INVESTMENTS & WEALTH MONITOR

*A reprinted article from January/February 2022*

# Assessing Market Vulnerability and Risk

*By Richard Bookstaber, PhD*

INVESTMENTS & WEALTH INSTITUTE®

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Current risk management methods rely on historical price movements, usually over the past year or two. At their foundation is the assumption that the future will be drawn from the same distribution as the past. This might be reasonable for evaluating risk over the very short term (though even in this instance, the approach tends to break down when it really matters, namely in times of market dislocation or crisis). But it's not appropriate for the longer investment time horizon of the registered investment advisor's client.

Most approaches to risk management rely on subjecting a portfolio to some sort of discrete market shock scenario, but the fundamental problem is that the past will not repeat. Even if a perfectly identical shock occurs in the future—to be sure, a dubious proposition in its own right—the market today is not the market of the past, so the impact may vary significantly. Leverage and liquidity are different. There are new strategies and an emphasis on new instruments. Investors might be concentrated in different parts of the market. It's also, by definition, no longer the market's first rodeo. Having learned from experience, investors will engage differently than they did in the first round. Any event will propagate in different directions and through different channels.

To adequately gauge the risk of a client's portfolio we need more than a view of the past. We need to understand the historical market behavior in the context of the market today. In particular, we need to pinpoint and assess market vulnerability as the market stands today. It might well be that a client has more risk than the recent past suggests, with a portfolio that is beyond the level of their individual risk tolerance or even risk capacity.

Market vulnerability is also an important consideration when building scenarios. A scenario posits some sort of market event. It might be rising inflation or a market break in the technology sector. The risk of that scenario comes from two sides: the event's severity and proximity to the market, and the vulnerability of the market to the event. It can be difficult to anticipate the range of possible events and their scale, but we can more easily get a read on the vulnerability of the market.

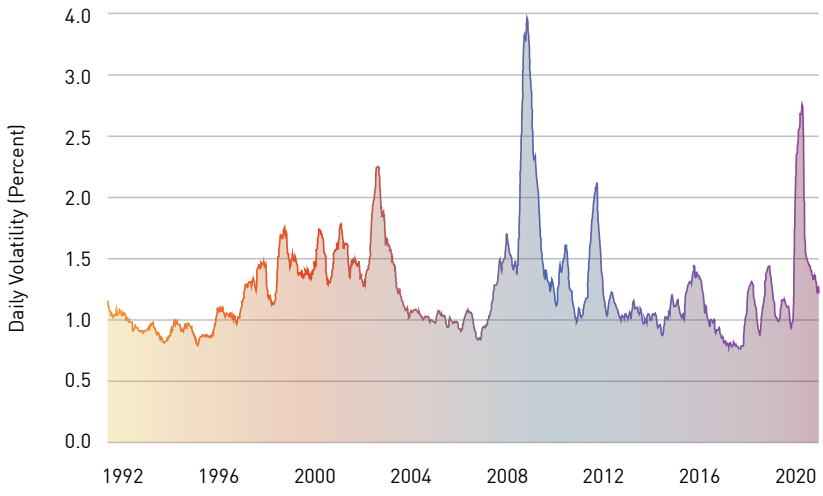
## LEVERAGE, LIQUIDITY, AND CONCENTRATION

Figure 1 charts the volatility of the S&P 500 over the past 30 years. Volatility is measured as the simple one-day standard deviation using daily returns over the past 100 business days.

Note the long-term stability punctuated by periodic peaks. It is clear that any estimate based on history will grossly err near the peaks—the very points of greatest risk concern. Using the period before a peak, say around 1996, will underestimate forward volatility; using the period during a peak, say 2002, will overestimate forward volatility. So, simply put, we need a way to assess the likelihood of a peak—we need to deal with the prospects of high volatility and high risk. That boils down to assessing periods

Figure 1

**VOLATILITY OF THE S&P 500 OVER THE PAST 30 YEARS**




*Source: Bloomberg*

when the market is highly vulnerable along with events that seize upon that vulnerability.

A starting point for assessing risk based on current market conditions is to look at the market through three components: leverage, liquidity, and concentration. A good analogy can be found in how people escape from a fire in a crowded nightclub.

For the fire marshal trying to manage this risk, the critical question is whether the space is too crowded, and this depends on three things: the number of people in the space, how many people can exit per minute based on the number and size of the exits, and the time available to exit based on the flammability of the space.

