THOUGHTS FROM THE FRONTLINE

Ubiquity, Complexity, and Sandpiles

By John Mauldin | August 14, 2021

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> *"How did you go bankrupt?"*
> *"Two ways. Gradually, then suddenly."*
>
> —Ernest Hemingway, *The Sun Also Rises*

Change happens quickly and, often, unpredictably. And as we will see, the unpredictable part is actually a mathematical principle. As in the Hemingway quote above, not just bankruptcy but change also happens slowly and then, seemingly, all at once. It's time passing *without* change that causes the worst problems, including some historic economic catastrophes. It turns out we shouldn't just accept change; we actually need it.

Last week, I said we would skip this letter since I'm fishing with friends at Camp Kotok. But over the weekend, I realized it would be a perfect opportunity to repeat part of a letter I originally wrote in 2006 and have referred to several times. It is the single most-read letter I have written and the most commented-on, too. I consider it, in some ways, my most important letter. You should read it again if you've read it before. I have updated it a little bit, but the principles are timeless.

I'll be quoting from a very important book by Mark Buchanan called *Ubiquity, Why Catastrophes Happen*. I HIGHLY recommend it if you, like me, are trying to understand the complexity of the markets. The book isn't directly about investing—although he touches on it—it's about chaos theory, complexity theory, and critical states. It is written so any layman can understand—no equations, just easy-to-grasp, well-written stories and analogies.

Here's that story with some new comments and thoughts afterward.

Ubiquity, Complexity Theory, and Sandpiles

As kids, we all had the fun of going to the beach and playing in the sand. Remember taking your plastic bucket and making sandpiles? Slowly pouring the sand into ever bigger piles until one side of the pile starts to collapse?

Imagine, Buchanan says, dropping one grain of sand after another onto a table. A pile soon develops. Eventually, just one grain starts an avalanche. Most of the time, it's a small one. But sometimes, it builds up, and it seems like one whole side of the pile slides down to the bottom.

Well, in 1987, three physicists named Per Bak, Chao Tang, and Kurt Wiesenfeld began to play the sandpile game in their lab at Brookhaven National Laboratory in New York. Actually, piling up one grain of sand at a time is a slow process, so they wrote a computer program to do it. Not as much fun, but a whole lot faster. Not that they really cared about sandpiles; they were more interested in what are called "nonequilibrium systems."

They learned some interesting things. What is the typical size of an avalanche? After a huge number of tests with millions of grains of sand, they found out there is no typical number:

> *Some involved a single grain; others, ten, a hundred, or a thousand. Still others were pile-wide cataclysms involving millions that brought nearly the whole mountain down. At any time, literally anything, it seemed, might be just about to occur.*

The pile was indeed completely chaotic in its unpredictability. Now, let's read this next paragraph slowly. It is important as it creates a mental image that helps clarify the organization of the financial markets and the world economy.

> *To find out why [such unpredictability] should show up in their sandpile game, Bak and colleagues next played a trick with their computer. Imagine peering down on the pile from above and coloring it in according to its steepness. Where it is relatively flat and stable, color it green; where steep and, in avalanche terms, "ready to go," color it red. What do you see? They found that at the outset, the pile looked mostly green, but that, as the pile grew, the green became infiltrated with ever more red. With more grains, the scattering of red danger spots grew until a dense skeleton of instability ran through the pile.* ***Here then was a clue to its peculiar behavior: a grain falling on a red spot can, by domino-like action, cause sliding at other nearby red spots.***

> *If the red network was sparse, and all trouble spots were well isolated one from the other, then a single grain could have only limited repercussions. But when the red spots come to riddle the pile, the consequences of the next grain become fiendishly unpredictable. It might trigger only a few tumblings, or it might instead set off a cataclysmic chain reaction involving millions. The sandpile seemed to have configured itself into a hypersensitive and peculiarly unstable condition in which the next falling grain could trigger a response of any size whatsoever. (Emphasis mine.)*

Something only a math nerd could love? Scientists refer to this as a *critical state*. The term critical state can mean the point at which liquid water would change to ice or steam or the moment that critical mass induces a nuclear reaction, etc. It is the point at which something triggers a change in the basic nature or character of the object or group. Thus (and very casually, for all you physicists), we refer to something being in a critical state (or use the term *critical mass*) when there are the conditions for significant change.

> *But to physicists, [the critical state] has always been seen as a kind of theoretical freak and sideshow, a devilishly unstable and unusual condition that arises only under the most exceptional circumstances [in highly controlled experiments]... . In the sandpile game, however, a critical state seemed to arise naturally through the mindless sprinkling of grains.*

Thus, they asked themselves, could this phenomenon show up elsewhere? In the earth's crust, triggering earthquakes, in wholesale changes in an ecosystem, or in a stock market crash? "Could the special organization of the critical state explain why the world at large seems so susceptible to unpredictable upheavals?" Buchanan asks.

