Projects and prediction

Just as when you add uncertainty to a flight, the planes tend to land later, not earlier, projects tend to cost more (and take longer). This applies to many, in fact, almost all projects. In *The Black Swan* I showed that the underestimation of the random structure of the world (Mediocristan as opposed to Extemistan) caused such problems —these unexpected Black Swan events tend to hit by lengthening, not shortening project time. Black Swan blindness was the source.

The puzzle was of course that many large-scale projects one and a half centuries ago were completed on time; many of the tall buildings and monuments we see today were completed within, and often ahead of schedule. These include not just the Empire State Building (still standing in New York), but such items such as the Crystal Palace erected during the Great Exhibition of 1851, the hallmark of Victorian reign, based on the inventive ideas of a gardener. The Palace, which housed the exhibition, went from its organization to the grand opening in just nine months. The building took the form of a massive glass house, 1848 feet long by 454 feet wide and 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 away from the source, with a small number of entities as part of the food chain. Further, there were, thankfully, no business schools at the time to teach something called "project management" and increase overconfidence. And there were no consulting firms and the agency problem was weak. In other words, it was a much more linear economy —less complex— than today.

I had been telling anyone who would listen to me that Black Swan effects had to be increasing, necessarily as a result of complexity, interdependence between parts, globalization, and the beastly thing called "efficiency" that make 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 their weakest link in the 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. My colleague Bent Flyvbjerg in his studies of "Black Swan Management" showed that 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 costs overruns and it is better to focus on these principally (Black Swan Risks are often solved with small rules, not complicated ones)[xxi]. But even outside of these IT-heavy projects, we tend to have very severe delays. And, of course there is the fallacy of prediction: these are underestimated, and chronically so.

But the logic is simple: negative convexity effects are the cause. There is an asymmetry in the way errors hit you. 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 shorter with recourse to psychological factors, which play a role but less than Black Swan effects. Decision scientists ground it in human errors, not in exposure to Extremistan, with in this case exposure to negative Black Swans rather than positive Black Swans. But no psychologist realized that, at the core, it is not the psychological problem, but part of the nonlinear structure of the project. Just as time cannot be negative, a three month project cannot be completed in zero or negative time. So errors add to the right end, not the left end of it. If uncertainty were linear we would observe some projects completed early (just as we would arrive sometimes early, sometimes late). But this is not the case.

Wars, Deficits, and Bonds

The second war was estimated to last only a few month; by the time it was over it got France and Britain heavily in debt, at least ten times what they thought their financial costs would be, aside from all the destruction. The same of course for the second war caused the U.K. 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 billions, and so far can be at more than two trillion. Complexity, once again.

But wars are only illustrative of the way governments underestimate convexity effects and why they should not be trusted with finances. Governments do not need wars to run deficits: the underestimation is chronic for the very same reason ninety-eight percent of modern projects have overruns.

A GRAPHICAL AND TECHNICAL INTERLUDE[19]

Let us look at the point graphically.

The Horizontal line presents outcomes, the vertical one their probability (i.e., their frequency). This is a different representation —this time, probabilistic — of the outcomes. Before that we saw functions and variable, with nonlinear responses between one and the other.

No convexity effects lead to the first graph, Figure x —the symmetric case, as the potential gain is somewhat equal to potential harm.

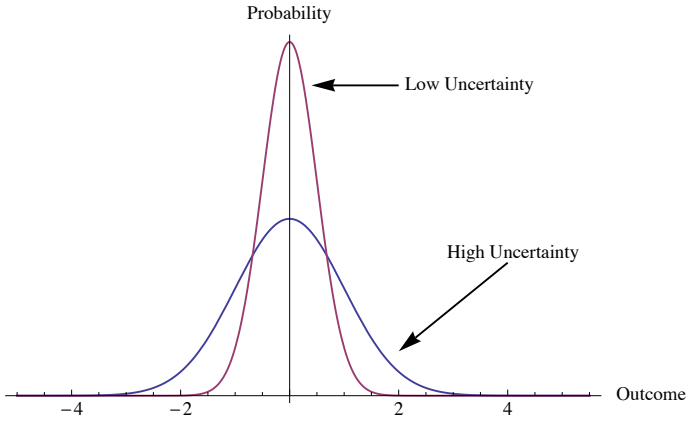

Figure 11- Case 1, the Symmetric. Injecting uncertainty in the system makes us move from one graph —the first, with narrow possible spate of outcomes—to the second, a lower peak but more spread out. So it causes an increase of both positive and negative surprises, both positive and negative Black Swans.

Negative convexity effects lead to the second graph , there is a possibility of a severe unfavorable outcome (left), much more than a hugely favorable one, as the left side is thicker than the right one.

[19] The intelligent reader innocent of social science and economics can most certainly skip these graphs as there is nothing for him to unlearn.

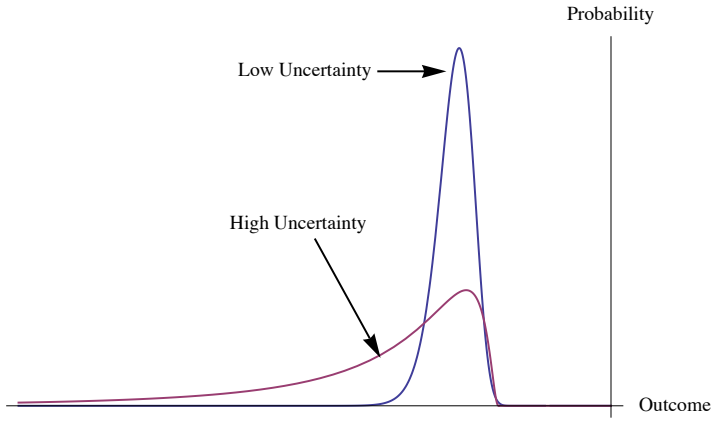

Figure 12- Case 2, Fragile, prone to negative asymmetries, negative convexity effects (Example, projects). Injecting uncertainty in the system causes an increase of only negative outcomes, just negative Black Swans.

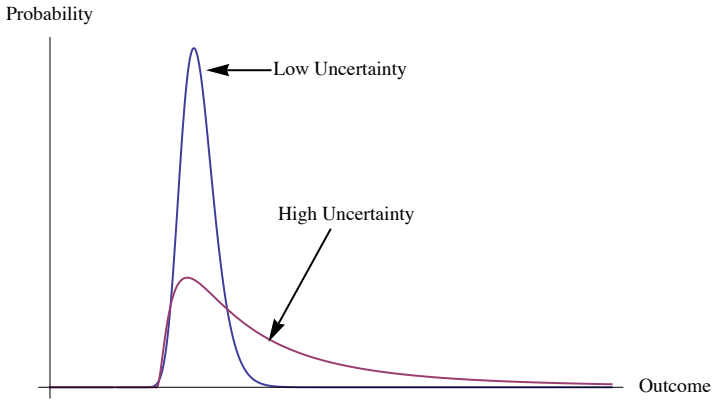

Figure 13- Case 3, Antifragile, prone to positive asymmetries, positive convexity effects. Injecting randomness and uncertainty in the system increase the possibility of very favorable outcomes, and raises the expected payoff. Note that it is the EXACT opposite of figure x {previous}, which means that discovery is, mathematically, exactly like an anti-airplane delay.

