for the ancients, the worst possible outcome was not death, but a dishonorable death, or even just a regular one. For a classical hero, dying in a retirement home with a rude nurse and a network of tubes coming into and out of your nose would not be the attractive *telos* for a life.

And, of course, we have this modern illusion that we should live as long as we can. As if we were each the end product. This idea of the "me" as a unit can be traced to the Enlightenment. And, with it, fragility.

Before that, we were part of the present collective and future progeny. Both present and the future tribes exploited the fragility of individuals to strengthen themselves. People engaged in sacrifices, sought martyrdom, died for the group, and derived pride from doing so; they worked hard for future generations.

Sadly, as I am writing these lines, the economic system is loading future generations with public governmental debt, causing depletion of resources, and environmental blight to satisfy the requirements of the security analysts and the banking establishment (once again, we cannot separate fragility from ethics).

As I wrote in Chapter 4, while the gene is antifragile, since it is information, the carrier of the gene is fragile, and needs to be so for the gene to get stronger. We live to produce information, or improve on it. Nietzsche had the Latin pun *aut liberi*, *aut libri*—either children or books, both information that carries through the centuries.

I was just reading in John Gray's wonderful *The Immortalization Commission* about attempts to use science, in a postreligious world, to achieve immortality. I felt some deep disgust—as would any ancient—at the efforts of the "singularity" thinkers (such as Ray Kurzweil) who believe in humans' potential to live forever. Note that if I had to find the anti-me, the person with diametrically opposite ideas and lifestyle on the planet, it would be that Ray Kurzweil fellow. It is not just neomania. While I propose removing offensive elements from people's diets (and lives), he works by adding, popping close to two hundred pills daily. Beyond that, these attempts at immortality leave me with deep moral revulsion.

It is the same kind of deep internal disgust that takes hold of me when I see a rich eighty-two-year-old man surrounded with "babes," twentysomething mistresses (often Russian or Ukrainian). I am not here to live forever, as a sick animal. Recall that the antifragility of a system comes from the mortality of its components—and I am part of that larger population called humans. I am here to die a heroic death for the sake of the collective, to produce offspring (and prepare them for life and provide for them), or eventually, books—my information, that is, my genes, the antifragile in me, should be the ones seeking immortality, not me.

Then say goodbye, have a nice funeral in St. Sergius (Mar Sarkis) in Amioun, and, as the French say, *place aux autres*—make room for others.

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[1] While there are some controversies concerning conditional life expectancy, the numbers are quite revealing. For instance, on one extreme, Richard Lewontin estimates, "in the last 50 years, only four months have been added to the expected life span of a person who is already 60 years old." Data from the Centers for Disease Control and Prevention (CDC) show a few more years (but we are still unsure how much of it came from medicine as compared to improvements in life conditions and social mores). Still, the CDC shows that life expectancy at age 20 only increased from 42.79 (additional years) in 1900–1902 to 51.2 in 1949–1951 and to 58.2 in 2002.

[2] A technical comment: in the so-called Bayesian (or conditional probability) analysis, it would be equivalent to looking at *A* conditional on *B* rather than *B* conditional on *A*.

[3] One example of lack of empirical wisdom in the use of "evidence": in a *New York Times Magazine* article, a doctor who claimed that he stopped eating sugar because of its potential harm was apologetic for doing so "without full evidence." The best test of empirical wisdom in someone is in where he puts the

burden of evidence.

[4] I am trying to avoid discussing the placebo effect; I am in the business of nonlinearities and it does not relate to the nonlinearities argument.

[5] Some people claim that we need more fat than carbohydrates; others offer the opposite (they all tend to agree on protein, though few realize we need to randomize protein intake). Both sides still advocate nonrandomness in the mixing and ignore the nonlinearities from sequence and composition.

[6] The principal disease of abundance can be seen in habituation and jadedness (what biologists currently call dulling of receptors); Seneca: “To a sick person, honey tastes better.”

BOOK VII

The Ethics of Fragility and Antifragility

Now, ethics. Under opacity and in the newfound complexity of the world, people can hide risks and hurt others, with the law incapable of catching them. Iatrogenics has both delayed and invisible consequences. It is hard to see causal links, to fully understand what's going on.

Under such epistemic limitations, skin in the game is the only true mitigator of fragility. Hammurabi's code provided a simple solution—close to thirty-seven hundred years ago. This solution has been increasingly abandoned in modern times, as we have developed a fondness for neomanic complication over archaic simplicity. We need to understand the everlasting solidity of such a solution.

CHAPTER 23

Skin in the Game: Antifragility and Optionality at the Expense of Others

Making talk less cheap—Looking at the spoils—Corporations with random acts of pity?—Predict and inverse predict

This chapter will look at what we are getting ourselves into when someone gets the upside, and a different person gets the downside.

The worst problem of modernity lies in the malignant transfer of fragility and antifragility from one party to the other, with one getting the benefits, the other one (unwittingly) getting the harm, with such transfer facilitated by the growing wedge between the ethical and the legal. This state of affairs has existed before, but is acute today—modernity hides it especially well.

It is, of course, an agency problem.

And the agency problem, is of course, an asymmetry.

We are witnessing a fundamental change. Consider older societies—those societies that have survived. The main difference between us and them is the disappearance of a sense of heroism; a shift away from a certain respect—and power—to those who take downside risks for others. For heroism is the exact inverse of the agency problem: someone elects to bear the disadvantage (risks his own life, or harm to himself, or, in milder forms, accepts to deprive himself of some benefits) for the sake of others. What we have currently is the opposite: power seems to go to those, like bankers, corporate executives (nonentrepreneurs), and politicians, who steal a free option from society.

And heroism is not just about riots and wars. An example of an inverse agency problem: as a child I was most impressed with the story of a nanny who died in order to save a child from being hit by a car. I find nothing more

honorable than accepting death in someone else's place.

In other words, what is called sacrifice. And the word "sacrifice" is related to *sacred*, the domain of the holy that is separate from that of the profane.

In traditional societies, a person is only as respectable and as worthy as the downside he (or, more, a lot more, than expected, *she*) is willing to face for the sake of others. The most courageous, or valorous, occupy the highest rank in their society: knights, generals, commanders. Even mafia dons accept that such rank in the hierarchy makes them the most exposed to be whacked by competitors and the most penalized by the authorities. The same applies to saints, those who abdicate, devote their lives to serve others—to help the weak, the deprived, and the dispossessed.

So Table 7 presents another Triad: there are those with no skin in the game but who benefit from others, those who neither benefit from nor harm others, and, finally, the grand category of those sacrificial ones who take the harm for the sake of others.

Click here for a larger image of this table.