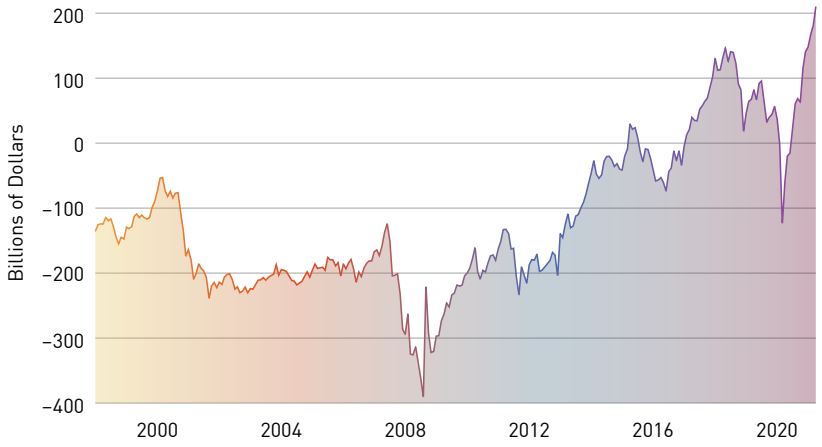
In the financial system, market concentration measures the number of people meaningfully invested in the same stocks or sectors, which is analogous to crowding in the nightclub. Liquidity determines the rate at which investors can exit the market, which is akin to how quickly people can flee the nightclub. Leverage or, more generally, the potential for forced or panicked selling, corresponds to the flammability of the space and thus the time available to make it to the exit.

## LEVERAGE

Leverage is basically a measure of how far investors are out over their skis. They might be ready to fall out of the market because a margin call is forcing them out, or they may simply be out ahead of themselves in terms of the level of risk they are taking and be primed to pull back at the first sign of trouble. Of course, the margin calls are more dramatic and immediate, but in terms of potential broad market impact, selling based on risk tolerance—and fear—is often more destructive.

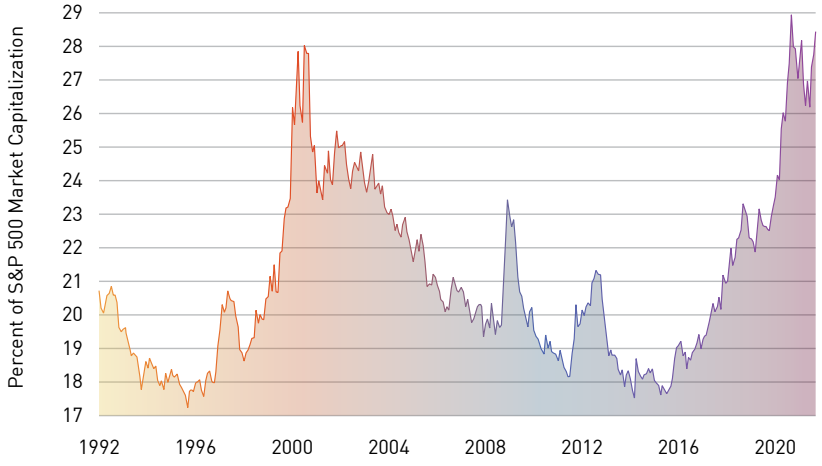
Figure 2 shows where leverage is today. It is a measure of margin, looking at margin debt adjusted for free cash that is immediately available to cover the margin. This measure has been rising over time, but there is a recent surge, with the level of this leverage at an all-time high. Add to this the proportion of household financial assets held in equities, also at an all-time high. This suggests many retail investors are overextended, and this will add selling pressure to the market in the face of a downturn.

**Figure 2 MARGIN DEBT MINUS FREE CASH BALANCES**




*Source: Financial Industry Regulatory Authority*

**Figure 3 CONCENTRATION IN TOP 10 STOCKS OF THE S&P 500**




*Source: Bloomberg*

## CONCENTRATION

Concentration occurs when a disproportionate exposure, as measured by market capitalization, is held in one part of the market, usually in one sector. Before the 2000 bubble burst, there was high concentration in the TMT stocks—technology, media, and telecom. Before the 2008 crisis, there was high concentration in banking and financials, not to mention collateralized debt obligations and McMansions. Before that, there was high concentration in oil stocks. When concentration becomes very high, things finally settle back down and the concentrated portion of the market then declines, sometimes dramatically. With the internet bubble, internet stocks fell more than 75 percent; with the financial crisis of 2008, banking stocks dropped

more than 70 percent. And of course, the market overall headed down, too, although not so dramatically.