Buchanan concludes in his opening chapter:

> *There are many subtleties and twists in the story... but the basic message, roughly speaking, is simple: The peculiar and exceptionally unstable organization of the critical state does indeed seem to be ubiquitous in our world. Researchers in the past few years have found its mathematical fingerprints in the workings of all the upheavals I've mentioned so far [earthquakes, eco-disasters, market crashes], as well as in the spreading of epidemics, the flaring of traffic jams, the patterns by which instructions trickle down from managers to workers in the office, and in many other things.*
>
> *At the heart of our story, then, lies the discovery that networks of things of all kinds—atoms, molecules, species, people, and even ideas—have a marked tendency to organize themselves along similar lines. On the basis of this insight, scientists are finally beginning to fathom what lies behind tumultuous events of all sorts, and to see patterns at work where they have never seen them before.*

Fingers of Instability

So, what happens in our game?

> *[A]fter the pile evolves into a critical state,* ***many grains rest just on the verge of tumbling, and these grains link up into "fingers of instability" of all possible lengths****. While many are short, others slice through the pile from one end to the other. So, the chain reaction triggered by a single grain might lead to an avalanche of any size whatsoever, depending on whether that grain fell on a short, intermediate, or long finger of instability.*

Now we come to a critical point in our discussion of the critical state. Read this next excerpt with the markets in mind (and this is critical to our understanding of markets and change. Maybe you should read it two or three times.):

> *In this simplified setting of the sandpile, the power law also points to something else: the surprising conclusion that even the greatest of events have no special or exceptional causes.* ***After all, every avalanche large or small starts out the same way, when a single grain falls and makes the pile just slightly too steep at one point.***
>
> *What makes one avalanche much larger than another has nothing to do with its original cause, and nothing to do with some special situation in the pile just before it starts.* ***Rather, it has to do with the perpetually unstable organization of the critical state, which makes it always possible for the next grain to trigger an avalanche of any size.*** *(Emphasis mine.)*

Now, let's couple this idea with a few other concepts. First, economist Dr. Hyman Minsky showed how stability leads to instability. The more comfortable we get with a given condition or trend, the longer it will persist, and then the more dramatic the correction when the trend fails.

The problem with long-term macroeconomic stability is that it tends to produce unstable financial arrangements. If we believe that tomorrow and next year will be the same as last week and last year, we are more willing to add debt or postpone savings in favor of current consumption. Thus, says Minsky, the longer the period of stability, the higher the potential risk for even greater instability when market participants must change their behavior.

Relating this to our sandpile, the longer a critical state builds up in an economy—or in other words, the more fingers of instability that are allowed to develop a connection to other fingers of instability—the greater the potential for a serious avalanche.

A second related concept is from game theory. The Nash equilibrium (named after John Nash, subject of the Oscar-winning movie *A Beautiful Mind*) is a kind of optimal strategy for games involving two or more players, whereby the players reach an outcome to mutual advantage. If a game has a set of strategies with the property that no player can benefit by changing his strategy while the other players keep their strategies unchanged, then that set of strategies and the corresponding payoffs constitute a Nash equilibrium.

A Stable Disequilibrium

So, we end up in a critical state of what Paul McCulley calls a "stable disequilibrium." We have players all over the world tied inextricably together in a vast dance through equities, debt, derivatives, trade, globalization, international business, and finance. Each player works hard to maximize their personal outcome and reduce their exposure to fingers of instability.

But the longer the game runs, says Minsky, the more likely it is to end in a violent avalanche, as the fingers of instability have more time to build, and, eventually, the state of stable disequilibrium goes critical.

Go back to 1997. Thailand began to experience trouble. The debt explosion in Asia began to unravel. Russia was defaulting on its bonds. (Astounding. Was it less than 25 years ago? Now Russia is awash in capital. Who could have anticipated such a dramatic turn of events?) Things on the periphery, small fingers of instability, began to impinge on fault lines in the major world economies.

Something that had not been seen before happened. The historically sound and mathematically logical relationship between 29- and 30-year bonds broke down. Then country after country suddenly and inexplicably saw that relationship in their bonds begin to correlate, an unheard-of event. A diversified pool of debt was suddenly no longer diversified. The fingers of instability reached into Long Term Capital Management and nearly brought the financial world to its knees.

And now, different fingers of instability are creating an even worse crisis in the credit markets.

Sandpiles 2021

All right, back to the present. When I originally wrote that letter, it was 2006, and the fingers of instability hadn't yet created the Great Recession. You could certainly see red dots in the sandpile, most notably subprime debt, but there were literally hundreds of dots scattered throughout the world economy, most of them innocuous until they weren't. And then the scramble for liquidity began, except the liquidity wasn't there, and, well, you know the rest of the story.