Let us apply this analysis to how planners make the mistakes we discussed earlier, and why deficits tend to do worse than planned:

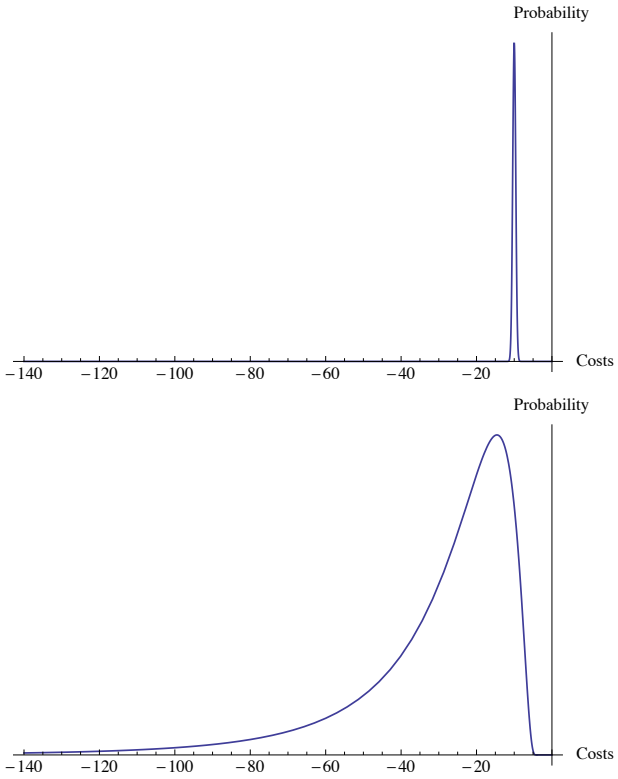

Figure 14- Probability distribution of outcomes from costs of projects in the minds of planners (above) and in reality (below). In the top graph they assume that the costs will be both low and quite certain. The lower graph show outcomes to be both worse and more spread out, particularly with higher possibility of unfavorable outcomes. These are on the left as a left tail is forming). This misunderstanding of the effect of uncertainty applies to government deficits, plans that have IT component, travel time (to a lesser degree) and many more.

The greater dispersion shows underestimation of uncertainty. The worse average outcome shows underestimation of the expected outcome.

Innovation, on the other hand, have exact opposite properties of the graph in Figure x: errors tend to cause more benefits than harm. When you inject more uncertainty in the system, it improves.

Next: Discovery as an Anti-deficit

This chapter got deeper into the plumbing behind antifragility, evolution, and survivorship. We used the grandmother story to present convexity effects —sort of, the grammar of antifragility —and the story of Thales to present this notion of "convexity", "optionality", something that tends to benefit from variation and lessens our dependence on knowledge; how convexity can supersede understanding and how Aristotle —and about most of traditional Greek and Arabic philosophy missed the point. The opposite situation is that of the grandmother suffering from thermal variations.

Next, let us discuss discovery —and how it is grounded in antifragility, hardly anything else.

Chapter 4. Lecturing Birds on How to Fly

Finally, the wheel — Proto-Fat Tony thinking —Combining stupidity with wisdom rather than the opposite — Where we look for the arrow of discovery — A vindication of trial and error — Can a philosopher be called nouveau riche?

To watch antifragility in action, see how trial and error, tinkering, the domestication of luck, the use of options, how the Thalesian approaches are smarter than what we call intelligence, and that what we call intelligence is usually an after-the-fact explanation and narrative; to see all these effects at work consider the story of the wheeled suitcase.

I carry a large wheeled suitcase mostly filled with books in almost all my travels. It is heavy (books that interest me when I travel always happen to be in hardcover —I am repelled by eReaders, avoid them for hedonic and intellectual reasons as I tend to remember much better what I read in physical books).

In July 2011, I was rolling that generic, heavy, book filled, suitcase outside the JFK international terminal and, looking at the small wheels at the bottom of the case and the metal handle that helps pulling it, I suddenly remembered the days when I had to haul my book-stuffed luggage through the very same terminal, with regular stops to rest and let the lactic acid flow out of my sore arms. I could not afford a porter and, even if I did, I would not have felt comfortable doing so. I have been going through the same terminal for three decades, with and without wheels, and the contrast was eerie. It struck me how lacking in imagination we are: we had been putting our suitcases on top of a cart with wheels, but nobody thought of putting tiny wheels directly under the suitcase.

Can you imagine that it took close to six thousand years between the invention of the wheel (by, we assume, the Mesopotamians) and this brilliant implementation (by some luggage maker in a drab industrial suburb). And billions of hours spent by travelers like myself lifting luggage through corridors full of rude custom officers.

Worse, this took place three decades after we put a man on the Moon. And consider all this sophistication used in sending someone into space, and its totally negligible impact on my life, and compare it to this lactic acid in my arms, pains in my lower back, soreness inside the palms of my hands, and sense of helplessness in front of a long corridor. Indeed, though extremely consequential, we are talking about something trivial: a very simple technology.

But the technology is only trivial retrospectively –not prospectively. All those brilliant minds you see at conferences who discuss Gödel, Shmodel, Riemann's conjecture, quarks, shmarks, had to carry their suitcases through airport terminals, without thinking about applying their brain to such an insignificant transportation problem. And even if they did apply their supposedly overdeveloped brains, they probably would not have gotten anywhere. So just by intelligence we cannot go very far. You need action, antifragile action.

This tells us something about the way we map the future. We humans lack imagination, to the point of not even knowing where tomorrow's important things look like. We use randomness to spoon-feed us with discoveries —which is why antifragility is necessary.

The story of the wheel itself is even more humbling than that of the suitcase: we keep being reminded that the Mesoamericans did not invent the wheel. They did. They had wheels. But the wheels were on small toys for children. It was just like the story of the suitcase: the Mayans and Zapotecs did not make the leap to the application. They used vast quantities of human labor, corn maize, and lactic acid to move these gigantic slabs of stone in the flat spaces ideal for pushcarts and chariots where they build their pyramids. They even rolled them on logs of wood. Meanwhile, their small children were rolling their toys on the stucco floors (or, perhaps, not even doing that as the toys might have been solely used for mortuary purposes).