Today the concentration is in FAANG (Meta, Amazon, Apple, Netflix, and Alphabet) and related stocks. Figure 3 shows that the top 10 stocks in the S&P 500 make up 25 percent of the index's total market capitalization. For the Nasdaq, the top 10 make up almost twice that. And depending on the method of measurement, technology makes up anywhere between 25 percent and 40 percent of the S&P 500 market capitalization.

So, investors who are holding a market-capitalization weighted index—which most are—might be unwittingly concentrated. And if they start to reduce their exposure, they will be heading out the door with the crowds in a small subset of the index.

## LIQUIDITY

If many investors must get out of the markets quickly, it is no problem if there is enough liquidity in the market—if the exits are wide and plentiful. We care about liquidity when volume is relatively high. This is difficult to measure. A day-to-day measure of exits might show they are more than adequate. What matters is when a crowd tries to go out all at once. We don't get many chances—if any—to see this in practice. Simulation methods are used for the study of unusual periods of congestion such as traffic jams or panicked exits. These same methods can be used to understand the implications that a sudden surge of selling will have on liquidity. I discuss these simulation methods, which are centered on agent-based modeling, below.

## WHAT THIS MEANS FOR THE MARKETS TODAY

Market risk comes from the interplay of vulnerability and events. If a market is vulnerable but that vulnerability is not tested by any market events, then the underlying risk will not become manifest. We cannot predict when or if an event will occur—although we certainly can posit scenarios of events that might occur, and we can, as demonstrated above, get a sense of how things might progress if a spark sets it in motion. But when we look at leverage, concentration, and liquidity in the current market environment, we do not come away with a rosy picture.

Leverage is very high—by some measures at a record high, by other measures at a level similar to 2000—and things did not go well that time around. The same is true for concentration. The only saving grace, possibly, is liquidity. If the Fed can be counted on to be the liquidity provider of last resort the next time around, all is good. Absent Fed action, we have to scan the markets and ask where liquidity supply will be coming from if an event spurs widespread selling. Is there dry powder, and is it in the hands of those who will put that capital into play, buying aggressively in the face of a downward trend? Investor behavior is difficult to gauge, but dry powder, measured as money market assets versus total market value, is the lowest it's been in the past 20 years.

Things get more complicated because leverage, concentration, and liquidity interact. If there is high leverage but low concentration, those forced out are a fraction of the market volume and they can get out the door without causing much disruption. If the markets are illiquid but leverage is low, then investors can take their time moving in or out, accommodating the level of liquidity. If markets are crowded but very liquid, hordes can rush out without a problem.

But messy dynamics are also at work, just like in the nightclub analogy. Calculating the number of people who can depart per minute is difficult, because we are not looking at people walking through the exits in any orderly way. There is the potential for panic, for stampedes. For financial markets, the exits can shrink because liquidity dries up. At the nightclub, the building doesn't become more flammable if the exits happen to be smaller. But in financial markets, a drop in liquidity can propel investors toward the exit; investors who weren't planning to leave or had been inclined to do so in an orderly fashion suddenly start running, knocking down anyone in their way. Likewise, the number of people in the nightclub does not increase as the fire becomes more intense, but in financial markets, bystanders and those who are in other markets get caught up in the panic to flee.

The interactions between concentration, liquidity, and leverage are best understood by looking at scenarios, which try to depict the market effects of various events. A scenario has to be calibrated based on the characteristics of the market in which it occurs. How bad it will be and how long it will take to run its course depend on the market. Complicating the matter further is that relevant, material scenarios often haven't even occurred in the recent past. Take the most widely discussed scenario today, inflation, which has not occurred in the United States for half a century. Does anyone believe that today's market would react to inflation the same way it did when we were all wearing bell-bottoms and three-inch-wide ties?

These sorts of interactions require us to resort to models—not standard financial models with concise mathematical equations that seem to have things all figured out, but ones that admit the vagaries of the market. There is a reason it is called risk. Risk is impossible to pin down and tightly define. The approach for dealing with the complex dynamics of the market, in the context of the current market environment, is robust, simulation based, and adopted from the burgeoning field of complexity theory.

## MARKET DYNAMICS AND AGENT-BASED MODELS

Agent-based models are a form of structured machine learning used to

treat problems such as cascades, which involve complex dynamics and interactions. These models are used to understand traffic flows and to anticipate potential stampedes from panicking crowds. Unsurprisingly, they find an application with markets, too.