This should be even more concerning if you think about my recent series on what I think is a major policy mistake being made by the Federal Reserve and central banks worldwide. We are adding sand to not just one inevitably collapsing sandpile, but dozens and maybe hundreds of them. They won't keep growing forever.

Which particular sandpile will fall first? It could be many, but it will likely be debt-oriented. And the fingers of instability tell us that it doesn't matter which grain of sand is the trigger, just that there will be one. Millions of investors think they can continue acting as if today will just be like yesterday, which will be like tomorrow, and then be able to sell when trouble appears.

They're partly right. They *will* be able to sell… but well below the prices they expect.

I write often about the connectedness of so many global markets and how the debt crisis, unfunded pension liabilities, and government promises all over the world seemingly keep mounting, yet markets go up more.

I think the mother of all Minsky moments is building. It will not be an instant sandpile collapse but instead, take years because we have $500 trillion of debt to work through. Remember, that debt just can't be swept away. It is both money somebody owes and an asset on somebody else's balance sheet. If you are retired, your pension and healthcare benefits are part of your net worth. They are assets on your balance sheet that you count on to cover future spending. We can't just take that away without huge consequences to culture and society.

But the fingers of instability, the total credit system, are seemingly growing with more red sand dots every month. All are inextricably linked. One day, another Thailand or Russia or something else (it makes no difference which) will start a cascade.

Remember, very astute people saw the subprime crisis and made a lot of money shorting that market. I saw it coming but didn't know how to trade it. I guarantee you, I'm paying attention now to who can profit from the next credit crisis. Maybe I'll succeed, and maybe I won't, but just once, I would like to be on the right side of a crisis.

No More Business Cycles

One last comment that I picked up over the years. My friend Peter Boockvar actually crystallized this thought, but I think I'm going to make it part of my own liturgy: **We no longer have business cycles; we have credit cycles.** Central banks and governments, not to mention investment banks and investors, are all using credit in formerly unbelievable ways, and I am here to shout that the world is becoming *one massive finger of instability*.

Let's go back to that 1987 mathematical experiment. The simple fact is there are green sand dots all over the world. They represent stability in the global system, which is allowing the fingers of instability to build up in a potentially deadlier way than we have ever seen before.

While we have had to deal with a virus-triggered recession, we are thankfully watching the economy begin to grow again. It is happening in ways that will make the world look different in 2022 than it did in 2019.

We take comfort from the stability we see around us. Corporate profits are up. We are greeted every day with some amazing new technological innovation that changes everything in some industry. Living standards keep rising.

And yet, Minsky tells us stability breeds instability. That sandpile experiment, as simple as it seems now, shows that the longer the stability lasts, with the fingers of instability connecting in hidden and unknown ways, the greater the avalanche will be.

I suggest you read at least the first half of Nassim Nicholas Taleb's book, *Antifragile*. Here are three lessons that will show you what it means to be antifragile:

1. Fragile items break under stress; antifragile items get better from it.

2. In order for a system to be antifragile, most of its parts must be fragile.

3. Antifragile systems work because they build extra capacity when put under stress.

This is a great way to explain the sandpile game in economic terms. Economic sandpiles that have many small avalanches never have large fingers of stability and massive avalanches. The more small, economically unpleasant events you allow, the fewer large and, eventually, massive fingers of instability will build up.

Efforts by regulators and central bankers to prevent small losses actually *create* the large fingers of instability that bring down whole systems and spark global recessions. And, increasingly, the unfunded liability of government promises will be the most massively unstable finger.

In that crisis, things that should be totally unrelated will suddenly become intertwined. The correlations of formerly unrelated asset classes will all go to one at the absolute worst time. Panic and losses will follow. Governments will try to stem the tide, perhaps appropriately so, but, eventually, the markets have to clear.

There is a surprising but critically powerful thought in that computer model from 35 years ago: **We cannot accurately predict when the avalanche will happen.** You can miss out on all sorts of opportunities because you see lots of fingers of instability and ignore the base of stability. And then you can lose it all at once because you ignored the fingers of instability.

You need your portfolios to both *participate and protect*. Don't blindly buy index funds and assume they will recover as they did in the past. This next avalanche is going to change the nature of recoveries as other market forces and new technologies change what makes an investment succeed.

I cannot stress that enough. Don't get caught in a buy-and-hold, traditional 60/40 portfolio. Don't walk away from it. *Run* away.

Cautious optimism is always the long-term winner. Always. But a buy-and-hold portfolio in today's world is neither cautious nor optimistic. Hope is not a strategy. That's precisely what a buy-and-hold portfolio is.

And with that, I will hit the send button, and as you read this, hopefully, my son Trey and I will find the bass hitting our lines. The food will be great and the conversation some of the best anywhere. You have a great week!

Your in a bit of a philosophical mood analyst,

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