Challenges to Stock Market Efficiency: Evidence from Mean Reversion Studies

By Charles Engel and Charles S. Morris

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Analysts have traditionally regarded the stock market as an efficient market because they believe stock prices reflect the market value of future dividends. Dividends, in turn, depend on a company's profits. As a result, stock prices should change only in response to new information about future profits. For example, a company's stock price will rise if it patents a new way to harness solar power because future profits will rise. Conversely, its stock price will fall if its chief competitor discovers the new way first.

In recent years, however, many analysts have begun to question the efficiency of the stock market. What information, they ask, could have possibly caused the profitability of the companies in the Dow Jones Industrial Average to fall 23 percent on October 19, 1987? These analysts claim the stock market is inefficient because many traders pay attention to information unrelated to future profits. For example, some traders may jump on the bandwagon and buy stocks only because past returns were high. While prices will ultimately reflect true values, such behavior causes prices to overshoot true values in the short run. The tendency for prices to overshoot but eventually revert to true values is called *mean reversion*.

Is the stock market efficient? This article surveys the mean reversion evidence. The article finds that stock prices might be mean reverting, but the evidence is not strong enough to rule out market efficiency. The first section of the article discusses the features of an efficient stock market. The second section shows why prices may be mean reverting in an inefficient stock market. The third section shows that the evidence on mean reversion is mixed. Thus, more evidence is needed before declaring the stock market inefficient.

Efficient Markets

The efficient market theory describes how prices are determined in a securities market. In an efficient stock market, a stock's price reflects the current market value of its expected future income stream. If a stock's price is less than the value of its expected income stream, investors will quickly buy the stock. As they do, the price will rise until it equals the current value of the income. Conversely, if a stock's price is above the current value of expected income, selling pressure will quickly drive down the price to its current value.[1]

The income from a stock can be divided into two parts. One part is the dividends that are paid over the investment horizon. The second part is the price for which investors can sell the stock at the end of the investment horizon.

The market value of the expected income from a stock depends on the size of the income stream relative to the return on other investments that are equally risky. The return on equally risky investments can be represented by the inflation-adjusted, or real, interest rate on such investments. The real interest rate on a risky investment is the sum of the real interest rate on a riskless investment, such as Treasury bills, and a risk adjustment factor that rises with the riskiness of an investment. Thus, the current price of a stock, P_0, is

$$7P_0 = \frac{ED_I + EP_I}{1 + r} \qquad (1)$$

where ED_I is the dividends that investors expect to be paid at the end of the investment period, EP_I is the expected end-of-period price, and r is the real interest rate.[2] Thus, a stock will have a high price if it is expected to pay high dividends (high ED_I), if it is expected to appreciate rapidly (high EP_I), or if it is not very risky (low r).[3]

One feature of an efficient stock market is that highly profitable companies will have higher stock prices than unprofitable companies. In an efficient market, stock prices reflect the market value of future dividends, which ultimately depend on profits. Thus, stock prices reflect the market value of a company's future profits—that is, the company's *fundamental* value.

The economy benefits when stock prices reflect fundamental values because investment funds flow to their most valuable uses. Companies with profitable investment opportunities have high fundamental values, while companies without such opportunities have low fundamental values. As a result, companies with profitable investment opportunities can sell their stock for a higher price, and therefore get more investment funds, than companies without such opportunities.

A second feature of an efficient stock market is that expected real returns on stocks should be constant and equal to the real interest rate (Figure 1). Like most stock price indexes, such as the Dow Jones Industrial Average, the price in the figure includes the returns from dividends so that the percentage change in price is the total return.[4] If the real interest rate is constant over time, prices will grow along a straight line with a slope equal to the interest rate. The slope of the line is just the percentage change in price.[5] Thus, because the percentage change in price, is the total return, the expected return on the stock is constant and equal to the real interest rate.

A third feature is that only new information about future profits causes real stock returns to deviate from the real interest rate. Because stock prices already reflect everything that investors expect about future profits, prices should rise more or less than expected only if investors get new information about future profits. For example, suppose the interest rate is 10 percent and the stock price is $10 (Figure 2). At the end of period one, the stock price can be expected to rise to $11. But if the company