TABLE 7 • ETHICS AND THE FOUNDATIONAL ASYMMETRY

NO SKIN IN THE GAME	*SKIN IN THE GAME*	*SKIN IN THE GAME FOR THE SAKE OF OTHERS, OR SOUL IN THE GAME*
(Keeps upside, transfers downside to others, owns a hidden option at someone else's expense)	*(Keeps his own downside, takes his own risk)*	*(Takes the downside on behalf of others, or universal values)*
Bureaucrats	Citizens	Saints, knights, warriors, soldiers
Cheap talk ("tawk" in Fat Tony's lingo)	Actions, no tawk	Expensive talk
Consultants, sophists	Merchants, businessmen	Prophets, philosophers (in the pre-modern sense)
Businesses	Artisans	Artists, some artisans
Corporate executives (with suit)	Entrepreneurs	Entrepreneurs/Innovators

Theoreticians, data miners, observational studies	Laboratory and field experimenters	Maverick scientists
Centralized government	Government of city-states	Municipal government
Editors	Writers	Great writers
Journalists who "analyze" and predict	Speculators	Journalists who take risks and *expose* frauds (powerful regimes, corporations)
Politicians	Activists	Rebels, dissidents, revolutionaries
Bankers	Traders	(They would not engage in vulgar commerce)
Fragilista Prof. Dr. Joseph Stiglitz	Fat Tony	Nero Tulip
Risk vendors		Taxpayers (not quite voluntarily soul in the game, but they are victims)

Let me follow my emotions and start with the third column, on the far right, the one about heroes and people of courage. The robustness—even antifragility—of society depends on them; if we are here today, it is because someone, at some stage, took some risks for us. But courage and heroism do not mean blind risk taking—it is not necessarily recklessness. There is a pseudocourage that comes from risk blindness, in which people underestimate the odds of failure. We have ample evidence that the very same people become chicken and overreact in the face of real risks; the exact opposite. For the Stoics, prudence is connatural to courage—the courage to fight your own impulses (in an aphorism by—who else—Publilius Syrus, prudence was deemed the courage of the general).

Heroism has evolved through civilization from the martial arena to that of ideas. Initially, in preclassical times, the Homeric hero was someone principally endowed with physical courage—since everything was physical. In later classical times, for such people as the great Lacedaemonian king Agiselaus, a truly happy life was one crowned by the privilege of death in battle, little else, perhaps even nothing else. But for Agiselaus, courage had already evolved from purely martial prowess into something greater. Courage was often seen in acts of

renunciation, as when one is ready to sacrifice himself for the benefit of others, of the collective, something altruistic.

Finally, a new form of courage was born, that of the Socratic Plato, which is the very definition of the modern man: the courage to stand up for an idea, and enjoy death in a state of thrill, simply because the privilege of dying for truth, or standing up for one's values, had become the highest form of honor. And no one has had more prestige in history than two thinkers who overtly and defiantly sacrificed their lives for their ideas—two Eastern Mediterraneans; one Greek and one Semite.

We should pause a little when we hear *happiness* defined as an economic or otherwise puny materialistic condition. You can imagine how distraught I feel when I hear about the glorified heroism-free "middle class values," which, thanks to globalization and the Internet, have spread to any place easily reached by British Air, enshrining the usual opiates of the deified classes: "hard work" for a bank or a tobacco company, diligent newspaper reading, obedience to most, but not all, traffic laws, captivity in some corporate structure, dependence on the opinion of a boss (with one's job records filed in the personnel department), good legal compliance, reliance on stock market investments, tropical vacations, and a suburban life (under some mortgage) with a nice-looking dog and Saturday night wine tasting. Those who meet with some success enter the gallery of the annual billionaire list, where they will hope to spend some time before their fertilizer sales are challenged by competitors from China. They will be called heroes—rather than lucky. Further, if success is random, a conscious act of heroism is nonrandom. And the "ethical" middle class may work for a tobacco company—and thanks to casuistry call themselves ethical.

I am even more distraught for the future of the human race when I see a nerd behind a computer in a D.C. suburb, walking distance from a Starbucks coffeehouse, or a shopping mall, capable of blowing up an entire battalion in a remote place, say Pakistan, and afterward going to the gym for a "workout" (compare his culture to that of knights or samurai). Cowardice enhanced by technology is all connected: society is fragilized by spineless politicians, draft dodgers afraid of polls, and journalists building narratives, who create explosive deficits and compound agency problems because they want to look good in the short term.

A disclaimer. Table 7 does not imply that those with soul in the game are necessarily right or that dying for one's ideas makes one necessarily good for the rest of us: many messianic utopians have caused quite a bit of harm. Nor is a

grandiose death a necessity: many people fight evil in the patient grind of their daily lives without looking like heroes; they suffer society's ingratitude even more—while media-friendly pseudoheroes rise in status. These people will not get a statue from future generations.

A half-man (or, rather, half-person) is not someone who does not have an opinion, just someone who does not take risks for it.

The great historian Paul Veyne has recently shown that it is a big myth that gladiators were forced labor. Most were volunteers who wanted the chance to become heroes by risking their lives and winning, or, when failing, to show in front of the largest crowd in the world how they were able to die honorably, without cowering—when a gladiator loses the fight the crowd decides whether he should be spared or put to death by the opponent. And spectators did not care for nonvolunteers, as these did not have their soul in the fight.

My greatest lesson in courage came from my father—as a child, I had admired him before for his erudition, but was not overly fazed since erudition on its own does not make a man. He had a large ego and immense dignity, and he demanded respect. He was once insulted by a militiaman at a road check during the Lebanese war. He refused to comply, and got angry at the militiaman for being disrespectful. As he drove away, the gunman shot him in the back. The bullet stayed in his chest for the rest of his life so he had to carry an X-ray image through airport terminals. This set the bar very high for me: dignity is worth nothing unless you earn it, unless you are willing to pay a price for it.

A lesson I learned from this ancient culture is the notion of *megalopsychon* (a term expressed in Aristotle's ethics), a sense of grandeur that was superseded by the Christian value of "humility." There is no word for it in Romance languages; in Arabic it is called *Shhm*—best translated as *nonsmall*. If you take risks and face your fate with dignity, there is nothing you can do that makes you small; if you don't take risks, there is nothing you can do that makes you grand, nothing. And when you take risks, insults by half-men (small men, those who don't risk anything) are similar to barks by nonhuman animals: you can't feel insulted by a dog.

HAMMURABI

Let us now work with the elements of Table 7 and bring the unifying foundational asymmetry (between upside and downside) into our central theme, ethics. Just as only business school professors and similar fragilistas separate robustness and growth, we cannot separate fragility and ethics.

Some people have options, or have optionality, at the expense of others. And the others don't know it.

The effects of transfers of fragility are becoming more acute, as modernity is building up more and more people on the left column—inverse heroes, so to say. So many professions, most arising from modernity, are affected, becoming more antifragile at the expense of our fragility—tenured government employees, academic researchers, journalists (of the non-myth-busting variety), the medical establishment, Big Pharma, and many more. Now how do we solve the problem? As usual, with some great help from the ancients.

Hammurabi's code—now about 3,800 years old—identifies the need to reestablish a symmetry of fragility, spelled out as follows:

> If a builder builds a house and the house collapses and causes the death of the owner of the house—the builder shall be put to death. If it causes the death of the son of the owner of the house, a son of that builder shall be put to death. If it causes the death of a slave of the owner of the house—he shall give to the owner of the house a slave of equal value.

It looks like they were much more advanced 3,800 years ago than we are today. The entire idea is that the builder knows more, a lot more, than any safety inspector, particularly about what lies hidden in the foundations—making it the best risk management rule ever, as the foundation, with delayed collapse, is the best place to hide risk. Hammurabi and his advisors understood small probabilities.

Now, clearly the object here is not to punish retrospectively, but to save lives by providing up-front disincentive in case of harm to others during the fulfillment of one's profession.

These asymmetries are particularly severe when it comes to small-probability extreme events, that is, Black Swans—as these are the most misunderstood and their exposure is easiest to hide.

Fat Tony has two heuristics.