The same story holds for the steam engine: the Greeks had an operating version of it for amusement, of course, the aeolipyle, a turbine that spins when heated, as described by Hero of Alexandria. But it took the industrial revolution for us to discover this earlier discovery.

Just as great geniuses invent their predecessors, practical discoveries create their theoretical ancestry.

***

There is something sneaky in the process of discovery and implementation –something people usually call evolution. We are managed by small (or large) accidental changes, more accidental than we admit. We talk big but hardly have any imagination, except for a few visionaries. We need some randomness to help us out —with a double dose of antifragility. For randomness plays a role at two levels: the invention and the implementation. The first point is not overly surprising, though we play down the role of chance, especially when it comes to our own discoveries.

But I was shocked that it took me a lifetime to figure out the second point: implementation does not necessarily proceed from invention. It too requires luck and circumstances. The history of medicine is littered with the strange sequence of discovery of a cure followed, much later, with the implementation –as if the two were completely separate ventures, the second harder, much harder, than the first. Just taking something to market requires struggling against a collection of naysayers, bureaucrats, empty-suits, formalists, mountains of details that invite you to drown, and one's own discouraged mood on the occasion. This is where all you need is wisdom to realize what you have on your hand.

Another element to retain for now: the simplest "technologies", or perhaps not even technologies but tools, such as the wheel, are the ones that seem to run the world. In spite of the hype, what we call *technologies* have a very high mortality rate, as I will show in Chapter x. Just consider that of all the means of transportations that have been designed in the past 3000 years since the attack weapons of Hyksos and the drawings of Hero of Alexandria, individual transportation today is limited to bicycles and cars (and a few variants in between the two).

Once More , Less is More

This story of the suitcase came to tease me when I realized, looking at a porcelain cup, that there existed a simple definition of fragility hence a straightforward and practical testing heuristic —the simpler and most obvious the discovery, the less equipped we are to figure it out by complicated methods. The key is that they could only be revealed through practice. How many are there of these simple, trivially simple heuristics are looking are laughing at us?

Also, the story of the wheel illustrates the point of this chapter: both governments and universities have done very, very little for innovation and discoveries, precisely because, in addition to their blinding rationalism, they look for the complicated, the lurid, the scientistic, and the grandiose, rarely for the wheel on the suitcase. Simplicity, I realized, does not lead to complication. As Fat Tony would say, they "tawk" too much. Less is usually more.

That, alas, seems to apply to every field, from medicine to economic policy, to the size of bureaucracies or nature of the medical treatment.

In addition, there is a quite potent argument that when you hear someone theorize about innovation, you can pretty much bet that he has no clue about innovation.

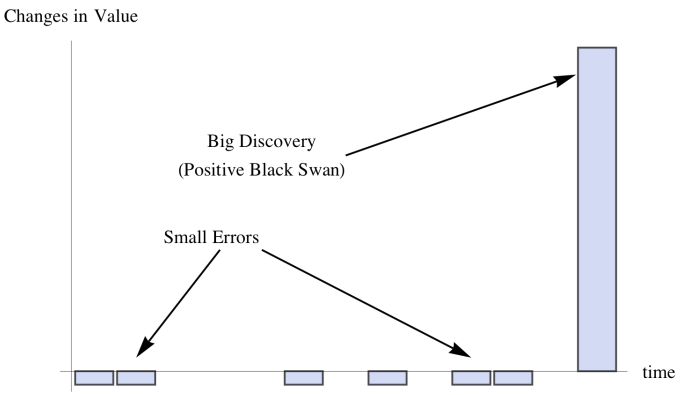

Figure 15 The mechanism of antifragile tinkering, or trial-and-error. Low costs mistakes, large payoff (unbounded). The graph does not show a specific feature of positive Black Swans: the gains is unbounded (unlike a lottery ticket), or, rather with an unknown limit; but the losses from errors are limited and known.

Figure 16- Example of a significant discovery. Same losses as the previous figure, larger payoff.

Mind the Gaps

As we saw with the stories of Thales and the wheel, history shows that antifragility (thanks to the convexity effects of trials and error) supersedes intelligence. But some intelligence is needed: all we need is the ability to accept that what we have on our hands is better than what we had before —in other words, use the option (or "exercise the option" as people say in finance, that is, take advantage of a valuable alternative that is superior to what precedes it, with a certain gain from switching from one into the other). And from the history of technology, this ability to use the option given to us by antifragility is not guaranteed: things can be looking at us for a long time. We saw the gap between the wheel and its use. Medical researchers call such lag the "translational gap", the time difference between formal discovery and first implementation, which, if anything, owing to excessive noise and academic interests, has been shown by Contopoulo-Ioannidis and her peers to be lengthening in modern times[xxii].

The historian David Wooton[xxiii] relates a gap of two centuries between the discovery of germs and the acceptance of germs as a cause of disease, a delay of thirty years between the germ theory of putrefaction and the development of antisepsis, and a delay of sixty years between antisepsis and drug therapy.

But things can get bad. In the dark ages of medicine, doctors used to rely on the rationalistic idea of a balance of humors in the body, and disease was assumed to originate with some imbalance, leading to a series of treatments that were perceived as needed to restore such balance. In her book on humors, Noga Arikha[xxiv] " shows that after William Harvey demonstrated the mechanism of blood circulation in the 1620s, one would have expected that such theories and its related practices should have disappeared. Yet people continued to refer to spirits and humors, and doctors continued to prescribe, for centuries more, phlebotomies (blood letting), enemas (I prefer to not explain), and cataplasms (application of a moist piece of bread or cereal on inflamed tissue). This continued even after Pasteur's evidence that germs were the cause of these infectious diseases.

Now, as a skeptical empiricist, I do not consider that resisting new technology is necessarily irrational: waiting for time to operate its testing might be a valid approach if one holds he has an incomplete picture of things. This is what naturalistic risk-management is about. However it is downright irrational and foolish if one holds on to an old technology that is not naturalistic at all yet visibly harmful, or when the switch to a new technology (like the wheel on the suitcase) is obviously free of possible side effects that did not exist with the previous one. In other words, I do not give the resistance to the implementations of such discoveries any intellectual credit, or some hidden wisdom and risk-management attitude: this is plain foolish. It partakes of the chronic lack of heroism and cowardice on the part of professional (usually academic) researchers: few want to jeopardize their jobs and reputation for the sake of truth. Researchers are fragile, one needs someone robust, even antifragile to stand up, that is, a person with strong personality, no reputational downside, or one who doesn't give a hoot about what his colleagues think of him.