Figure 1

Stock Prices in an Efficient Market

Stock price (ratio scale)
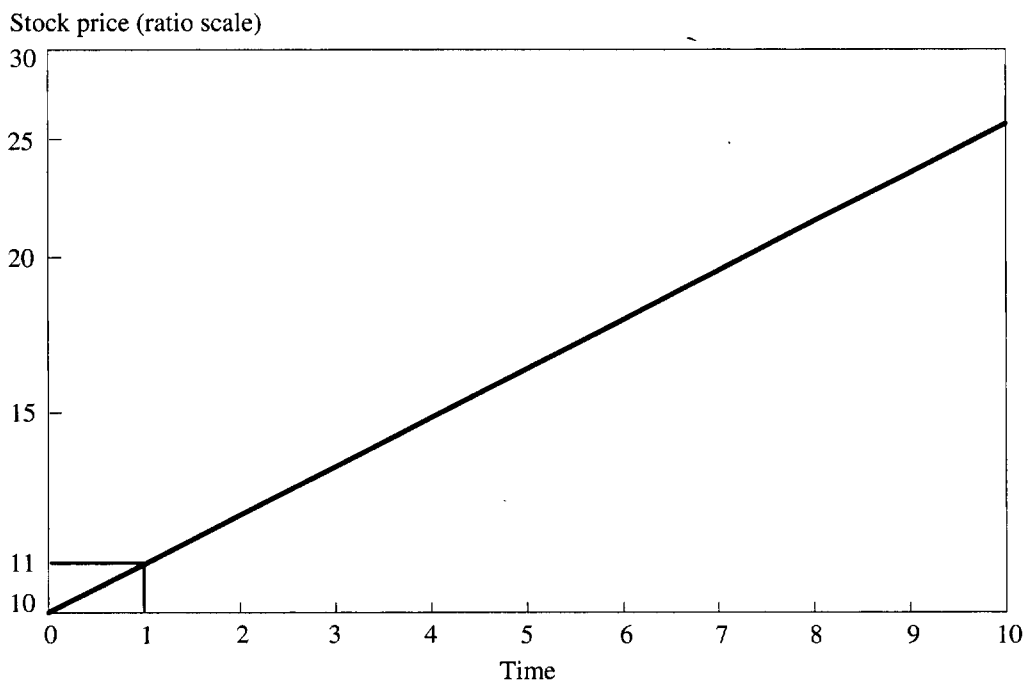
announces it will pay higher dividends with the profits from a new discovery, the stock is a bargain at $11. As investors buy more of the stock, the price might rise to $13. Thus, while the expected return on the stock was only 10 percent, the unexpected news led to a 30 percent return.

A final feature of efficient markets is that when actual returns differ from what was expected, investors should still expect future returns to be constant and equal to the real interest rate. In other words, if prices rise more than expected, investors should not expect prices to continue to grow faster just because they did so in the past. Furthermore, investors should not expect prices to grow slower to offset the unexpected increase. For example, in

Figure 2, the stock price rose 20 percent more than expected over the first period. The unexpected increase reflected the *entire* value of the increase in future dividends. As a result, the stock price should resume growing at the old rate. This is shown in Figure 2 by the high-dividend path having the same slope as the low-dividend path.

Inefficient Markets

Many analysts claim the stock market is inefficient because they believe prices often overreact to new information and overshoot fundamental values in the short run. If stock prices do not always reflect fundamental values, the stock market will not direct investment funds to

Figure 2

Stock Prices in an Efficient Market: Change in Dividends

Stock price (ratio scale)
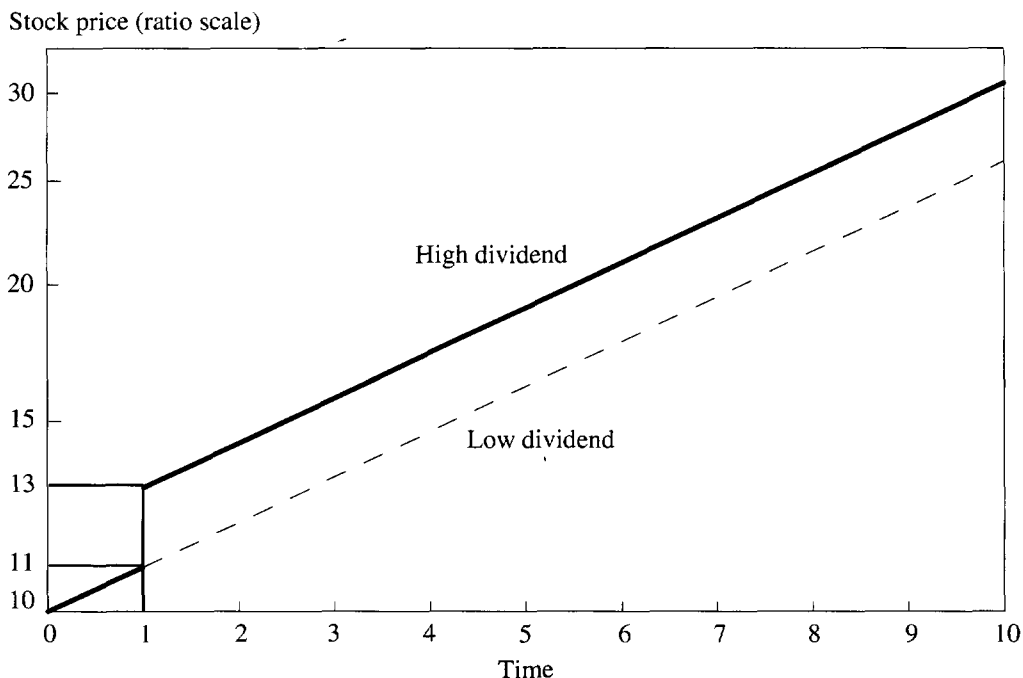
where they are most valuable. Moreover, expected returns will vary over time because prices will be mean reverting. Finally, stock prices that overreact to new information are excessively volatile.