First, *never get on a plane if the pilot is not on board.*

Second, *make sure there is also a copilot.*

The first heuristic addresses the asymmetry in rewards and punishment, or transfer of fragility between individuals. Ralph Nader has a simple rule: people voting for war need to have at least one descendant (child or grandchild) exposed to combat. For the Romans, engineers needed to spend some time under the bridge they built—something that should be required of financial engineers today. The English went further and had the families of the engineers spend time with them under the bridge after it was built.

To me, every opinion maker needs to have "skin in the game" in the event of harm caused by reliance on his information or opinion (not having such persons as, say, the people who helped cause the criminal Iraq invasion come out of it completely unscathed). Further, anyone producing a forecast or making an economic analysis needs to have something to lose from it, given that others rely on those forecasts (to repeat, forecasts induce risk taking; they are more toxic to us than any other form of human pollution).

We can derive plenty of sub-heuristics from Fat Tony's rules, particularly to mitigate the weaknesses of predictive systems. Predicting—any prediction—without skin in the game can be as dangerous for others as unmanned nuclear plants without the engineer sleeping on the premises. Pilots should be on the plane.

The second heuristic is that we need to build redundancy, a margin of safety, avoiding optimization, mitigating (even removing) asymmetries in our sensitivity to risk.

The rest of this chapter will present a few syndromes, with, of course, some ancient remedies.

THE TALKER'S FREE OPTION

We closed Book I by arguing that we need to put entrepreneurs and risk takers, "failed" or not, on top of the pyramid, and, unless they take personal risks when they expose others, academizing academics, talkers, and political politicians at the bottom. The problem is that society is currently doing the exact opposite, granting mere talkers a free option.

The idea that Fat Tony milked suckers when they ran to the exit door seemed at first quite inelegant to Nero. Benefiting from the misfortune of others—no matter how hideous these are and can be—is not the most graceful approach to life. But Tony had something at risk, and would have been personally harmed by an adverse outcome. Fat Tony had no agency problem. This makes it permissible. For there is an even worse problem associated with the opposite situation: people who just *talk*, prognosticate, theorize.

In fact, speculative risk taking is not just permissible; it is mandatory. No opinion without risk; and, of course, no risk without hope for return. If Fat Tony had an opinion, he felt he needed, for ethical reasons, to have a corresponding exposure. As they say in Bensonhurst, you got to do so if you have an opinion. Otherwise, you do not really have an opinion at all. You need to be earmarked as someone who has no downside for his opinion, with a special status in society, perhaps something below that of ordinary citizen. Commentators need to have a status *below* ordinary citizens. Regular citizens, at least, face the downside of their statements.

So counter to the entire idea of the intellectual and commentator as a detached and protected member of society, I am stating here that I find it profoundly unethical to talk without doing, without exposure to harm, without having one's skin in the game, without having something at risk. You express your opinion; it can hurt others (who rely on it), yet you incur no liability. Is this fair?

But this is the information age. This effect of transferring fragility might have been present throughout history, but it is much more acute now, under modernity's connectivity, and the newfound invisibility of causal chains. The intellectual today is vastly more powerful and dangerous than before. The "knowledge world" causes separation of knowing and doing (within the same person) and leads to the fragility of society. How?

In the old days, privilege came with obligations—except for the small class of

intellectuals who served a patron or, in some cases, the state. You want to be a feudal lord—you will be first to die. You want war? First in battle. Let us not forget something embedded in the U.S. Constitution: the president is commander in chief. Caesar, Alexander, and Hannibal were on the battlefield—the last, according to Livy, was first-in, last-out of combat zones. George Washington, too, went to battle, unlike Ronald Reagan and George W. Bush, who played video games while threatening the lives of others. Even Napoleon was personally exposed to risks; his showing up during a battle was the equivalent of adding twenty-five thousand troops. Churchill showed an impressive amount of physical courage. They were in it; they believed in it. Status implied you took physical risks.

Note that in traditional societies even those who fail—but have taken risks—have a higher status than those who are not exposed.

Now, again, the idiocy of predictive systems, making me emotional. We may have more social justice today than before the Enlightenment, but we also have more, a lot more transfers of optionality, more than ever—a patent setback. Let me explain. This knowledge shknowledge business necessarily means shifting to talk. Talk by academics, consultants, and journalists, when it comes to predictions, can be just *talk*, devoid of embodiment and stripped of true evidence. As in anything with words, it is not the victory of the most correct, but that of the most charming—or the one who can produce the most academic-sounding material.

We mentioned earlier how the political philosopher Raymond Aron sounded uninteresting in spite of his predictive abilities, while those who were wrong about Stalinism survived beautifully. Aron was about as colorless as they come: in spite of his prophetic insights he looked, wrote, and lived like a tax accountant while his enemy, say, Jean-Paul Sartre, who led a flamboyant lifestyle, got just about everything wrong and even put up with the occupying Germans in an extremely cowardly manner. Sartre the coward looked radiant, impressive, and, alas, his books survived (please stop calling him a Voltaire; he was no Voltaire).

I got nauseous in Davos making eye contact with the fragilista journalist Thomas Friedman who, thanks to his influential newspaper op-eds, helped cause the Iraq war. He paid no price for the mistake. The real reason for my malaise was perhaps not just that I saw someone I consider vile and harmful. I just get disturbed when I see wrong and do nothing about it; it is biological. It is guilt, for Baal’s sake, and guilt is what I do not have to put up with. There is another

central element of ancient Mediterranean ethics: *Factum tacendo, crimen facias acrius:* For Publilius Syrus, he who does not stop a crime is an accomplice. (I've stated my own version of this in the prologue, which needs to be reiterated: if you see fraud and don't say fraud, you are a fraud.)

Thomas Friedman was a bit responsible for the Iraq invasion of 2003, and not only paid no penalty for it but continues to write for the op-ed page of *The New York Times*, confusing innocent people. He got—and kept—the upside, others get the downside. A writer with arguments can harm more people than any serial criminal. I am singling him out here because, at the core, the problem is his promotion of the misunderstanding of iatrogenics in complex systems. He promoted the "earth is flat" idea of globalization without realizing that globalization brings fragilities, causes more extreme events as a side effect, and requires a great deal of redundancies to operate properly. And the very same error holds with the Iraq invasion: in such a complex system, the predictability of the consequences is very low, so invading was epistemologically irresponsible.

Natural and ancestral systems work by penalties: no perpetual free option given to anyone. So does society in many things with visible effects. If someone drives a school bus blindfolded, and has an accident, he either exits the gene pool the old-fashioned way, or, if for some reason he is not harmed by the accident, he will incur enough penalties to be prevented from driving other people ever again. The problem is that the journalist Thomas Friedman is still driving the bus. There is no penalty for opinion makers who harm society. And this is a very bad practice. The Obama administration was after the crisis of 2008 populated with people who drove the bus blindfolded. The iatrogenists got promoted.

Postdicting

Words are dangerous: postdictors, who explain things after the fact—because they are in the business of talking—always look smarter than predictors.

Because of the retrospective distortion, people who of course did not see an event coming will remember some thought to the effect that they did, and will manage to convince themselves that they predicted it, before proceeding to convince others. There will be after every event many more postdictors than true predictors, people who had an idea in the shower without taking it to its logical conclusion, and, given that many people take a lot of showers, say, nearly twice

a day (if you include the gym or the episode with the mistress), they will have a large repertoire to draw from. They will not remember the numerous bath-generated ideas they had in the past that were either noise, or that contradicted the observed present—but as humans crave self-consistency, they will retain those elements of what they thought in the past that cohere with their perception of the present.