Creative and Uncreative Destructions

Someone who got a (minor) version of the point that generalized trial and error has, well, *errors*, but without much grasp of the nature of the process is the economist Joseph Schumpeter. He vaguely realized that some things need to break for the system to improve —what is labeled as *creative destruction* —a notion developed among so many other ones by the philosopher Karl Marx and a concept discovered, we will show, by Nietzsche. But a reading of Schumpeter shows that he was completely fooled by the intervention bias, under the illusion that governments could innovate. Second, more crucially, both he and his detractors (the Harvard economists who thought that he did not know mathematics) missed both the notions of

antifragility as convexity effects, and the opposition between tinkering and top-down planning. Indeed there is in academia a pattern of detractors being even worse than the subject being criticized: whenever you hear some economist accusing another for being "not mathematical enough" or "not mathematically rigorous", you can be sure of the sweet irony that he himself understands little math (beyond the idiot-savantic exercises) and got himself into a Procrustean bed. It is like hearing someone calling another "insecure" —it tells you more about the accuser.

This heuristic is effective in detecting pseudo-scientists. For instance, one application that helped me with the ideas of fragility in economic systems presented later the book. I knew little about the ideas of the journalist and academic economist Paul Krugman until I heard him accusing another economist, Raghuram Rajan who was skeptical of his argument, of "handwaving" (handwaving means in the jargon devoid of mathematical rigor). So I ordered all of Krugman works and downloaded his papers and immediately saw that it was Krugman who lacked rigor, as his mathematics were one step below primitive, and completely misplaced (for instance all his works reposes on simplified argument that miss convexity effects, on which a bit more, later). They lead to fragility! This led me to the ideas of the dangers of specialization for countries, as presented in Chapter x.

So, to close, Schumpeter entirely missed the central point of convexity effects.

The Soviet-Harvard Illusion

Now since technological know-how comes from trial-and-error, someone and some institutions want to hide the fact from us.

I recently looked for definitions of technology. Most texts define it as *the application of scientific knowledge to practical projects* —leading us to believe in a flow of knowledge going chiefly, even exclusively, from lofty science (organized around a priestly group of persons with titles before their name) to lowly practice (exercised by uninitiated people with intellectual limitations to gain membership into the priestly group).

So, in the corpus, knowledge is presented as derived in the following manner: basic research yields scientific knowledge, which in turn generates technologies, which in turn leads to practical applications, which in turn lead to economic growth and other seemingly interesting matters. The payoff from the "investment" in basic research will be partly directed to more investments in basic research, and the citizens will prosper and enjoy the benefits of such knowledge-derived wealth with Volvo cars, ski vacations, Mediterranean diets, and long summer hikes in the beautifully maintained public parks.

This is called the Baconian linear model, after the philosopher of science Francis Bacon; I am adapting its representation by the scientist Terence Kealey (who, crucially, as a biochemist, is a practicing scientist, not a historian of science) as follows[xxv]:

Academia → Applied Science & Technology → Practice

Well, while this model may have applied to some very narrow (but highly advertised fields), such as the atomic bomb, the exact reverse seems to be true, at least in most of the domains I've examined. Or, at least, this model is not guaranteed to be true and, what is shocking, we have no rigorous evidence of it.

Think of the following event. A collection of hieratic persons from Harvard *or some such place) lecture birds how to fly. For the vivid image imagine many of them bald males in their sixties, dressed in black robes, officiating in a form of English that is full of jargon, with equations here and there for good measure. The bird flies. Wonderful confirmation! They rush to the department of ornithology to write books, articles, and reports, stating that the bird has obeyed them, an impeccable causal inference. The Harvard Department of Ornithology is now indispensable for bird flying. It will get government research funds for its contribution.

It also happens that birds write no such papers and books, conceivably because they are just birds, so we never get their side of the story. Meanwhile, the priests keep broadcasting theirs to the new generation of humans who completely unaware of the conditions of the pre-Harvard lecturing days. Nobody discusses the possibility of the birds not needing lectures —and nobody has the incentive to look at the number of birds that fly without such help from the great scientific establishment.

So the illusion grows and grows, with government funding, tax dollars, swelling (and self-feeding) bureaucracies in Washington all devoted to help birds fly better. Problems occur when people start cutting such funding — accusations of killing birds by not helping them fly. We will see later in the next chapter the results of the wonderful controlled experiment showing that

almost nothing of note came out of top-down, government-funded National Institute of Health driven cancer research, compared to the results of, say, the side effects of mustard gas.

These illusions of contribution result largely from the confirmation fallacies: in addition to the sad facts that history belongs to those who can write about it, a second bias appears as those who write the accounts can deliver confirmatory facts (what has worked) not a complete picture of what has worked and what has failed. For instance directed research would tell you what has worked from funding (like AIDS drugs or some modern designer drugs), not what has failed — so you have the impression that they fare better than random.

And of course iatrogenics are never part of the discourse.

So we are blind to the possibility of the alternative process, a loop:

Random Tinkering (antifragile) → Heuristics (Technology) → Practice & Apprenticeship → Random Tinkering (antifragile) → Heuristics (Technology) → Practice & Apprenticeship...

Now, crucially, one can detect the scam in the so-called Baconian model by looking at events in the days that preceded the Harvard lectures on flying and examining the birds. This is what I accidentally found (indeed, accidentally) in my own career of practitioner-turned-researcher in finance, thanks to some lucky turn of events. {But before that, let me explain epiphenomena and the arrow of education}.

Epiphenomena and the Narrative Fallacy

The Soviet-Harvard illusion (i.e., lecturing birds on flying and believing in being the cause behind these wonderful skills) belongs to a class of causal illusions called *epiphenomena*. What are these illusions? When you spend time in the cabin of the captain of a ship or the coxswain's station with a large compass in front, you can easily develop the impression that the compass is directing the ship rather than merely reflecting the direction. The lecturing birds how to fly effect is an epiphenomena — there is nothing to disprove the argument that education comes with wealth, instead of being the generator of wealth.

An epiphenomena is when you don't observe A without observing B with it, so you are likely to think that A causes B, or that B causes A, depending on the cultural framework or what seems plausible to the local journalist.

One rarely has the illusion that, given that so many boys have haircuts, that haircuts determine gender, or that wearing a tie causes one to become a businessman. But it is easy to fall into epiphenomena, particularly when one is exposed to news.

The narrative fallacy is a more general disease of always wanting narratives instead of disconnected facts, or facts not glued by cause and effects. That's how our minds work and that's the prime reason I hate the media because it exploits our mental defects and gives us the illusion that more things on Planet Earth are explainable than they really are, hence more predictable. Journalists exacerbate the illusion of causality since they always impart causes to things, forgetting sometimes that they have imparted the same cause to an event and its exact opposite ("interest rates higher on fears of European crisis", followed a few days later by "interest rates lower on fears of European crisis".)

