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Evidence for Mean Reversion in Equity Prices

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In this paper we review the evidence for and against the existence of long-term mean reversion within equity prices.

Definitions and Initial Observations

In simplest terms*, mean reversion* refers to any negative correlation between stock price movements in one period and subsequent periods. If such a correlation exists, then it will be possible to predict, with better-than-even accuracy, how stock prices will move in a given period based on how the prices moved during prior periods. Thus, if a stock showed a below-average return during one period and its price movements were mean reverting, then the price would be more likely than usual to show an above-average return during the subsequent period. If a stock price has this property then it is also said to exhibit *memory*, as future price movements depend on prior price movements rather than moving according to the same random distribution each period.

The property of equity prices reverting to the mean is distinct from the property of showing positive returns. The fact that an equity index shows positive returns on average does not imply that it is mean reverting: in order to establish mean reversion, the index would have to have returns that are higher on average after a downward movement in the index than they are after an upward movement. The property of mean reversion is also distinct from the property of moving in cycles. As an example, regime-switching lognormal models move randomly between boom and bust cycles, with higher average returns in boom cycles following lower average returns in bust cycles. However, these models are not mean reverting because the beginning and end points of the cycles are random and do not depend on how long the current cycle has persisted, nor on the returns that have occurred within the cycle.

In assessing a claim of mean reversion it is important to specify the length of the period over which the reversion is claimed to occur. If it is claimed that the reversion occurs over periods measured in weeks or days, then the phenomenon is described as *short-term mean reversion*. It may also be described as *momentum*, since the short-term returns may be positively correlated rather than negatively correlated. If it is claimed that the reversion occurs over periods measured in years, then the phenomenon is described as *long-term mean reversion*. Questions about the existence of short-term mean reversion form a distinct area of study from the existence of long-term mean reversion. Because there is more data available to measure short-term returns than there is to measure long-term returns, many more academic papers have been published on short-term mean reversion than on long-term mean reversion. The question we specifically address here is the existence of long-term mean reversion.

From the perspective of an insurance company writing equity guarantees, mean reversion is highly desirable, as any decrease in stock prices during a period is more likely to be offset by stock price increases in subsequent periods, which lowers the likelihood of having to make a guarantee payout. Thus, models that assume that stock prices revert to

the mean over the long term will produce lower reserve and capital requirements than models that assume that stock prices are truly random (i.e. uncorrelated from period to period).

However, the existence of mean reversion would contradict the Efficient Markets Hypothesis, which states that stock price movements cannot be predicted based on previous movements. If they could be, then traders would be able to earn excess returns (i.e. in excess of the overall market return) by buying stocks that have had lower-than-average returns in prior periods and short selling stocks that have had higher-than-average returns in prior periods. However, if there really is money to be made by following this strategy, what will happen (according to the hypothesis) is that traders alert to this opportunity will, in the current period, push up the prices of stocks that underperformed in prior periods and pull down the prices of stocks that overperformed in prior periods, so that the opportunity to make an excess profit will vanish. For this reason, tests of whether mean reversion exists are considered to be a subfield of tests of market efficiency.

Academic Literature and Economic Considerations

The body of academic literature on long-term mean reversion is more tractable than that on short-term mean reversion. The primary case for the existence of long term mean reversion was made in two papers published in 1988, one by James Poterba and former US Treasury Secretary Larry Summers [1], and the other published by Eugene Fama and Kenneth French [2]. In summary, what these papers conclude is that for period lengths of between 3 and 5 years, long-term mean reversion was present in stock market returns between 1926 and 1985. Three-year returns showed a negative correlation of 25%, while 5-year returns showed a negative correlation of 40%. However several people have questioned whether these results actually establish the existence of long-term mean reversion. Some of the problems identified by Fama himself in [2] and [3] are:

- The tests used in both papers have very little statistical power, i.e. the results could plausibly be due to pure chance. With long time horizons, there are not enough independent data observations available for statistical tests to be robust.
- The results in both papers are almost all accounted for by stock returns before World War II (1926-1940). If returns from this time period are removed from the data set then mean reversion disappears.
- In any time series analysis, it is impossible to distinguish between irrational (hence inefficient) bubbles or crashes, and rational variations in expected returns that occur randomly over time.

Two widely cited papers that argue against interpreting the results in [1] and [2] as evidence of mean reversion are by Kim, Nelson and Startz [4] and by Matthew Richardson [5]. Kim et al. noted that previous tests depended on the assumption of normality of stock returns. Using computationally intensive methods that are free of distributional assumptions, they concluded that the behaviour of stock returns changed at the end of World War II, with the evidence for long-term positive correlation after the

war being just as strong as the evidence for long-term negative correlation before the war. Richardson, using simulations, demonstrated that large autocorrelations between returns in the 3-5 year range are consistent with (i.e. do not disprove) the hypothesis that long-term stock returns are truly random, because autocorrelations within this range are subject to high sampling variation. Some researchers reject the existence of long-term mean reversion while accepting the existence of short-term mean reversion. For example, Andrew Lo published a paper [6] in 1988 concluding that weekly stock returns are positively correlated and do not follow a random walk. Even so, he did not conclude that this is evidence of market inefficiency, and then published a paper [7] in 1991 concluding that there is no evidence of long-term mean reversion for any index once short-term mean reversion is taken into account.