So opinion makers who were so proudly and professionally providing idle babble will eventually appear to win an argument, since they are the ones writing, and suckers who got in trouble from reading them will again look to them for future guidance, and will again get in trouble.

The past is fluid, marred with selection biases and constantly revised memories. It is a central property of suckers that they will never know they were the suckers because that's how our minds work. (Even so, one is struck with the following fact: the fragilista crisis that started in 2007–2008 had many, many fewer *near-predictors* than random.)

> *The asymmetry (antifragility of postdictors): postdictors can cherry-pick and produce instances in which their opinions played out and discard mispredictions into the bowels of history. It is like a free option—to them; we pay for it.*

Since they have the option, the fragilistas are personally antifragile: volatility tends to benefit them: the more volatility, the higher the illusion of intelligence.

But evidence of whether one has been a sucker or a nonsucker is easy to ferret out by looking at actual records, actions. Actions are symmetric, do not allow cherry-picking, remove the free option. When you look at the actual history of someone's activities, instead of what thoughts he will deliver after the facts, things become crystal clear. The option is gone. Reality removes the uncertainty, the imprecision, the vagueness, the self-serving mental biases that make us appear more intelligent. Mistakes are costly, no longer free, but being right brings actual rewards. Of course, there are other checks one can do to assess the b***t component of life: investigate people's decisions as expressed through their own investments. You would discover that many people who claim to have foreseen the collapse of the financial system had financial companies in their portfolios. Indeed, there was no need to "profit" from events like Tony and Nero to show nonsuckerness: just avoiding being hurt by them would have been sufficient.

I want predictors to have visible scars on their body from prediction errors, not distribute these errors to society.

You cannot sit and moan about the world. You need to come out on top. So Tony was right to insist that Nero take a ritual look at the physical embodiment of the spoils, like a bank account statement—as we said, it had nothing to do with financial value, nor purchasing power, just symbolic value. We saw in Chapter 9 how Julius Caesar needed to incur the cost of having Vercingetorix brought to Rome and paraded. An intangible victory has no value.

Verba volent, words fly. Never have people who talk and don't do been more visible, and played a larger role, than in modern times. This is the product of modernism and division of tasks.

Recall that I said that America's strength was risk taking and harboring risk takers (the right kind, the Thalesian king of high-failure, long-optionality type). Sorry, but we have been moving away from this model.

The Stiglitz Syndrome

There is something more severe than the problem with Thomas Friedman, which can be generalized to represent someone causing action while being completely unaccountable for his words.

The phenomenon I will call the Stiglitz syndrome, after an academic economist of the so-called "intelligent" variety called Joseph Stiglitz, is as follows.

Remember the fragility detection in Chapter 19 and my obsession with Fannie Mae. Luckily, I had some skin in the game for my opinions, be it through exposure to a smear campaign. And, in 2008, no surprise, Fannie Mae went bust, I repeat, costing the U.S. taxpayer hundreds of billions (and counting)—generally, the financial system, with similar risks, exploded. The entire banking system had similar exposures.

But around the same period, Joseph Stiglitz, with two colleagues, the Orszag brothers (Peter and Jonathan), looked at the very same Fannie Mae. They assessed, in a report, that "on the basis of historical experience, the risk to the government from a potential default on GSE debt is effectively zero."[1] Supposedly, they ran simulations—but didn't see the obvious. They also said that the probability of a default was found to be "so small that it is difficult to detect." It is statements like these and, to me, only statements like these (intellectual hubris and the illusion of understanding of rare events) that caused

the buildup of these exposures to rare events in the economy. This is the Black Swan problem that I was fighting. This is Fukushima.

Now the culmination is that Stiglitz writes in 2010 in his *I-told-you-so* book that he claims to have "predicted" the crisis that started in 2007–2008.

Look at this aberrant case of antifragility provided to Stiglitz and his colleagues by society. It turns out that Stiglitz was not just a nonpredictor (by my standards) but was also part of the problem that caused the events, these accumulations of exposures to small probabilities. But he did not notice it! An academic is not designed to remember his opinions because he doesn't have anything at risk from them.

At the core, people are dangerous when they have that strange skill that allows their papers to be published in journals but decreases their understanding of risk. So the very same economist who caused the problem then postdicted the crisis, and then became a theorist on what happened. No wonder we will have larger crises.

The central point: had Stiglitz been a businessman with his own money on the line, he would have blown up, terminated. Or had he been in nature, his genes would have been made extinct—so people with such misunderstanding of probability would eventually disappear from our DNA. What I found nauseating was the government hiring one of his coauthors.[2]

I am reluctantly calling the syndrome by Stiglitz's name because I find him the smartest of economists, one with the most developed intellect for things *on paper*—except that he has no clue about the fragility of systems. And Stiglitz symbolizes harmful misunderstanding of small probabilities by the economics establishment. It is a severe disease, one that explains why economists will blow us up again.

The Stiglitz syndrome corresponds to a form of cherry-picking, the nastiest variety because the perpetrator is not aware of what he is doing. It is a situation in which someone doesn't just fail to detect a hazard but contributes to its cause while ending up convincing himself—and sometimes others—of the opposite, namely, that he predicted it and warned against it. It corresponds to a combination of remarkable analytical skills, blindness to fragility, selective memory, and absence of skin in the game.

Stiglitz Syndrome = fragilista (with good intentions) + ex post cherry-picking

There are other lessons here, related to the absence of penalty. This is an

illustration of the academics-who-write-papers-and-talk syndrome in its greatest severity (unless, as we will see, they have their soul in it). So many academics propose something in one paper, then the opposite in another paper, without penalty to themselves from having been wrong in the first paper since there is a need only for consistency *within* a single paper, not *across* one's career. This would be fine, as someone may evolve and contradict earlier beliefs, but then the earlier "result" should be withdrawn from circulation and superseded with a new one—with books, the new edition supersedes the preceding one. This absence of penalty makes them antifragile at the expense of the society that accepts the "rigor" of their results. Further, I am not doubting Stiglitz's sincerity, or some weak form of sincerity: I believe he genuinely thinks he predicted the financial crisis, so let me rephrase the problem: the problem with people who do not incur harm is that they can cherry-pick from statements they've made in the past, many of them contradictory, and end up convincing themselves of their intellectual lucidity on the way to the World Economic Forum at Davos.

There is the iatrogenics of the medical charlatan and snake oil salesperson causing harm, but he sort of knows it and lies low after he is caught. And there is a far more vicious form of iatrogenics by experts who use their more acceptable status to claim later that they warned of harm. As these did not know they were causing iatrogenics, they cure iatrogenics with iatrogenics. Then things explode.

Finally, the cure to many ethical problems maps to the exact cure for the Stiglitz effect, which I state now.

> *Never ask anyone for their opinion, forecast, or recommendation. Just ask them what they have—or don't have—in their portfolio.*

We now know that many innocent retirees have been harmed by the incompetence of the rating agencies—it was a bit more than incompetence. Many subprime loans were toxic waste dressed as "AAA," meaning near-government grade in safety. People were innocently led into putting their savings into them—and, further, regulators were forcing portfolio managers to use the assessment of the rating agencies. But rating agencies are protected: they present themselves as press—without the noble mission of the press to expose frauds. And they benefit from the protection of free speech—the "First Amendment" so ingrained in American habits. My humble proposal: one should say whatever he wants, but one's portfolio needs to line up with it. And, of course, regulators should not be fragilistas by giving their stamp to predictive approaches—hence

junk science.