For instance of an invented cause, I present an example that will be used again in Chapter x, in the context of the vulnerability to size and convexity effects. On January 21, 2008, the Parisian bank Société Generale rushed to sell in the market close to seventy billion dollars 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. 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 exposure from the main computer system. They had to immediately sell these stocks they didn't know they owned. Markets collapsed worldwide by close to 10% in response to the liquidation. It is clearly obvious that the market drop was in response to such fire sale; the causal link is about as good as they come. But the bank kept the story secret and nobody knew about the liquidation until it was over and they had their press statement.

The next morning, before the fire sale and the story of the rogue trader were disclosed, the *New York Times* had the following headline: "*The fears of recession* have roiled markets from Frankfurt to Mumbai on Monday..." (my emphasis). An innocent reader would feel that fears or recession is the cause. But there were fears of recession the previous week, and the market went up. So the innocent reader would have the illusion that these events are

predictable, and that next time there are fears of recession, he should sell his stocks. Now the problem of journalists not having the skin in the game is that a practitioner would have noticed the absence of causal linkage between the two events, but journalists need to get your attention and a false narrative is much better than no narrative. When I tell journalists that this is downright unethical they invoke "fact checking" —but this is worse than bad facts. Actually a journalist confessed to me that their editor would never let them report a fact without "an explanation".

So newspapers foster the impression that the world is more explainable, hence more predictable, that exposing a "cause" is superior intellectually, and that suspending causation is not good thing to do. It has taken me years of convincing people that suspension of causal beliefs is vastly, vastly more rigorous than producing a cause.

We discussed the intervention bias in Chapter 2. One can easily see the trap of having these epiphenomena fuel action, then justify it retrospectively. A dictator —just like a government— will feel indispensable because the alternative is not easily visible, or hidden by special interest groups. The Federal Reserve of the U.S., for instance, can wring havoc on the economy yet feel convinced of its effectiveness.

The rest of the chapter will look at evidence debunking the role of intervention —or, rather, naive centralized government intervention— as well as the role of what we call universities in human discovery. In other words, anything top-down, the reverse of tinkering and trial and error.

But we can dig out epiphenomena in the consciousness and cultural discourse by looking at sequence, a method refined by Clive Granger a well-deserved "Nobel" in economics, that Bank of Sweden (Sverige Riksbank) Prize in Honor of Alfred Nobel. It is the only rigorously scientific method that philosophers of science tend to talk about, as they can now extract, if not measure the so-called "Granger cause" by looking at sequences. In epiphenomenal situations, you end up seeing A and B together. But if you refine your analysis to the sequence —what takes place before, A or B, and analyze evidence to support the existence of "Granger causality". I do not believe that Granger's method can lead me to believe that A causes B" so much as "the statement that A causes B is wrong". In other words, in what is called a falsification.

TURING OIL INTO KNOWLEDGE

So we can answer a lot of questions by just thinking hard, out of the box, or taking slow long walks. {Or playing Fat Tony.}

Indeed, if knowledge flowed equally in both directions, then theory without experience should be equivalent to experience without theory— which I will maintain is not the case.

Consider the following: would you rather have your brain operated on by someone with enormous book knowledge, but no practical one, or by the reverse? Visibly we can see that theory without practice is less desirable than practice without theory. So why would we then have the blindness to it when it comes to so many things like following mother nature, who has a lot of practice, and no theory?

Indeed, I am now in an appropriate place to think about these problems. For I am writing these lines in Abu-Dhabi, a city that sprung out of the desert, as if watered by oil. Like every Levantine, we feel a strange relation to the place, the artificiality of which makes me queasy. It is the anti-Mediterranean in every respect. As a Levantine we share language with them but not looks, genes, mentality, habits, or foods (their cuisine is closer to that of India and Pakistan); with Greeks and Turks, we share looks, genes, mentality, habits, and foods, but not language.

What makes me even more queasy is the building of these huge universities, funded by the oil revenues of governments, under the notion that oil reserves can be turned into knowledge by a single process of hiring professors from prestigious universities and putting their kids through school (or, as it is the case, waiting for their kids to feel the desire to go to school as many students in Abu Dhabi are from Bulgaria, Serbia or Macedonia getting a free education). Even better they can, with a single check, import an entire school from overseas, as the Sorbonne and New York University have done (among many more). So, in a few years, they will be reaping the benefits of this technological improvement of the members of their society.

So it would seem a reasonable investment, if one accepts that *university knowledge generates economic wealth*. But, recall the story of Switzerland in Chapter x. I wonder if my nausea comes from the feeling that these desert tribes who share-my-language-but-not-my-ethnicity are being separated from their money by the establishment that has been sucking resources and diverting them to parasitic tenured professors from Western

universities. Their wealth came from oil, not from some vocational know-how, so I am certain that spending on education is completely sterile and a great transfer of resources (rather than milking antifragility by forcing their citizens to make money naturally, through circumstances).

A Return to Amioun

We saw with the intervention bias how some systems degrade under absence of stressors and get stronger when stressed —a prime example is the human body. Well, we have to go back to the ancients to find people with the wisdom to generalize it to growth. Recall the quote by Seneca and Ovid to the effect that sophistication is born of need, and success out of difficulties —in fact many such variations, sourced in Medieval days (such as *necessitas magistra* in Erasmus) found their way to our daily vernaculars, with "necessity is the mother of invention". The best is as usual from my mentor the master aphorist, the freed Syrian slave Publilius Syrus: poverty makes experiences (*hominem experiri multa paupertas iubet).* But the expression and idea appears in one form or another in so many classical writers, including Euripides, Pseudo-Theoctitus, Plautus, Apuleus, Zenobius, Juvenal. That's certainly something that escapes the Abu Dhabi model. Let us see it ancient wisdom at work.

A total contrast with the situation in Abu Dhabi is my Levantine village of origin, Amioun. Recall from Chapter 1 that I suspect that innovation and growth comes largely as overcompensation for a stressor. Well, the story of my ancestral village which, owing to war, was subjected to an extraordinary amount of stress illustrates the conjecture.

Amioun was rather prosperous before the civil war of 1975, but today it is off the chart relative to other villages in area, and, of course, other places in the Levant (in fact it had been rather prosperous a hundred years ago, when Abu Dhabi was composed of a few tents and camels). In 1975, the place, although Greek Orthodox, sided partly with the Moslems (to spite the mountain Maronite Catholics, a long story). The situation was untenable and most nongeriatrics fled, some to study overseas, some to hide with their great-aunt in Altoona, Pennsylvania, others to seek work as they knew that whomever would win the Lebanese war would make them pay for it. Then the village was invaded by the Maronite Christians, who supposedly had done so in 1860 and still remembered how to do it; it was pillaged. Many houses were burned to the ground. Amioun became literally deserted of all males between the age of zero and eighty-one. All one could find there was old men playing backgammon and elderly females with pictures of their grandchildren studying in American Universities. As part of a complicated sequence of events, our country house, on hilltop, visible from all parts of the village, was dynamited to the ground. One could see the rubble as a perfect postcard of what happens in civil war and the transmogrification of the majestic into the naggingly blighted. For my parents (and me), it was mostly an insult.

