Random Walks, Chaos, and Volatility

New research suggests that market movements may be predictable.

by Steven R. Cunningham, PhD, Director of Research and Education

In recent weeks the financial markets have been in convulsions. Price volatility has hit new highs. As a result, many are panicking. Some argue that this volatility is not consistent with finance theory—that markets evolve in orderly random walks according to the efficient markets hypothesis (EMH). The current volatility is enough to challenge the validity of the accepted theory.

Most people associate EMH with the idea that throwing darts at the financial page is as likely to produce good results as is the most high-powered stock analyst. But there is more to it.

The notion underlying EMH is simple enough. Markets run on information. People buy and sell in response to news that affects their current and future valuations of securities. Since new information arrives randomly, changes in the prices also will be random. A price series in which changes are random is referred to as a random walk.

Famed scholars Paul Samuelson, Eugene Fama, and Benoit Mandelbrot, among many others, have demonstrated rigorously that EMH leads to random walks. In fact, we have come to question the very idea of randomness. According to mathematical chaos theory, most of what we know as random is simply... complicated. This is highly significant. If stock prices are not random, but are based on some discernible, underlying generating process, then they can be predicted—hence the interest in employing rocket scientists on Wall Street.

On the other hand, if EMH holds, financial or economic series must evolve as random walks, which require certain forms of analysis. This has led economists and financial analysts to want to find out whether a given series is, in fact, a random walk.

Statistical tests for random walks boil down to determining whether a certain critical mathematical parameter, called the root, is equal to one for a specific series. Because informational efficiency is a natural by-product of a market economy, unit roots (or roots equal to one) do not only occur in securities prices. Most of the important economic series, including GDP, exchange rates, and sales figures, may be also unit root processes. These series appear, at least, to form random walks.

In a sequence of articles in the early 1980s, researchers were able to demonstrate that almost every analysis performed on economic and financial data was at best suspect, and at worst garbage, if the researchers did not know the series were random walks. Random walks have no trends or patterns, so most methods of securities technical analysis are futile. This implies that before you can do any analysis on economic or financial series, you need to find out if it is a random walk. If it is, then beware.

But just when economists thought we had a handle on something critical, an important obstacle arose. It proved to be extremely difficult to empirically demonstrate...
that a series is a random walk. In other words, the unit root tests don’t work very well.

Markets themselves also suggest a challenge to the notion that their changes are random.

If the markets are so efficient and are discounting all available information, how could broad swings occur? What would explain the volatility we have seen recently?

The explanation from EMH is that new information must be entering the marketplace. But it seems that there are wild swings in the market even when there is no new information. It also seems that when there is new information, the market swings are disproportionate, even extreme. One explanation for this apparent mystery is that the market is not random—driven by unpredictable and unknowable forces. It is mathematically chaotic, which means it is complex rather than random, and exquisitely sensitive to small changes.

Take a look at the chart above. This could easily be passed off as the price history of some stock or even a stock market index such as the Dow Jones Industrial Average. It passes every econometric test for a random walk. An economist or financial analyst would feel justified in applying the techniques of standard securities analysis to such series.

The problem is that the series is not random at all. I generated it from a simple mathematical formula related to the quadratic equations people study in high school algebra. Since this series is generated by a simple algebraic equation and contains no randomness, it is a trivial exercise to forecast the entire series. If this were a stock series, this would amount to knowing all the future prices of the stock before you buy!

It is not always easy to tell the difference between randomness and chaos. But the difference is critical. Chaos can be predicted, whereas randomness cannot.

Here’s another peculiarity. The starting price of the series is 100. Change the starting price by even a tiny fraction, say to 100.0001, and the series looks entirely different. This sensitivity to initial conditions is characteristic of mathematical chaos.

More generally, chaos theory is a branch of nonlinear mathematics. In nonlinear relationships, changes in variables have a disproportionate response to changes in other variables. A tiny change in one thing can have a huge impact on another.

This in turn implies that broad price swings should be the norm. It explains the volatility we have seen in the markets. Small changes in other markets or in government policy, or shifts in anxiety levels among market participants, can cause disproportionately large swings in the market.

Chaos also incorporates near-cyclical change. If you examine the series in the chart, you will see variation that looks almost cyclical—similar to what you see in real-world stock series. That is, there is a variation that is almost regular.

We also see similar patterns in series such as GDP. We often describe business cycles by saying that while there are stylized facts regarding business cycles, no two recessions are exactly the same. Eerily, chaos seems to fit reality.

As a result, economists have been hard at work to find or create tests for chaos in economic series. Frank and Scheinkman (1986), for example, find evidence of chaos in the stock market, while Barnett and Chen (1987) find evidence of chaos in certain monetary aggregates. My own research has focused on discriminating between random walks and chaos, and understanding the implications in practice.

The tests and measures for chaos in series are revealing—to a point. For example, we can use a computer random number generator to create a “random” series. Computerers only understand patterns and rules, so the series really could not be random. Typical statistical tests tell us that the series is random, but generalized chaos tests tell us that the series is not random at all. They also tell us something about the level of complexity involved. The computer-created “random” series is actually chaotic with a dimension of six or seven. In contrast, a purely random process has a dimension of infinity.

In other words, the computer-constructed series appears random. It isn’t. But the algorithm creates a series complicated enough to fool most tests.

Many things that appear to be random, and therefore unpredictable, are not. Theoretically, at least, we might be able to know what the winning lottery number will be. More importantly, we might be able to beat the stock market and make huge profits.

