



Aaron Brown

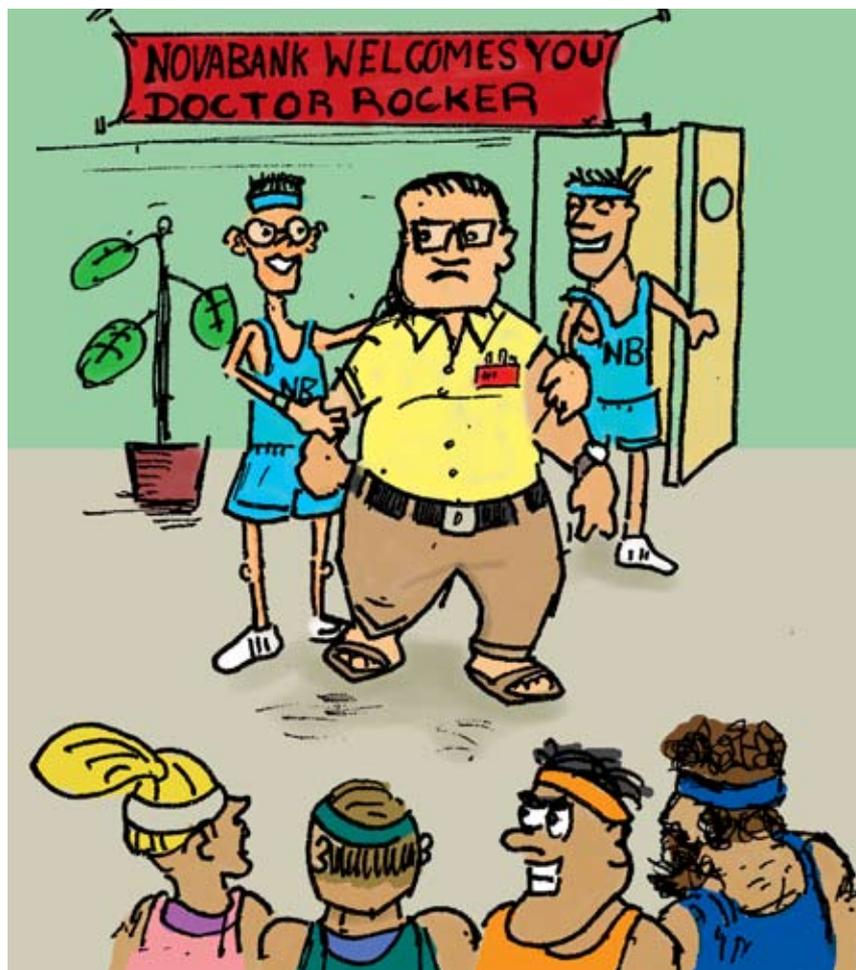
# Old Beds, Standard Deviation, Can Openers, Trampolines, and Risk

Standard deviation is/is not risk...

These days, it's hard to pick up a good anti-quant rant without seeing the phrase, "standard deviation is not risk." The trouble with this thought is it has many meanings, some valid, some absurd; some true and trivial, some false but useful. I'm going to devote this month's column to tracking down the meanings.

I will enlist the help of arguably the two most important American philosophers/cognitive scientists of the 20th century, Daniel Dennett and Jerry Fodor. Dennett looks like a cheerful, absent-minded philosophy professor, Fodor looks like a pugnacious union boss who remembers exactly where the bodies are buried. The two have engaged in many bare-knuckled debates over the years and in 1971, Dennett came up with a great back-handed compliment:

*Most philosophers are like old beds: you jump on them and sink deep into qualifications, revisions, addenda. But Fodor is like a trampoline: you jump on him and he springs back, presenting claims twice as trenchant and outrageous. If some of us can see further, it's from jumping on Jerry.*



The scene was all too familiar to the esteemed visitor

Unfortunately, there aren't a lot of trampolines among the anti-quant crowd. It's not that they resort to qualifications, revisions, and addenda, it's that their basic arguments are too imprecise to interpret. When pressed, they fall back on the charge that precision is a quant

weapon and that truth can only be found through simple, homey, folk wisdom. I don't agree with that charge, but even if I did, it disqualifies the speaker from discussing standard deviation.

Therefore, we're going to have to construct our own trampolines, and try to see further by jumping on them. For the purpose, we will invent a mythical quant named Wandom Rocker who will take the unpopular view that standard deviation is risk. Wandom believes that market prices are a random walk, and the best predictor of future value is current price. He thinks price changes are independent, and relies on the Central Limit Theorem to dampen any moments higher than variance to insignificance over even brief periods of time. Wandom thinks he can measure standard deviation exactly through option prices. If anyone disagrees with him, he can make arbitrage profits. He believes he can buy and sell unlimited quantities at the market price, without slippage or other transaction costs. And even without option prices, he can make accurate statistical forecasts

of standard deviation.