Twenty-five years later, I came back from America hoping to purchase land there. For starters, I helped rebuild the country house —which my parents had designed on a much larger scale than before, driven by some kind of pride that I found foolish to inhibit. The house was larger, even more visible on top of the hill. But it was no longer the only house on hilltop: a myriad of copycat villas were growing in the countryside, usually on hilltops, with a similar architecture. It was also impossible for me to buy additional land: prices had been rising steadily, faster than any other village in the area. Emigration, forced emigration made those who left too successful, causing real estate to become much more expensive, certainly more expensive than Westchester in the New York area. For a hundred or so Amiouni millionaires had been descending from around the world to buy land and build themselves their dream house with Italian kitchens and playrooms with a ping pong tables. By some mystery, so many had become rich overseas. (The evidence for the subsequent success of these émigrés shows in the price of land in Amioun compared to the other villages who were spared the war). My father showing me the multiplication of villas in the countryside, while bemoaning these nouveau rich, calmly told me: "You too, had you stayed here, would have become a beach bum. People from Amioun only do well when shaken." That's antifragility.

One fact that is hard to grasp for people outside the area: in the Levant, your identity is linked to your village of origin, where your family is from, regardless of whether you were born and grew up there or not. And you could feel a stranger in a village only one mile away. Hence people return to a precise piece of real estate. I am certain (as you can see from the comparative land prices) that the economic success of the children of Amioun —and the other Lebanese who fled the war is the result of stressors. Many people of my generation left in the seventies as war refugees, and came back better off than if there had been no war.

To conclude, when people ask me what to do for economic growth, my recommendation would be: have someone dynamite your house. Or find a less harmful and less traumatic stressor; but find a stressor. Also, please read the classics for some wisdom.

L'Art Pour l'Art, To Learn for Learning's Sake

Now let us look at evidence of the direction of the causal arrow, that is, whether it is true that such form of armchair knowledge leads to prosperity. Serious empirical investigation (thanks to one L. Pritchet, a World Bank economist) shows no evidence that raising the general level of education raises income at the level of a country[xxvi] . But we know that the opposite is true, that wealth leads to the rise of education, not an optical illusion. We don't need to go to the World Bank figures, we could derive this from an armchair. Let us figure out the direction of the arrow:

Education → Wealth and economic growth
or
Wealth and economic growth → Education

And the evidence is so easy to check, just lying out there in front of us in the open. It can be obtained in looking at countries that are both wealthy and have education and consider which condition preceded the other.[xxvii] Take the following potent and *less-is-more* style argument by the rogue economist Ha-Joon Chang. In 1960 Taiwan had a much lower literary rate than the Philippines and half the income per person; today Taiwan has ten times the income. At the same time Korea had also a much lower literacy than Argentina (who had one of the highest in the world) and about one-fifth the income per person; today it is three times. Further, over the same period Sub-Saharan Africa had literacy rates markedly increasing, accompanied with decrease in their standards of living. We can multiply the examples (Pritchet's study is quite thorough) but I wonder why don't people realize the simple truism, that is, the *Fooled by Randomness* effect: mistaking the association for the causal, that is if rich countries are educated, that education makes a country rich. (The error in reasoning is a bit from wishful thinking, because education is considered "good"; I wonder why people don't make the epiphenomenal association between wealth of a country and something "bad", say, decadence and infer that decadence too generates wealth).

Now, note that I am not saying that universities do not generate knowledge at all and help growth (outside, of course economics and other superstition driven disciplines that I am most certain set us back); all I am saying is that their role is overly hyped up and that their members seem to exploit some of the gullibility we have in establishing wrong causal links, mostly on superficial impressions. In other words, a sucker problem. But there are two consequences.

Consequence 1, neutral: Overestimation of the arrow of knowledge. This is not destructive, an illusion among many others.

Consequence 2, nefarious: Underestimation of the negative aspect of top-down knowledge, leading to iatrogenics. This is more prevalent in economics and will be proved later in the book.

History Written by the Losers

One fact about Kealey that made these ideas natural to him: as mentioned earlier, he was a practicing scientist and witnessed the real-life production of pharmacological innovations. Practitioners can avoid falling for epiphenomena, unless they have been brain-washed initially prior to starting practice. Kealey was not a historian hence was able to watch the formation of technologies, not read about it.

The problem started screaming at me, as follows, around 1998. I was then sitting in a Chicago restaurant with an economist, though a true, thoughtful gentleman. He was advising one of the local exchanges on new complicated financial products and wanted my opinion on these, as I had published a textbook on the so-called "exotic options". He recognized that the demand for these products was going to be very large, but wondered "how traders could handle these exotics if they do not understand the Girsanov theorem." The Girsanov theorem is something mathematically complicated that at the time was only known by a very small number of persons. And we were talking about pit traders who would most certainly mistake Girsanov for a vodka brand. Traders, usually uneducated, were considered overeducated if they could spell their street address correctly, while the professor was truly under the impression that traders studied mathematics to produce a price.

Something hit me then. Nobody worries that a child ignorant of the various theorems of aerodynamics and incapable of solving an equation of motion would be unable to ride a bicycle. So why didn't he transfer the point from one domain to another? Didn't he realize that these Chicago pit traders respond to supply and demand, little more, competing to make a buck, do the Girsanov theorem, any more than a trader of pistachios in the Souk of Damascus needs to solve general equilibrium equations to set the price of his product?

For a minute I wondered if I was living on another planet or if the gentleman's PhD and research career led to this blindness and his strange loss of common sense—or if people without practical sense usually manage to get the energy to acquire a PhD in economics.

Well, then I called another trader-turned-researcher, Espen Haug, who had observed the same mechanism. Recall from Chapter 3 on convexity effects that there has been plenty of formulas to price financial options (financial options, as a reminder, are antifragile because, owing to convexity effects, they gain from volatility and uncertainty). We as professionals had spent our lives in the field of financial options and smelled a rat. So we immediately embarked on an investigation about the source of the option pricing formula that we were using: what did people use before? It is thanks to the academically derived formula that we are able to operate, or did the formula follow? I already had a hint as I worked as a pit trader in Chicago and had observed veterans traders who refused to touch formulas, using simple heuristics and had a saying "real men don't use sheets", the "sheets" were what came out of computers. Yet their prices were sophisticated and more efficient that the formula and it was obvious what came first.