Markets appear random, but we know that prices are the products of countless buyers and sellers all systematically expressing their interest in bids and asking prices. Markets are complex, not random. It is only when the complexity exceeds
our ability to compute that we call something random.

Statisticians often use the word “stochastic,” to refer to things that cannot be predicted, except in terms of broad probabilities. “Deterministic” is the opposite of random. Deterministic things are entirely knowable and can be perfectly predicted. Chaos is deterministic. If markets are chaotic, then we don’t have to guess or take odds—we can know whether the prices are going up or down. Chaotic markets look random, but they are not.

As Brock and Sayer (1988) point out: “There is a deep philosophical question concerning the difference between determinism and stochasticity or ‘randomness.’ Indeed it can be said that the more you think about randomness the less random things get.”

But we are a long way from being able to use these insights to predict market behavior.

In the real world, it turns out that chaos is extremely difficult to test for. Specialized chaos tests have limited power because real-world data have noise, irrelevant factors that can’t be statistically eliminated. Real data also contain random variation related to measurement and valuation errors. GDP and price levels are estimated, not computed. Stock prices have a variety of random errors related to informational problems, trading systems, discrete price increments, etc. In the presence of noise, my own research shows that it is nearly impossible to get consistent and reliable tests for chaos. With current technology, it may be impossible to completely detect chaos in economic or financial data.

Simply testing for chaos is not enough. To put the practical implications of chaos to use, the underlying data-generating process also needs to be identified. Traditional econometric methods typically focus on identifying linear relationships. But linear is one of an infinite number of possibilities, and chaos is nonlinear.

To test for chaos exhaustively, you would effectively have to test an infinite number of possible specifications. Specialized chaos tests tell us something about where to look. If only they were more reliable…. This is one of the reasons why economists and financial analysts continue to use linear analysis. It is easy. It tests a single type of specification.

It is also not clear that treating chaotic series as if they were random causes problems. It may be that with sufficiently complex series the methods based on assumptions of randomness produce solid, reliable results.

But the unknowable future may bring new information about this as well.

For the present, there is every reason to believe that modern portfolio theory and the EMH upon which is it based will continue to produce the best possible results. All the best research tells us that a well-diversified portfolio, built according to the principles of modern portfolio theory, will produce the highest returns with the lowest risk. It remains the best approach to long-term investing.

The techniques for uncovering the underlying nonlinear relationships, the chaotic relationships, are sort of the Holy Grail of finance. Crack this nut, and you can systematically predict future stock prices, and make a fortune. At least for a while.

Shortly after one person has the underlying nonlinear relationships worked out, so will everyone else. Economics tells us that people will trade on this knowledge and attempt to out-maneuver each other. In other words, another, higher level of complexity will arise, thwarting the efforts of traders.

In any case, if and when it does happen, we’ll be on top of it. You and AIER’s wholly-owned subsidiary American Investment Services (AIS) will be the first to know. And you’ll be in there with the best of them.
Social Security Checks Slated to Go Up

The index that determines benefit increases has finally surpassed the 2008 level.

by Polina Vlasenko, PhD, Research Fellow

Beginning January 2012, American retirees will be getting a cost-of-living increase in Social Security payments for the first time since 2009. The cost-of-living adjustment, or COLA, as it’s commonly called, triggers a number of other changes that have implications not only for retirees but also for people currently working.

The COLA is tied to the Consumer Price Index for Urban Wage Earners and Clerical Workers (CPI-W). The percentage change in this index from the third quarter of one year to the third quarter of the next determines the size of the COLA.

At the time of this writing, not all data are available to compute the exact value of the CPI-W in the third quarter of 2011. The value of the index for September 2011 will be released on October 19, several days after we go to print. Nevertheless, the trend in the chart above clearly indicates that COLA will be positive. We estimate it will be between 3.5 and 3.7 percent.

The chart also explains why there has been no COLA for the past two years. The law specifies that the COLA cannot be negative, even if prices decrease. From 2008 to 2009, that’s exactly what happened, and the COLA was zero in January 2010.

In January 2011, there still was no COLA, even though the CPI-W increased from 2009 to 2010. The COLA is triggered only if the index surpasses the value it had the last time the COLA was positive. In this case, the CPI-W had to surpass its value of the third quarter of 2008, shown on the chart by a dotted line. That didn’t happen until this year.

The COLA that will come into effect in January 2012 will be determined by how much the value of CPI-W in the third quarter of this year exceeds its 2008 value, not by how much it increased over the past year.

A positive COLA triggers several automatic adjustments that affect people other than retirees. One such adjustment pertains to the maximum amount of earnings subject to the Social Security payroll tax.

This change is triggered by COLA, but is not equal to it in size. Instead, it is based on the increase in the national average wage index. The maximum earnings subject to Social Security tax has been constant at $106,800 since 2009. The increase triggered by this year’s COLA will be determined by the Social Security Administration in the next few weeks. If the average wage index increased, the maximum earnings subject to tax may also increase.

There are other automatic adjustments triggered by changes in the average wage index and the COLA. They affect Supplemental Security Income benefits, retirement earnings exempt amounts, and the earnings required for one Social Security credit.

The complete list of all automatic adjustments will be published in the Federal Register in late October. The Social Security Administration also usually publishes them on their website at http://www.socialsecurity.gov.

If Medicare Part B premiums are deducted from Social Security benefits, an increase in the premiums may cut into the COLA increase or even eliminate it. The Centers for Medicare and Medicaid Services determine Medicare premiums, which are usually published in the Federal Register in early November.