Consumer Protection Old Bed (CPOB) doesn't understand any of that. Her point is that it is misleading to use the English word "risk" to mean standard deviation. Risk is complex and multidimensional.

mensional and means something much more to investors than price volatility.

*Wandom:* If you object to quantitative financial professionals using words like “risk,” how do you feel about physicists using words like “energy”?

*CPOB:* No one is misled by physicists. But when a financial advisor calls an investment “low risk” because it has low historical price volatility, his client is not likely to understand him.

*Wandom:* We agree that a financial advisor should not use words his client will misunderstand. So he shouldn’t speak Swahili to a client who doesn’t know the language. But are you going to forbid anyone speaking Swahili because some investor doesn’t understand it?

*CPOB:* When he speaks Swahili, his client knows he’s speaking Swahili, or at least that he isn’t speaking English. But when he says “risk,” his client thinks he is speaking English.

*Wandom:* Now we’re back to the physicist. What if a patient tells her doctor that she doesn’t have enough energy, and her doctor replies she should put on weight because  $E = MC^2$  and a gram of extra mass equals more energy than she will ever need?

*CPOB:* That never happens. Financial advisors confuse their clients, doctors don’t.

*Wandom:* A debatable assertion, at best. But I agree doctors don’t mislead their clients in that way. Most of them don’t know enough physics. That’s not the point, however. There is no single measure that corresponds to a patient complaining about lack of energy. That’s not a blood test or something you can measure with calipers. So redefining energy wouldn’t help and redefining risk won’t help investors. Physicists and financial quants will continue using precise terms, and doctors and financial advisors will have to communicate with their patients. The issues have nothing to do with each other.

*CPOB:* I don’t care what you say. Standard deviation is not risk.

Our next old bed has a mathematical point, not a language one. Higher Moments Matter Old Bed (HMMOB) thinks the shape of the probability distribution is important, not just the standard deviation.

*HMMOB:* I care about every aspect of my prob-

ability distribution, the entire shape.

*Wandom:* I don’t care about your probability distribution at all. I don’t care much about the shape of mine, because it changes quickly. Only standard deviation endures.

*HMMOB:* That’s theoretical nonsense. Over intervals of practical interest to humans, measures like the 99 percent VaR point and the expected shortfall matter.

*Wandom:* Okay, fine. Do you think you know the shape of your probability distribution?

*HMMOB:* What do you mean?

*Wandom:* Well, if you don’t know the shape, it doesn’t matter whether you care about it or not. It can’t affect your decision.

## I don’t care about your probability distribution at all. I don’t care much about the shape of mine, because it changes quickly. Only standard deviation endures

*HMMOB:* Sure, that’s right. Of course I know the shape.

*Wandom:* For a given shape, all measures of scale are proportional. So I can convert from standard deviation to VaR point, expected shortfall, whatever you want. But I think that’s all theoretical nonsense, I don’t think you know anything useful about the shape of a diversified portfolio held over a reasonably long period of time. Higher moments might matter for individual positions or over short time intervals, but they wash away quickly.

And if they don’t, no one knows how to predict them anyway.

*HMMOB:* Maybe so, but what if your position is levered? Then you have to care about the probability of blow-up.

*Wandom:* Not really. If you buy a house for \$500,000 and borrow \$400,000, there’s nothing special about the value of the house falling under \$400,000. You’ll decide to sell or not, but the lender won’t force you. If you have demand leverage, like public futures or prime brokerage

financing, you can adjust the level of the financing, hence the volatility of the position, anytime. The unmanaged position’s risk might not be captured by standard deviation, but the risk of your position is.

*HMMOB:* How about if your position is levered with demand funds, and illiquid?

*Wandom:* Then standard deviation cannot be estimated or even defined. I don’t claim standard deviation is a useful measure of risk for any situation. I claim that in finance when standard deviation is available, it is the best measure to use.

Location Old Bed (LOB) is concerned with the location of the distribution, not just the standard

deviation. He wants to use something like downside volatility, semi-variance, underperformance risk, benchmark lagging, or drawdowns to measure risk.

*LOB:* Let’s say you own a stock and someone staples a lottery ticket to it. Are you telling me it just got riskier, because the combined securities have higher standard deviation than the stock alone?

*Wandom:* Absolutely it has more risk. There is more uncertainty about future value.

*LOB:* That’s crazy. So you’d tear off the lottery ticket and throw it away to reduce risk?

*Wandom:* No I wouldn’t. The additional expected return more than compensates for the additional risk.