It should be noted that even if long term mean reversion has occurred in the past, there may still be doubt as to whether it will continue to occur in the future. There have been several examples of short-term mean reversion or other market inefficiencies that were clearly proven to exist (e.g. the small firm in January effect), but which then just as clearly disappeared after their existence was publicized in the literature. The fact that the strongest evidence to support long-term mean reversion occurs in the earliest part of the data series may be a sign that it is no longer present.

Beyond detailed statistical analysis, there are more general economic reasons that suggest caution in assuming mean reversion. Past experience has shown that growth rates of national economies in real terms are not inherently mean reverting over the long run, even if they appear to exhibit cyclical fluctuations over short periods of time. Long run economic performance in real terms is generally a function of population and productivity growth, neither of which are inherently mean reverting. Since the performance of many asset classes has a tendency to be broadly linked to economic growth prospects, this casts doubt as to whether mean reversion in equity prices will always occur.

Another factor affecting equity prices is the behaviour of risk preferences. Major shocks like the 1929 equity market crash and the collapse in Japanese equity prices in 1990 were accompanied by fundamental reassessments of risk and changes to the public's risk appetite that lasted many years. Regardless of actual growth prospects, public distaste for holding equities following a crash may hamper price recovery.

As a final consideration, we can look to the market to see what its consensus view is on mean reversion. If market participants truly believe that equity markets revert to the mean over the long run then this should be observable in option prices, which reflect the market price of hedging long-dated equity guarantees. In particular, the cost of purchasing put option protection against a long-run decline in equity markets should be minimal. However, the cost of purchasing such protection is in fact very expensive, if it is available at all, which suggests that the market does not believe in mean reversion.

The Drawdown Model

We now examine one particular model, called the *drawdown model*, which is developed in [8]. This model has thus far been confined to Canadian actuarial circles and has not been cited in the broader economics or finance literature. The way that this model incorporates a mean reversion assumption is by adding a term to the expected return equation that is proportional to the difference, if positive, between the value of the index at its last peak and its current market value. Adding such a term is equivalent to assuming that after an index has crashed from a peak, the market will exert pressure for the index to return to the previous peak, so that average returns will be higher than when the index is on an upswing. This model is asymmetric: it contains an additional term that boosts returns when an index is below its previous peak, but there is no similar term that dampens returns when the index is rising above its previous peak. Consequently, the model assumes that all mean reversion is to a company's benefit.

An argument that has been put forth in support of this model is that, after experiencing a crash, equity markets tend to recover to a new peak within a reasonable period of time. However, the fact that most stock indexes have recovered to their previous highs after a crash does not constitute evidence of mean reversion, because the natural tendency of any stock index is to increase over time. A more robust test would involve comparing expected recovery times in the presence of mean reversion against expected recovery times in its absence. Thus, cited examples of past recoveries amount only to anecdotal evidence. Counterbalancing this are several examples where the time taken for an index to recover has been extremely long or has not yet occurred:

- The Dow Jones Industrial Average did not return to its 1929 high until 1954, representing a recovery time of 25 years.
- The NASDAQ Composite Index, after 12 years, is still only at 60% of its January 2000 high.
- The Nikkei 225 index, 22 years after its peak at the end of 1989, has still not recovered and is currently worth less than a quarter of its all-time high.

The probability of any scenario similar to the above three occurring under the drawdown model is vanishingly small, which calls into question whether this model accurately represents real-world equity returns.

Conclusion

The claim that equity returns revert to the mean over the long term is not completely unfounded, and cannot be dismissed out of hand. However, there is at least as much evidence to refute this claim as there is to support it, and there is certainly no consensus answer within the economics profession. OSFI must therefore rely on its own judgement as to whether to accept mean reversion assumptions in modeling segregated funds.

As noted earlier, assuming mean reversion within a model will lead to a significant decrease in the reserve and capital requirements that are determined by the model. Using such a model will also affect how companies view and manage their segregated fund guarantee risk: if mean reversion really does exist, then there is little need to hold reserves for, capitalize or hedge guarantees that are payable beyond a period of about five years. According to this view, while there may be some short-term market drops that will trigger guarantee payouts, over the long term mean reversion will make up for them, thereby rendering the prospect of payouts on the bulk of a company's business unlikely.

Given the large reduction in segregated fund guarantee reserve and capital requirements that would result from assuming mean reversion in equity returns, it would not be prudent for OSFI to approve equity return models that are based on the assumption of mean reversion without strong evidence that mean reversion actually occurs in the market and is likely to continue in the future. The current state of research does not provide such evidence to a sufficiently high degree of certainty.

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