Haug has some interests that diverge from mine: he was interested in finance and eager to collect historical papers by practitioners. He went to collect books and articles written before the Great War, and from there we built an image of what took place. Well, to our great excitement, we discovered that traders had vastly, vastly more sophistication than the formula. It was of course picked-up through natural selection, survivorship, apprenticeship from experienced practitioners, and one's own experience[xxviii].

Traders trade → figure out products → academics find formulas and claim traders are using them → new traders believe academics → blowups

We also figured out a less interesting fact for us, but more interesting for academics, that two persons, Myron Scholes and Robert Merton got the Memorial Prize in Economics called "Nobel" for the packaging of a formula that other people discovered in more sophisticated form before them, as I mentioned Louis Bachelier, but also an American wiz-kid called Ed Thorpe who became independent, then extremely rich gambling —he invented the method called "card counting" in Black Jack. Worse, unlike Thorpe's, the problem of the equation by Scholes and Merton is that, not being organic, it fostered bets against Black Swans and led to series of blowups, including spectacular blowups for Scholes and Merton themselves.

Our paper sat for close to seven years before publication by an academic economics journal —until then, a strange phenomenon: it became one the most downloaded papers in the history of economics, but was not cited at all during its first few years. Nobody wanted to stir the pot.

Practitioners don't write; they do. Birds fly and those who lecture them are the one who write their story. So it is easy to see that history is truly written by losers with time on their hands and a protected academic position.

In the greatest irony is that we watched firsthand how narratives of thought is made, as we were lucky to face another episode. We received an invitation to publish our side of the story —being option practitioners— in the honorable *Wiley Encyclopedia of Quantitative Finance*. Shock: we caught the editor of the historical section, one Perry Mehling red handed trying to modify our account. A historian of economic thought, he proceeded to rewrite our story to reverse its message and change the formation of the arrow of knowledge. This was scientific history in the making. Mehling sitting in his office in Barnard College was now dictating to us what we saw as traders —we were supposed to override what we saw with our own eyes with his logic.

That was our story, so it is easy to infer from it that other stories as well have suffered similar fate. And, obviously, many did.

So I started hunting for historians of science working on other subjects to figure out if they have given thought to the epiphenomenon. I found in Davos my next victim with Peter Galison, the Harvard professor who wrote *Einstein's Clocks, Poincaré's Maps* a book I read when I was not consciously

aware of this intellectual farce. I presented to him the idea of lecturing birds how to fly and the differences between *technë* and *episteme* (know how and know what) in the formation of ideas—he was not remotely aware of the possibility.

The Evidence Staring at Us

Right after the two previous nauseating episodes (nauseating for an intellectual to see the downgrade of intellectualism and realize how fragile historical narratives), I presented the joint paper I had with Haug on the idea of *lecturing birds how to fly* in finance at the London School of Economics, in their sociology of science seminar. I was, of course, heckled (but was by then very well trained at being heckled by economists). Then, surprise. At the conclusion of the session, the organizers informed me that, exactly a week earlier, Phil Scranton, a professor from Rutgers, delivered the exact same story. But it was not about the option formula; it was about the jet engine.

Scranton showed that he have been building and using jet engines, in a complete trial-and-error experiential manner, without anyone truly understanding the theory. Builders needed the original engineers who knew how to twist things to make the engine work. *Theory came later,* in a lame way, to satisfy the intellectual bureaucrats. But that's not what you tend to read in standard histories of technology: my son who student in aerospace engineering was not aware of this. Scranton was polite and focused on situations in which innovation is messy, "distinguished from more familiar analytic and synthetic innovation approaches", as if the latter was the norm which it is obviously not[xxix].

Then I was hit with the following idea. We all learn geometry in the textbooks, based on axioms, like, say, Euclid's *Book of Elements* and would tend to think that it is thanks to such learning that we today have these beautiful geometric shapes in buildings, from houses to cathedrals; to think the opposite would be anathema. So I speculated immediately that the ancients developed an interest in Euclid and other mathematics because they were already using these methods, derived by tinkering, otherwise they would not have bothered at all. This is similar to the story of the wheel. Recall that the steam engine had been discovered and developed by the Greeks some two millennia before the industrial revolution. It is just that things that are implemented tend to want to be born from practice, not theory. They want to be positive Black Swans. The theory follows.

Not take a look at architectural objects around us: they appear so geometric, from the pyramids to the beautiful cathedrals of Europe. So a sucker problem would make us tend to believe that mathematics led to these beautiful objects, with exceptions here and there such as the pyramids as these preceded the more formal mathematics we had after Euclid and other Greek theorists. Well, some facts: architects (or, what was then called Master of Works) relied on heuristics, empirical methods, and tools and almost nobody knew any mathematics —according to the Medieval science historian Guy Beaujouan, before the thirteenth Century no more than five persons in the whole of Europe knew how to perform a division[xxx]. But builders could figure out the resistance of materials without the equations we have today — these buildings are, for the most part, still standing. Further, we are quite certain that the Romans, admirable engineers, built aqueducts without mathematics. We will see that use of mathematics tends to make people over-optimize and cut corners, causing fragility (the new is increasingly more perishable than the old). [xxxi]

Now I am not saying that science is not behind some practical technologies at all, directly from science for their final use (not for some tangential use) —what the researcher Joel Mokyr calls an "epistemic base", a sort of manual that embed the theoretical and empirical discoveries, and becomes contained in a rulebook of sorts, used to generate more knowledge and more applications. But the problem that I question is the role such epistemic base really played in the history of technologies. If so, it had to be a different kind of epistemic base, a body of heuristics and tricks that were transmitted from master to apprentice. And the role of such formal knowledge will be over-appreciated precisely because it is highly visible.

For an example of a chain of unintended uses, let us start with *Phase One*, the computer. The mathematical discipline of combinatorics, here basic science, hence from the "epistemic base" leads to the building of computers, or so the story says for now. Nobody had an idea what to do with these enormous boxes full of circuits as they were cumbersome, expensive, and their applications were not too widespread, outside of database management, only good to process quantities of data. it is as if one needed to invent an application for the thrill of technology. Babyboomers would still remember the mysterious punch cards. Then someone introduced the console to input with the aid of a screen monitor, using a keyboard. This led, of course to word processing, and the computer took off because its fitness to word processing, particularly with the microcomputer in the early 1980s. It

was convenient, but not much more than that until some other unintended consequence came to be mixed-into it. Now Phase Two, the internet. It had been set-up as a resilient military communication network device, financed by DARPA during the days when Ronald Reagan was obsessed with the Soviets, so the U.S. could survive a generalized attack. Great idea, but here add the personal computer *plus* internet and we get social networks, broken marriages, rise in nerdiness, hence allowing a post-Soviet person with social difficulty to finding a matching spouse thanks to this wonderful device. All that thanks to initial tax dollars (or rather budget deficit) during the Reagan crusade.