*LOB:* What additional risk? You can’t lose anything you wouldn’t lose owning the stock alone.

*Wandom:* Yes I can. I can lose the expected value of the lottery ticket.

*LOB:* But you got that ticket free.

*Wandom:* That’s irrelevant. However I got it, I own it now, and if it goes down in value, I lose.

*LOB:* You can't tell me that all losses hurt equally. The difference between making \$10 and making \$20 is less than the difference between losing \$5 and making \$5.

*Wandom:* The difference is exactly the same. \$10. Do the math if you can.

*LOB:* But what if I'm broke and can't afford the \$5 loss?

*Wandom:* Then the difference is between zero and making \$5, so it's only half as great as the difference between making \$10 or making \$20.

*LOB:* But what if losing money I don't have means I go to jail, or get shot? Certainly that's a bigger loss than \$10.

*Wandom:* Not at all, I think it would be a gain.

*LOB:* Very funny, suppose it was you who faced jail?

*Wandom:* Then the gamble is between some large negative amount, say minus \$10,000, and making \$5. Sure, then it is bigger than the difference between making \$10 and making \$20. But you're redefining the outcomes, not challenging the measure. Standard deviation is the right measure either way.

## You're living in a mathematical dreamland. On Earth, losing money matters

*LOB:* You're living in a mathematical dreamland. On Earth, losing money matters.

Value Investor Old Bed (VIOB) read Graham and Dodd's Security Analysis and says risk is the chance of permanent loss of capital. It has nothing to do with Mr. Market's unstable booms and busts of prices.

*Wandom:* You're misinterpreting Benjamin Graham. If you own a copper mine, and the price of copper goes down, you will have less revenue. That's a loss and Graham recognized it. However a temporary fall in the price of copper has a small effect on the value of the business. The temporary loss in revenue is real, and is risk. But there is small permanent loss of capital.

What Graham contrasted that to is paying a high price for a company based on predictions of

future earnings growth, and the plan to sell it to someone else rather than live off the earnings. For this company, one quarter of disappointing earnings could permanently reduce the market price of the stock, and you have no fundamental earnings value to fall back on.

Graham's argument was that the standard deviation of a value investment is smaller than the standard deviation of a growth investment. He didn't put it that way, but he was the last person to recommend overlooking a loss because it wasn't permanent. Temporary losses, that is declines in cash flow, are inherent to any kind of investing. They're real, and they're risk. Graham believed careful analysis could help you avoid additional permanent losses, when the decline in cash flow sets off an unfortunate spiral.

*VIOB:* You're the misinterpreter. Graham didn't care about Mr. Market's opinion. The risk of a stock is the long-term prospects of the business. If you own a copper mine, the market may double the price of the mine every time copper goes up and halve the price of the mine every time copper goes down, but that's not risk. The mine will

make money over the whole commodity cycle, and that's what matters.

*Wandom:* That's funny, I seem to recall Graham saying you should sell to Mr. Market when he got euphoric, and buy everything back cheaper when Mr. Market panicked.

*VIOB:* So? Of course that's what you do.

*Wandom:* That doesn't sound like not caring about Mr. Market's opinion. It sounds like Mr. Market's opinion is how Graham wanted to make money.

*VIOB:* Yes, but for Graham, standard deviation was opportunity, not risk. Standard deviation is what allowed him to buy low and sell high.

*Wandom:* Careful there, you're confusing two standard deviations. Graham believed that Mr. Market's standard deviation was the value investor's opportunity. But what of the standard

deviation of the value investor's portfolio? That was a risk.

*VIOB:* No it wasn't. It didn't matter if the market price went up or down, only the long-term value was important.

*Wandom:* And the value investor knows the long-term value for certain because...

*VIOB:* Of course he doesn't know for certain. The point is that Mr. Market's opinion contains no information.

*Wandom:* That's demonstrably wrong empirically. But say I stipulate that market prices have no information. You can still buy and sell at them. If the market price of your portfolio goes down, you can buy less with it.

*VIOB:* But that loss is offset by your higher expected future return. Remember, you stipulated that the change in market price has not changed your beliefs about the long-term future value.

*Wandom:* You can't say the two things offset. You have a loss. You think you also have an improved future opportunity. The loss was on the amount you happened to have invested at the time the price declined. The future opportunity is on however much money you can raise for investment today. For someone with all her money in the market, who needs the funds to live on, the future opportunity is worthless. For a billionaire with excellent credit who had only a trivial amount invested in the market, the future opportunity overwhelms the market value loss.

*VIOB:* So?

*Wandom:* So standard deviation is risk. Like all risk, it presents dangers and opportunities, dangers to the money you have invested in the market today, opportunities for future investments. Or you can just as well think of market rallies as opportunities for the money you have invested in the market today and dangers for your future investment return.