The psychologist Gerd Gigerenzer has a simple heuristic. Never ask the doctor what *you* should do. Ask him what *he* would do if he were in your place. You would be surprised at the difference.

The Problem of Frequency, or How to Lose Arguments

Recall that Fat Tony was in favor of just "making a buck" as opposed to being "proven right." The point has a statistical dimension. Let us return to the distinction between Thalesian and Aristotelian for a minute and look at evolution from the following point of view. The frequency, i.e., how *often* someone is right is largely irrelevant in the real world, but alas, one needs to be a practitioner, not a talker, to figure it out. On paper, the frequency of being right matters, but only on paper—typically, fragile payoffs have little (sometimes no) upside, and antifragile payoffs have little downside. This means that one makes pennies to lose dollars in the fragile case; makes dollars to lose pennies in the antifragile one. So the antifragile can lose for a long time with impunity, so long as he happens to be right once; for the fragile, a single loss can be terminal.

Accordingly if you were betting on the downfall of, say, a portfolio of financial institutions because of their fragilities, it would have cost you pennies over the years preceding their eventual demise in 2008, as Nero and Tony did. (Note again that taking the other side of fragility makes you antifragile.) You were wrong for years, right for a moment, losing small, winning big, so vastly more successful than the other way (actually the other way would be bust). So you would have made the Thekels like Thales because betting against the fragile is antifragile. But someone who had merely "predicted" the event with just words would have been called by the journalists "wrong for years," "wrong most of the time," *etc.*

Should we keep tally of opinion makers' "right" and "wrong," the proportion does not matter, as we need to include consequences. And given that this is impossible, we are now in a quandary.

Look at it again, the way we looked at entrepreneurs. They are usually wrong and make "mistakes"—plenty of mistakes. They are convex. So what counts is the payoff from success.

Let me rephrase again. Decision making in the real world, that is, deeds, are Thalesian, while forecasting *in words* is Aristotelian. As we saw in the discussion in Chapter 12, one side of a decision has larger consequences than the

other—we don't have evidence that people are terrorists but we check them for weapons; we don't believe the water is poisonous but we avoid drinking it; something that would be absurd for someone narrowly applying Aristotelian logic. To put in Fat Tony terms: suckers try to be right, nonsuckers try to make the buck, or:

Suckers try to win arguments, nonsuckers try to win.

To put it again in other words: it is rather a good thing to lose arguments.

The Right Decision for the Wrong Reason

More generally, for Mother Nature, opinions and predictions don't count; surviving is what matters.

There is an evolutionary argument here. It appears to be the most underestimated argument in favor of free enterprise and a society driven by individual doers, what Adam Smith called "adventurers," not central planners and bureaucratic apparatuses. We saw that bureaucrats (whether in government or large corporations) live in a system of rewards based on narratives, "tawk," and the opinion of others, with job evaluation and peer reviews—in other words, what we call marketing. Aristotelian, that is. Yet the biological world evolves by survival, not opinions and "I predicted" and "I told you so." Evolution dislikes the confirmation fallacy, endemic in society.

The economic world should, too, but institutions mess things up, as suckers may get bigger—institutions block evolution with bailouts and statism. Note that, in the long term, social and economic evolution nastily takes place by surprises, discontinuities, and jumps.[3]

We mentioned earlier Karl Popper's ideas on evolutionary epistemology; not being a decision maker, he was under the illusion that ideas compete with each other, with the least wrong surviving at any point in time. He missed the point that it is not ideas that survive, but people who have the right ones, or societies that have the correct heuristics, or the ones, right or wrong, that lead them to do the good thing. He missed the Thalesian effect, the fact that a wrong idea that is harmless can survive. Those who have wrong heuristics—but with a small harm in the event of error—will survive. Behavior called "irrational" can be good if it is harmless.

Let me give an example of a type of false belief that is helpful for survival. In your opinion, which is more dangerous, to mistake a bear for a stone, or mistake

a stone for a bear? It is hard for humans to make the first mistake; our intuitions make us overreact at the smallest probability of harm and fall for a certain class of false patterns—those who overreact upon seeing what may look like a bear have had a survival advantage, those who made the opposite mistake left the gene pool.

Our mission is to make talk less cheap.

THE ANCIENTS AND THE STIGLITZ SYNDROME

We saw how the ancients understood the Stiglitz syndrome—and associated ones—rather well. In fact they had quite sophisticated mechanisms to counter most aspects of agency problems, whether individual or collective (the circular effect of hiding behind the collective). Earlier, I mentioned the Romans forcing engineers to spend time under the bridge they built. They would have had Stiglitz and Orszag sleep under the bridge of Fannie Mae and exit the gene pool (so they wouldn't harm us again).

The Romans had even more powerful heuristics for situations few today have thought about, solving potent game-theoretic problems. Roman soldiers were forced to sign a *sacramentum* accepting punishment in the event of failure—a kind of pact between the soldier and the army spelling out commitment for upside and downside.

Assume that you and I are facing a small leopard or a wild animal in the jungle. The two of us can possibly overcome it by joining forces—but each one of us is individually weak. Now, if you run away, all you need to be is just faster than me, not faster than the animal. So it would be optimal for the one who can run away the fastest, that is, the most cowardly, to just be a coward and let the other one perish.

The Romans removed the soldiers' incentive to be a coward and hurt others thanks to a process called *decimation*. If a legion loses a battle and there is suspicion of cowardice, 10 percent of the soldiers and commanders are put to death, usually by random lottery. Decimation—meaning eliminating one in ten—has been corrupted by modern language. The magic number is one in ten (or something equivalent): putting more than 10 per cent to death would lead to weakening of the army; too little, and cowardice would be a dominant strategy.

And the mechanism must have worked well as a deterrent against cowardice, since it was not commonly applied.

The English applied a version of it. Admiral John Byng was court-martialed and sentenced to death as he was found guilty of failing to "do his utmost" to prevent Minorca from falling to the French following the Battle of Minorca in 1757.

Playing on one's inner agency problem can go beyond symmetry: give soldiers no options and see how antifragile they can get.

On April 29, 711, the armies of the Arab commander Tarek crossed the Strait of Gibraltar from Morocco into Spain with a small army (the name Gibraltar is derived from the Arabic *Jabal Tarek*, meaning "mount of Tarek"). Upon landing, Tarek had his ships put to the fire. He then made a famous speech every schoolchild memorized during my school days that I translate loosely: "Behind you is the sea, before you, the enemy. You are vastly outnumbered. All you have is sword and courage."

And Tarek and his small army took control of Spain. The same heuristic seems to have played out throughout history, from Cortés in Mexico, eight hundred years later, to Agathocles of Syracuse, eight hundred years earlier—ironically, Agathocles was heading southward, in the opposite direction as Tarek, as he was fighting the Carthaginians and landed in Africa.

Never put your enemy's back to the wall.

How Poetry Can Kill You

Ask a polyglot who knows Arabic who he considers the best poet—in any language—and odds are that he would answer Almutanabbi, who lived about a thousand years ago; his poetry in the original has a hypnotic effect on the reader (listener), rivaled only by the grip of Pushkin on Russian speakers. The problem is that Almutanabbi knew it; his name was literally "He who thinks of himself as a prophet," on account of his perceived oversized ego. For a taste of his bombast, one of his poems informs us that his poetry is so potent "that blind people can read it" and "deaf people can listen to it." Well, Almutanabbi was that rare case of a poet with skin in the game, dying for his poetry.