*Some market makers move prices more aggressively as they approach risk and capacity constraints. Some investors leverage and de-leverage rapidly in the face of market shocks that push them close to the margin ceilings of their funding agents.*

To get a sense of agent-based modeling, let's look at how it is used in one of its common applications: assessing the risk of traffic congestion.

For traffic flow, the agents are the drivers. Some drivers drive slowly in the left lane, some unerringly follow behind the car ahead, some are lane switchers, zigzagging around slower cars. Individual drivers react to changes in the environment—such as nearby cars and the roadway ahead, which in turn change the environment for other drivers. The result is a complex, constantly changing—and sometimes surprising—nonlinear dynamic system.

If we want to understand the likelihood of congestion on some strip of highway, we can unleash the agent-based model on the problem. We pepper a simulated roadway with various drivers, and second by second the drivers observe their environments. Each second, they alter their actions, changing the environment, with each driver adjusting, again and again. We do this many times, and then look at the distribution of congestion. If we want to understand how a particular scenario or change to the system—perhaps a lane closure or an off-ramp change—might affect traffic, we can introduce that change to the environment and run the simulation again.

Note that the model is looking at the world as it exists in the moment. It is not inferring the potential for congestion based on history. Indeed, when the model is trying to determine the effect of a change, history provides little insight.

In the investment markets, the agents are the full range of investors, traders, market makers, and funders. The heuristics governing their actions and determining their environments start with their objectives and strategies. Some agents trade quickly and look at recent price momentum; others are slower acting and adjust based on deviations from an asset allocation goal. Some market makers move prices more aggressively as they approach risk and capacity constraints. Some investors leverage and de-leverage rapidly in the face of market shocks that push them close to the margin ceilings of their funding agents.

For example, look at the interaction of two types of agents: institutional investors, particularly leveraged investment firms such as hedge funds, and their funding sources, notably the bank or dealer's prime broker, and the asset markets. A cascade can occur when there is a disruption to the market that forces a fund to sell positions. The fund's selling causes asset prices to drop, leading to further rounds of forced selling.

For another example, consider the interaction of the bank or dealer with its cash providers. Funding flows can be disrupted by a decline in the value of collateral or an erosion of confidence. This decline in funding available to the trading desk forces a liquidation of inventory, leading to a price drop, which further reduces funding. Assets and funding affect each other. One can precipitate a rise or a fall in the other or amplify an effect. For example, a cascading drop in asset prices will cause a drop in collateral value, leading to disruptions in funding.

Like the traffic example, the agent-based model in financial markets looks at these worlds from the vantage point of where things stand today rather than how they might have played out in the past. It does not rely solely on history, which likely reflects a different market world, one with different instruments and different strategies used in a different part of the market cycle by investors with a different market view.

By using history to be aware of present market conditions, then building an agent-based model of the market as a complex dynamic system, we integrate the client into the risk picture.

Within a fully specified agent-based model, the client is an agent, and not only because the client's portfolio is, so to speak, one of the cars driving down the road. Clients are part of their own risk pictures. Their risk tolerance and risk capacity will inform their portfolio and investment decisions, and the impact of the market on their portfolios will affect their risk tolerance and capacity. So, we have a dynamic market and a dynamic individual agent.

We acknowledge that time matters—that the future cannot be treated like the past—and that the client matters in the decision process. For most risk applications, the only concern is the market and the only metrics that matter are portfolio returns. Another dimension appears when we look at individuals and their goals. The edges of the portfolio and individual behavior come together to determine risk. This may be self-evident to the advisor, but at this point financial planning applications do not make the connection.

## CONCLUSION

Advisors guide their clients by helping them to balance risk. On the one hand they weigh clients' risk tolerance and risk capacity, and on the other hand they consider how those face off against market risk—forward-looking market risk, not market risk based in the past. Forward risk has two components, events and vulnerability. We can speculate about events through scenarios, although whether and when any scenario may be realized remains uncertain. We can assess vulnerability by monitoring the market characteristics of leverage, concentration, and liquidity, ideally within the framework of a model such as an agent-based model, which allows for the market's dynamic complexity.

We all know the warning that "past performance is not indicative of future results." We all apply this label when discussing the prospects for returns. We should apply it to the prospects for risk, as well. We can't be sure that a portfolio that looks reasonable based on its past level of risk will be appropriate when it comes to forward-looking risk.

Knowing a client's risk tolerance and risk capacity is helpful only to the extent that it can be married to a portfolio with the appropriate risk exposure. Performing that task as accurately as possible is the job of risk management, and agent-based models are the new tool for getting the job done.

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