*VIOB:* But, standard deviation is determined by an idiot: Mr. Market.

*Wandom:* I happen to respect Mr. Market's intelligence. It's yours that I don't. But Mr. Market's IQ is irrelevant, it's his bank balance that matters. As long as Mr. Market has the money to back his opinions, they present dangers and opportunities to all investors, whether Mr. Market is the wisdom of crowds or the madness of crowds.

Finally, we have an attack from Statistical Old Bed (SOB). Her gripe is that we can't predict standard deviation. Quants size positions based on historical standard deviation, so positions are by definition biggest when market volatility starts to increase. Thus the real risk, the crash or disaster risk, is caused by standard deviation, not measured by it.

*Wandom:* Estimating tomorrow's standard deviation? I can use implied volatility from option prices plus sophisticated Bayesian time series techniques on historical data to improve the estimates. I have a backtest showing high accuracy.

*SOB:* Sure, that works most of the time. Until it doesn't. Then you quants crash and burn, and take the rest of us down with you.

*Wandom:* That's largely a myth. Almost all market disasters are preceded by volatility increases. Careful attention to standard deviation has been a reliable tool for risk control over many market cycles.

*SOB:* "Almost" but not all.

*Wandom:* Sure. I don't say standard deviation is perfect. But nothing else works better. And if you don't have anything else, the only alternative is constant position sizes. That's suicide.

*SOB:* Well, I don't have anything better. But I know using standard deviation as a constraint is a crazy way to build a portfolio.

*Wandom:* The trouble isn't with maximizing Sharpe ratio, which amounts to maximizing excess return under a standard deviation constraint. The problem is people sometimes do it by estimating lots of correlations. Correlations are unstable and there are too many of them to estimate reliably. The problem is the way people maximize Sharpe ratio, not the goal. With robust optimization techniques, standard deviation works fine.

*SOB:* You're missing the point. Standard deviation says bonds are safer than stocks, but I am highly confident that over the next ten years bonds will underperform stocks. How can it be safe to almost certainly underperform?

*Wandom:* I am far less confident than you. Also, if stocks do underperform bonds, they could do so by a lot. And it's trivial to say that the safer investment could underperform. A sure dollar is

safer than a coin flip, heads you get one million dollars, tails you get two million. Everyone would prefer the second investment, but it's still riskier.

The more important point is that standard deviation is not a measure of individual position risk, it's a measure of portfolio risk. The choice is not stocks or bonds, but what combination of stocks and bonds produces the best Sharpe ratio. While that requires forecasting expected returns, which is nearly impossible, you will get better portfolios by careful attention to the portfolio standard deviation. That can be forecasted.

predicting long-term strategy standard deviations. Only with active management of volatility levels, and hedging, and luck, can you bring the volatility in on target.

Wandom's faith in option implied volatilities is misplaced. Changes in implied volatilities are a useful signal, but they are poor estimates of future realized standard deviation. And even in the most liquid markets, you cannot buy and sell unlimited quantities at the market price, without slippage or other transaction costs.

So standard deviation is not risk, but not

## It may be time to remind you that Wandom Rocker is wrong. He is our trampoline. We are jumping on him to see farther.

## He is wrong because market prices are only close to random walks most of the time, in the more liquid markets

*SOB:* You're putting your faith in a fogged rear view mirror. Look at the road ahead instead.

It may be time to remind you that Wandom Rocker is wrong. He is our trampoline. We are jumping on him to see farther.

He is wrong because market prices are only close to random walks most of the time, in the more liquid markets. It is possible to make predictions of future value that are better than current price. Price changes are a long way from independent. They're not even uncorrelated, but more important, volatility and other distributional features are changing. The Central Limit Theorem does work well, better than most quants assume, to suppress higher moments over time; but the joke is we have little idea what the mean and standard deviation is of the Gaussian distribution we will approach. More to the point of this essay, current estimates of short and medium-term standard deviation are virtually no help to

for the reasons the anti-quants think. There are specific reasons listed in the two paragraphs above that limit the direct translation of standard deviation to risk. Not all of them apply in all markets all the time, and even when they do apply, standard deviation is a useful concept to understand risk.

We started with a quote from Daniel Dennett about Jerry Fodor, we will end with a quote from Jerry Fodor:

*If you don't know what a can-opener is for, you are going to have trouble figuring out what its parts do. In the case of more complex machines, like for example people, your chance of getting the structure right is effectively nil if you don't know the function.*

Markets aren't as complicated as people, but they're more complicated than can openers. If you don't know what markets are for, you are going to have trouble figuring out what standard deviation has to do with risk.