For in the same egotistical poem, Almutanabbi boasts, in a breathtaking display of linguistic magic, that he walks the walk, in addition to being the most imaginably potent poet—which I insist he was—he knew "the horse, the night, the desert, the pen, the book"—and thanks to his courage he got respect from the lion.

Well, the poem cost him his life. For Almutanabbi had—characteristically—vilified a desert tribe in one of his poems and they were out to get him. They reached him as he was traveling. As he was outnumbered, he started to do the rational thing and run away, nothing shameful, except that one of his companions started reciting "the horse, the night …" back at him. He turned

around and confronted the tribe to his certain death. Thus Almutanabbi remains, a thousand years later, the poet who died simply to avoid the dishonor of running away, and when we recite his verses we know they are genuine.

My childhood role model was the French adventurer and writer André Malraux. He imbued his writings with his own risk taking: Malraux was a school dropout—while extremely well read—who became an adventurer in Asia in his twenties. He was an active pilot during the Spanish Civil War and later an active member of the French underground resistance during the Second World War. He turned out to be a bit of a mythomaniac, unnecessarily glorifying his meetings with great men and statesmen. He just could not bear the idea of a writer being an intellectual. But unlike Hemingway, who was mostly into image building, he was the real thing. And he never engaged in small talk—his biographer reports that while other writers were discussing copyrights and royalties, he would steer the conversation to theology (he supposedly said *the twenty-first century will be religious or will not be*). One of my saddest days was when he died.

The Problem of Insulation

The system does not give researchers the incentive to be a Malraux. The great skeptic Hume was said to leave his skeptical angst in the philosophical cabinet, then go party with his friends in Edinburgh (though his idea of partying was rather too … Edinburgh). The philosopher Myles Burnyeat called this the "problem of insulation," particularly with skeptics who are skeptics in one domain but not another. He provides the example of a philosopher who puzzles about the reality of time, but who nonetheless applies for a research grant to work on the philosophical problem of time during next year's sabbatical—without doubting the reality of next year's arrival. For Burnyeat, the philosopher "insulates his ordinary first order judgments from the effects of his philosophizing." Sorry, Professor Doctor Burnyeat; I agree that philosophy is the only field (and its sibling, pure mathematics) that does not need to connect to reality. But then make it a parlor game and give it another name …

Likewise, Gerd Gigerenzer reports a more serious violation on the part of Harry Markowitz, who started a method called "portfolio selection" and received the same iatrogenic Swedish Riskbank prize (called "Nobel" in economics) for it, like other fragilistas such as Fragilista Merton and Fragilista Stiglitz. I spent part of my adult life calling it charlatanism, as it has no validity outside of academic endorsements and causes blowups (as explained in the Appendix).

Well, Doctor Professor Fragilista Markowitz does not use his method for his own portfolio; he has recourse to more sophisticated (and simpler to implement) cabdrivers' methodologies, closer to the one Mandelbrot and I have proposed.

I believe that forcing researchers to eat their own cooking whenever possible solves a serious problem in science. Take this simple heuristic—does the scientific researcher whose ideas are applicable to the real world apply his ideas to his daily life? If so, take him seriously. Otherwise, ignore him. (If the fellow is doing pure mathematics or theology, or teaching poetry, then there is no problem. But if he is doing something applicable, then: red flag.)

This brings us to Triffat-type fakeness compared to Seneca, the talker versus the doer. I applied this method of ignoring what an academic writes and focusing on what he does when I met a researcher on happiness who held that *anything one makes beyond $50,000 does not bring any additional happiness*—he was then earning more than twice that at a university, so according to his metric he was safe. The argument seen through his "experiments" published in "highly cited papers" (that is, by other academics) seemed convincing on paper—although I am not particularly crazy about the notion of "happiness" or the vulgarity of the modern interpretation of "seeking happiness." So, like an idiot, I believed him. But a year or so later, I heard that he was particularly avid for dollars and spent his time on the road speaking for fees. That, to me, was more sufficient evidence than thousands of citations.

Champagne Socialism

Another blatant case of insulation. Sometimes the divorce between one's "tawk" and one's life can be overtly and convincingly visible: take people who want others to live a certain way but don't really like it for themselves.

Never listen to a leftist who does not give away his fortune or does not live the exact lifestyle he wants others to follow. What the French call "the caviar left," *la gauche caviar*, or what Anglo-Saxons call champagne socialists, are people who advocate socialism, sometimes even communism, or some political system with sumptuary limitations, while overtly leading a lavish lifestyle, often financed by inheritance—not realizing the contradiction that they want others to avoid just such a lifestyle. It is not too different from the womanizing popes, such as John XII, or the Borgias. The contradiction can exceed the ludicrous as with French president François Mitterrand of France who, coming in on a socialist platform, emulated the pomp of French monarchs. Even more ironic, his

traditional archenemy, the conservative General de Gaulle, led a life of old-style austerity and had his wife sew his socks.

I have witnessed even worse. A former client of mine, a rich fellow with what appeared to be a social mission, tried to pressure me to write a check to a candidate in an election on a platform of higher taxes. I resisted, on ethical grounds. But I thought that the fellow was heroic, for, should the candidate win, his own taxes would increase by a considerable amount. A year later I discovered that the client was being investigated for his involvement in a very large scheme to be shielded from taxes. He wanted to be sure that *others* paid more taxes.

I developed a friendship over the past few years with the activist Ralph Nader and saw contrasting attributes. Aside from an astonishing amount of personal courage and total indifference toward smear campaigns, he exhibits absolutely no divorce between what he preaches and his lifestyle, none. Just like saints who have soul in their game. The man is a secular saint.

Soul in the Game

There is a class of people who escape bureaucrato-journalistic "tawk": those who have more than their skin in the game. *They have their soul in the game.*

Consider prophets. Prophecy is a pledge of belief, little else. A prophet is not someone who first had an idea; he is the one to first believe in it—and take it to its conclusion.

Chapter 20 discussed prophecy, when done right, as subtraction, and detection of fragility. But if having skin in the game (and accepting downside) is what distinguishes the genuine thinker from ex post "tawk," there is one step beyond needed to reach the rank of prophet. It is a matter of commitment, or what philosophers call *doxastic commitment*, a type of belief-pledge that to Fat Tony and Nero needed to be translated into deeds (the reverse-Stiglitz). *Doxa* in Greek used to mean "belief," but distinguished from "knowledge" (episteme); to see how it involves a commitment of sorts beyond just words, consider that in church Greek it took the meaning of *glorification.*

Incidentally, this notion also applies to all manner of ideas and theories: the main person behind a theory, the person to be called the originator, is someone who believed in it, in a doxastic way, with a costly commitment to take it to its natural conclusion; and not necessarily the first person to mention it over dessert wine or in a footnote.

Only he who has true beliefs will avoid eventually contradicting himself and falling into the errors of postdicting.

OPTIONS, ANTIFRAGILITY, AND SOCIAL FAIRNESS

The stock market: the greatest, industrial-sized, transfer of antifragility in history —due to a vicious form of asymmetric skin in the game. I am not talking about investment here—but the current system of packaging investments into shares of "public" corporations, with managers allowed to game the system, and of course, getting more prestige than the real risk takers, the entrepreneurs.

A blatant manifestation of the agency problem is the following. There is a difference between a manager running a company that is not his own and an owner-operated business in which the manager does not need to report numbers to anyone but himself, and for which he has a downside. Corporate managers have incentives without disincentives—something the general public doesn't quite get, as they have the illusion that managers are properly "incentivized." Somehow these managers have been given free options by innocent savers and investors. I am concerned here with managers of businesses that are *not* owner-operated.