So for now we are looking at the forward arrow and at no point, although science was at some use along the way since computer technology relies on science in most of its aspects; at no point did it serve in setting its direction, rather as a slave to chance discoveries in an opaque environment, and nothing but college dropouts and high school students along the way. The process remained self-directed and unpredictable for us humans at everyone of its steps.

In the rest of this chapter we will examine two cases, first, the industrial revolution. Second, medicine. So let us start by debunking some causal myth with the Industrial Revolution.

The Industrial Revolution

Terence Kealey, who we mentioned was not a historian and thankfully, not an economist, in *The Economic Laws of Scientific Research*, questions the conventional "linear model"— for him, universities prospered as a consequence of national wealth, not the other way round. He even went further and claimed that like naive interventions, these had iatrogenics that provided a negative contribution. He showed that, in countries in which the government intervened by funding research with tax money, private investment was decreased and moved away. For instance, in Japan, the all-mighty MITI (Ministry for Technology and Investment) have a horrible record of investment. I am not using his ideas to prop up a political program against science funding, only to debunk causal arrows in the discovery of important things.

The Industrial revolution, for a refresher, came from "technologists building technology –academic science did not influence them", or, what he calls "hobby science".

Steam engine. Take the development of the steam engine, the one artifact that more than any other embodies the Industrial Revolution. It doesn't take a lot of reasoning to figure out that it did not come from science: as I said earlier we had a blueprint of how to build it from Hero of Alexandria. The theory didn't interest anyone for about two millennia. So practice had to be the cause of the interest in Hero, not the other way around.

For Kealey, the steam engine emerged from pre-existing technology, and it was created by uneducated, often isolated, men who applied practical common sense and intuition to address the mechanical problems that beset them, and whose solutions would yield obvious economic reward.

Textile technologies. Again, the main technologies that led to the jump into the modern world owe, according to Kealey notion to science.

> In 1733, however, John Kay invented the flying shuttle, which mechanized weaving, and in 1770 James Hargreaves invented the spinning jenny, which as its name implies, mechanized spinning. These major developments in textile technology, as well as those of Wyatt and Paul (spinning frame, 1758), Arkwright (water frame, 1769), presaged the Industrial Revolution, yet they owed nothing to science; they were empirical developments based on the trial error, and experimentation of skilled craftsmen who were trying to improve the productivity, and so the profits, of their factories[xxxii].

Instead of looking into a scholar's writings to see if he is credible or not, it is always best to consider what his detractors say —they will uncover what's worse in his argument. So I looked for Kealey's detractors, or people opposing his ideas to see if they address anything of merit —and to see where they come from. Aside from the comments by Joel Mokyr, a historian of science a bit innocent of epiphenomena, and an attack by an economist which of course, doesn't count, the main scientific argument against him in the influential journal *Nature* by a science bureaucrat was that he uses data from government sponsored agencies such as the OECD in his argument against tax-funded research[xxxiii]. So far, no substantive evidence that Kealey was wrong.

THE CASE IN MEDICINE

Unlike technology, medicine has a long history of domestication of luck. We have series: from Galen to others.

Controlled experiment can easily show absence of design in medical research: you compare the results of top-down directed research to randomly generated discoveries. Well, the U.S. government provides us with the perfect experiment for that: the National Cancer Institute that came out of the Nixon "war on cancer" in the early 1970s. Morton Meyers, a practicing doctor and researcher, writes in his wonderful *Happy Accidents: Serendipity in Modern Medical Breakthroughs*:

> Despite the Herculean effort and enormous expense, only a few drugs for the treatment of cancer were found through NCI's centrally directed, targeted program. Over a twenty-year period of screening more than 144,000 plant extracts, representing about 15,000 species, not a single plant-based anticancer drug reached approved status. This failure stands in stark contrast to the discovery in the late 1950s of a major group of plant-derived cancer drugs, the Vinca Alcaloids –a discovery that came about by chance, not through directed research.

We did not realize that cures for cancer had been coming from other brands of research. You search for noncancer drugs and find something you were not looking for (and vice versa). But the interesting constant: is that many of the results are initially discovered by an academic researchers who neglects the consequences because it is not his job --he has a script to follow. Or he cannot connect the dots because he is a nerd. Meyers uses Darwin as the ultimate model: the independent gentleman scholar who does not need anyone and can follow a lead when he sees it.

(fitback to some academic researcher)

Mustard gas in Bari in 1942, a classified information

{list of medicines}

Le Fanu

> p 179 – The therapeutic revolution of the post-war years was not ignited by a major scientific insight, rather the reverse: it was the realization by doctors and scientists that it was not necessary to understand in any detail what was wrong, but that synthetic chemistry blindly and randomly would deliver the remedies that had eluded doctors for centuries.

(He uses for example the sulphonamides identified by Gerhard Domagk].

> p 206 - It is perhaps predictable that doctors and scientists should assume the credit for the ascendency of modern medicine without acknowledging, or indeed recognizing, the mysteries of nature that have played so important a part. Not surprisingly, they came to believe their intellectual contribution to be greater than it really was, and that they understood more than they really did. They failed to acknowledge the overwhelmingly empirical nature of technological and drug innovation, which made possible spectacular breakthroughs in the treatment of disease without the requirement of any profound understanding of its causation or natural history.

{List of medications that came Black Swan style from serendipity —and the list of medications that came from design.}

The Charlatan, the Academic, and the Showman

So our misunderstanding of convex tinkering, antifragility and how to tame randomness is weaved into our institutions --though not consciously and explicitly.

There has been a conflict between two classes of people and methods, two opposite ways of doing things and attaining knowledge: those who rely on thinking and theorizing and those who rely on experience, with or without thinking and theorizing –and use that *option*. The first category include those called the rationalists, the Platonists, the classicists, the Weberian rationalists and rationalo-bureaucratists, the top-down social engineers, the orthodox economists, the social planners, the venerable members of the various academies of sciences, etc. The second one includes the empirics, or empirical skeptics, the doers, and that is about it --we do not have many names for them as they have not written a lot of books. Many of their works were destroyed or hidden from cultural consciousness, and their memories have been treated very badly by history. Formal thinkers and theorizing theorizers tend to write books; seats-of-the-pants people tend to be practitioners who are often content to make the money and make discourses at the bar. Their experiences are often formalized by the academics. So surviving history has been written by the rationalists because of a mental disease –our search for order and thirst for theories-- that gives us the illusion of design. Take the discovery of chemotherapy for the treatment of cancer. People do not realize that it came out of the side effects of mustard