As I am writing these lines the United States stock market has cost retirees more than three trillion dollars in losses over the past dozen years compared to leaving money in government money market funds (I am being generous, the difference is even higher), while managers of the companies composing the stock market, thanks to the asymmetry of the stock option, are richer by close to four hundred billion dollars. They pulled a Thales on these poor savers. Even more outrageous is the fate of the banking industry: banks have lost more than they ever made in their history, with their managers being paid billions in compensation—taxpayers take the downside, bankers get the upside. And the policies aiming at correcting the problem are hurting innocent people while bankers are sipping the Rosé de Provence brand of summer wine on their yachts in St. Tropez.

The asymmetry is visibly present: volatility benefits managers since they only get one side of the payoffs. The main point (alas, missed by almost everyone) is that they stand to gain from volatility—the more variations, the more value to this asymmetry. Hence they are antifragile.

To see how transfer of antifragility works, consider two scenarios, in which the market does the same thing on average but following different paths.

Path 1: market goes up 50 percent, then goes back down to erase all gains.

Path 2: market does not move at all.

Visibly Path 1, the more volatile, is more profitable to the managers, who can cash in their stock options. So the more jagged the route, the better it is for them.

And of course society—here the retirees—has the exact opposite payoff since they finance bankers and chief executives. Retirees get less upside than downside. Society pays for the losses of the bankers, but gets no bonuses from them. If you don't see this transfer of antifragility as theft, you certainly have a problem.

What is worse, this system is called "incentive-based" and supposed to correspond to capitalism. Supposedly managers' interests are aligned with those of the shareholders. What incentive? There is upside and no downside, no disincentive at all.

The Robert Rubin Free Option

Robert Rubin, former treasury secretary, earned $120 million from Citibank in bonuses over about a decade. The risks taken by the institution were hidden but the numbers looked good … until they didn't look good (upon the turkey's surprise). Citibank collapsed, but he kept his money—we taxpayers had to compensate him retrospectively since the government took over the banks' losses and helped them stand on their feet. This type of payoff is very common, thousands of other executives had it.

This is the same story as the one of the architect hiding risks in the basement for delayed collapse and cashing big checks while protected by the complexities of the legal system.

Some people suggest enforcing a "clawback provision" as a remedy, which consists of making people repay past bonuses in cases of subsequent failure. It would be done as follows: managers cannot cash their bonuses immediately, they can only do so three or five years later if there are no losses. But this does not solve the problem: the managers still have a net upside, and no net downside. At no point is their own net worth endangered. So the system still contains a high degree of optionality and transfer of fragility.

The same applies to the fund manager involved in managing a pension fund—he, too, has no downside.

But bankers used to be subjected to Hammurabi's rule. The tradition in Catalonia was to behead bankers in front of their own banks (bankers tended to skip town before failure was apparent, but that was the fate of at least one banker, Francesco Castello, in 1360). In modern times, only the mafia executes

these types of strategies to remove the free option. In 1980, the "Vatican banker" Roberto Calvi, the chief executive of Banco Ambrosiano that went bust, ran to take refuge in London. There, he supposedly committed suicide—as if Italy was no longer a good place for acts of drama such as taking one's own life. It was recently discovered that it was not quite suicide; the mafia killed him for losing their money. The same fate befell the Las Vegas pioneer Bugsy Siegel, who ran an unprofitable casino in which the mafia had investments.

And in some countries such as Brazil, even today, top bankers are made unconditionally liable to the extent of their own assets.

Which Adam Smith?

Many right-wingers-in-love-with-large-corporations keep citing Adam Smith, famous patron saint of "capitalism," a word he never uttered, without reading him, using his ideas in a self-serving selective manner—ideas that he most certainly did not endorse in the form they are presented.[4]

In Book IV of *The Wealth of Nations*, Smith was extremely chary of the idea of giving someone upside without downside and had doubts about the limited liability of joint-stock companies (the ancestor of the modern limited liability corporation). He did not get the idea of transfer of antifragility, but he came close enough. And he detected—sort of—the problem that comes with managing other people's business, the lack of a pilot on the plane:

> The directors of such companies, however, being the managers rather of other people's money than of their own, it cannot well be expected, that they should watch over it with the same anxious vigilance with which the partners in a private copartnery frequently watch over their own.

Further, Smith is even suspicious of their economic performance as he writes: "Joint-stock companies for foreign trade have seldom been able to maintain the competition against private adventurers."

Let me make the point clearer: the version of "capitalism" or whatever economic system you need to have is with the minimum number of people in the left column of the Triad. Nobody realizes that the central problem of the Soviet system was that it put everyone in charge of economic life in that nasty fragilizing left column.

THE ANTIFRAGILITY AND ETHICS OF (LARGE) CORPORATIONS

Have you noticed that while corporations sell you junk drinks, artisans sell you cheese and wine? And there is a transfer of antifragility from the small in favor of the large—until the large goes bust.

The problem of the commercial world is that it only works by addition (*via positiva*), not subtraction (*via negativa*): pharmaceutical companies don't gain if you avoid sugar; the manufacturer of health club machines doesn't benefit from your deciding to lift stones and walk on rocks (without a cell phone); your stockbroker doesn't gain from your decision to limit your investments to what you see with your own eyes, say your cousin's restaurant or an apartment building in your neighborhood; all these firms have to produce "growth in revenues" to satisfy the metric of some slow thinking or, at best, semi-slow thinking MBA analyst sitting in New York. Of course they will eventually self-destruct, but that's another conversation.

Now consider companies like Coke or Pepsi, which I assume are, as the reader is poring over these lines, still in existence—which is unfortunate. What business are they in? Selling you sugary water or substitutes for sugar, putting into your body stuff that messes up your biological signaling system, *causing* diabetes and making diabetes vendors rich thanks to their compensatory drugs. Large corporations certainly can't make money selling you tap water and cannot produce wine (wine seems to be the best argument in favor of the artisanal economy). But they dress their products up with a huge marketing apparatus, with images that fool the drinker and slogans such as "125 years of providing happiness" or some such. I fail to see why the arguments we've used against tobacco firms don't apply—to some extent—to all other large companies that try to sell us things that may make us ill.

The historian Niall Ferguson and I once debated the chairperson of Pepsi-Cola as part of an event at the New York Public Library. It was a great lesson in antifragility, as neither Niall nor I cared about who she was (I did not even bother to know her name). Authors are antifragile. Both of us came totally unprepared (not even a single piece of paper) and she showed up with a staff of aides who, judging from their thick files, had probably studied us down to our shoe sizes (I saw in the speakers' lounge an aide perusing a document with an ugly picture of yours truly in my pre-bone-obsession, pre-weight-lifting days).

We could say anything we wanted with total impunity and she had to hew to her party line, lest the security analysts issue a bad report that would cause a drop of two dollars and thirty cents in the stock price before the year-end bonus. In addition, my experience of company executives, as evidenced by their appetite for spending thousands of hours in dull meetings or reading bad memos, is that they cannot possibly be remarkably bright. They are no entrepreneurs—just actors, slick actors (business schools are more like acting schools). Someone intelligent—or free—would likely implode under such a regimen. So Niall immediately detected her weak point and went straight for the jugular: her slogan was that she contributed to employment by having six hundred thousand persons on her staff. He immediately exposed her propaganda with the counterargument—actually developed by Marx and Engels—that large bureaucratic corporations seized control of the state just by being "big employers," and can then extract benefits at the expense of small businesses. So a company that employs six hundred thousand persons is allowed to wreck the health of citizens with impunity, and to benefit from the implied protection of bailouts (just like American car companies), whereas artisans like hairdressers and cobblers do not get such immunity.

A rule then hit me: with the exception of, say, drug dealers, small companies and artisans tend to sell us healthy products, ones that seem naturally and spontaneously needed; larger ones—including pharmaceutical giants—are likely to be in the business of producing wholesale iatrogenics, taking our money, and then, to add insult to injury, hijacking the state thanks to their army of lobbyists. Further, anything that requires marketing appears to carry such side effects. You certainly need an advertising apparatus to convince people that Coke brings them "happiness"—and it works.

There are, of course, exceptions: corporations with the soul of artisans, some with even the soul of artists. Rohan Silva once remarked that Steve Jobs wanted the inside of the Apple products to look aesthetically appealing, although they are designed to remain unseen by the customer. This is something only a true artisan would do—carpenters with personal pride feel fake when treating the inside of cabinets differently from the outside. Again, this is a form of redundancy, one with an aesthetic and ethical payoff. But Steve Jobs was one of the rare exceptions in the Highly Talked About Completely Misunderstood Said to Be Efficient Corporate Global Economy.

Artisans, Marketing, and the Cheapest to Deliver

Another attribute of the artisanal. There is no product that I particularly like that I have discovered through advertising and marketing: cheeses, wine, meats, eggs, tomatoes, basil leaves, apples, restaurants, barbers, art, books, hotels, shoes, shirts, eyeglasses, pants (my father and I have used three generations of Armenian tailors in Beirut), olives, olive oil, *etc.* The same applies to cities, museums, art, novels, music, painting, sculpture (I had at some point an obsession with ancient artifacts and Roman heads). These may have been "marketed" in some sense, by making people aware of their existence, but this isn't how I came to use them—word of mouth is a potent naturalistic filter. Actually, the only filter.

The mechanism of *cheapest-to-deliver-for-a-given-specification* pervades whatever you see on the shelves. Corporations, when they sell you what they call cheese, have an incentive to provide you with the cheapest-to-produce piece of rubber containing the appropriate ingredients that can still be called cheese—and do their homework by studying how to fool your taste buds. Actually, it is more than just an incentive: they are structurally designed and extremely expert at delivering the cheapest possible product that meets their specifications. The same with, say, business books: publishers and authors want to grab your attention and put in your hands the most perishable journalistic item available that still can be called a book. This is optimization at work, in maximizing (image and packaging) or minimizing (costs and efforts).

I said about marketing by soft drink companies that it is meant to maximally confuse the drinker. Anything one needs to market heavily is necessarily either an inferior product or an evil one. And it is highly unethical to portray something in a more favorable light than it actually is. One may make others aware of the existence of a product, say a new belly dancing belt, but I wonder why people don't realize that, by definition, what is being marketed is necessarily inferior, otherwise it would not be advertised.

Marketing is bad manners—and I rely on my naturalistic and ecological instincts. Say you run into a person during a boat cruise. What would you do if he started boasting of his accomplishments, telling you how great, rich, tall, impressive, skilled, famous, muscular, well educated, efficient, and good in bed he is, plus other attributes? You would certainly run away (or put him in contact with another talkative bore to get rid of both of them). It is clearly much better if others (preferably someone other than his mother) are the ones saying good things about him, and it would be nice if he acted with some personal humility.

Actually this is not at all far-fetched. As I was writing this book, I overheard

on a British Air flight a gentleman explain to the flight attendant less than two seconds into the conversation (meant to be about whether he liked cream and sugar in his coffee) that he won the Nobel Prize in Medicine “and Physiology” in addition to being the president of a famous monarchal academy. The flight attendant did not know what the Nobel was, but was polite, so he kept repeating “the Nobel Prize” hoping that she would wake up from her ignorance. I turned around and recognized him, and the character suddenly deflated. As the saying goes, it is hardest to be a great man to one’s chambermaid. And marketing beyond conveying information is insecurity.

We accept that people who boast are boastful and turn people off. How about companies? Why aren’t we turned off by companies that advertise how great they are? We have three layers of violations:

First layer, the mild violation: companies are shamelessly self-promotional, like the man on the British Air flight, and it only harms them. Second layer, the more serious violation: companies trying to represent themselves in the most favorable light possible, hiding the defects of their products—still harmless, as we tend to expect it and rely on the opinion of users. Third layer, the even more serious violation: companies trying to misrepresent the product they sell by playing with our cognitive biases, our unconscious associations, and that’s sneaky. The latter is done by, say, showing a poetic picture of a sunset with a cowboy smoking and forcing an association between great romantic moments and some given product that, logically, has no possible connection to it. You seek a romantic moment and what you get is cancer.

It seems that the corporate system pushes companies progressively into the third layer. At the core of the problem with capitalism—again, please do not invoke Adam Smith—lies the problem of units that are different from individuals. A corporation does not have natural ethics; it just obeys the balance sheet. The problem is that its sole mission is the satisfaction of some metric imposed by security analysts, themselves (very) prone to charlatanism.

A (publicly listed) corporation does not feel shame. We humans are restrained by some physical, natural inhibition.

A corporation does not feel pity.

A corporation does not have a sense of honor—while, alas, marketing documents mention “pride.”

A corporation does not have generosity. Only self-serving actions are acceptable. Just imagine what would happen to a corporation that decided to unilaterally cancel its receivables—just to be nice. Yet societies function thanks

to random acts of generosity between people, even sometimes strangers.

All of these defects are the result of the absence of skin in the game, cultural or biological—an asymmetry that harms others for their benefit.

Now, such systems should tend to implode. And they do. As they say, you can't fool too many people for too long a period of time. But the problem of implosion is that it does not matter to the managers—because of the agency problem, their allegiance is to their own personal cash flow. They will not be harmed by subsequent failures; they will keep their bonuses, as there is currently no such thing as negative manager compensation.

In sum, corporations are so fragile, long-term, that they eventually collapse under the weight of the agency problem, while managers milk them for bonuses and ditch the bones to taxpayers. They would collapse sooner if not for the lobby machines: they start hijacking the state to help them inject sugary drinks into your esophagus. In the United States large corporations control some members of Congress. All this does is delay the corporation's funeral at our expense.[5]

Lawrence of Arabia or Meyer Lansky

Finally, if you ever have to choose between a mobster's promise and a civil servant's, go with the mobster. Any time. Institutions do not have a sense of honor, individuals do.

During the Great War, T. E. Lawrence, nicknamed Lawrence of Arabia, struck a deal with the Arab desert tribes to help the British against the Ottoman Empire. His promise: to deliver to them in return an Arab state. As the tribes did not know better, they made good on their side of the bargain. But, it turned out, the French and British governments had made a secret agreement, the Sykes-Picot Agreement, to divide the area in question between themselves. After the war, Lawrence went back to live in the U.K., supposedly in a state of frustration, but, of course, not much more. But he left us with a good lesson: never trust the words of a man who is not free.

Now on the other hand, a mobster's greatest asset is that "his word is gold." It was said that "a handshake from the famous mobster Meyer Lansky was worth more than the strongest contracts that a battery of lawyers could put together." In fact he held in his mind the assets and liabilities of the Sicilian mafia, and was their bank account, without a single record. Just his honor.

As a trader I never trusted transactions with "representatives" of institutions; pit traders are bound by their bonds, and I've never known a single self-