Why might the stock market be inefficient?

In an efficient market, stock prices reflect the current value of the future income that stocks generate because prices depend on *future* dividends, prices, and interest rates. If other factors, such as *past* prices and dividends, affect the value investors place on stocks, stock prices will deviate from fundamental values. When prices deviate from fundamental values, the market is inefficient.

One theory of why stock prices deviate from fundamental values is that many traders pay attention to recent trends in returns (Cutler, Poterba, and Summers). These "feedback traders" believe that if a stock's returns have been high in the recent past, they are likely to be high in the future. As feedback traders buy the stock to capture the excess returns, the price will rise above the stock's fundamental value. Likewise, if returns have been low in the recent past, feedback traders will sell the stock, driving the price below its fundamental value. Thus, in the short run, increases in stock prices are followed by further increases, and decreases are followed by decreases.

According to the theory, however, stock prices will ultimately return to fundamental

Figure 3
Stock Prices in an Inefficient Market

Stock price (ratio scale)
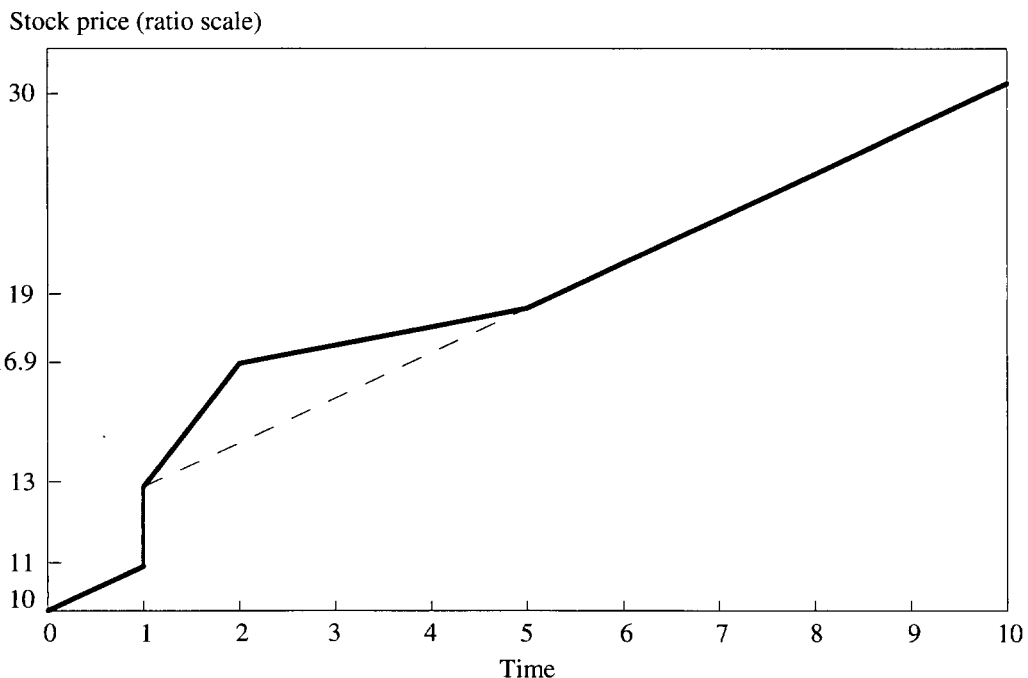
values. Arbitragers and traders who pay attention to fundamental values will discover which stocks are overvalued and which are undervalued. As they sell the overvalued stocks and buy the undervalued stocks, prices eventually reach their fundamental values.

An example may clarify how stock prices in an inefficient stock market differ from prices in an efficient stock market (Figure 3). Suppose a company's stock price jumps when it announces it will pay higher dividends with the profits from a new discovery. Because the return over the first period is 30 percent instead of 10 percent, feedback traders buy the stock. The upward pressure on the price drives the price above its fundamental value (shown by the dashed line segment). Traders who pay

attention to fundamentals will then begin selling the overvalued stock, putting downward pressure on its price and causing the average return to fall over the next few periods. With lower past returns, fewer feedback traders buy the stock. Indeed, some may start selling the stock, producing even greater downward pressure on the price. Eventually, the price returns to its fundamental value. Prices that follow such a pattern of rising above their fundamental trend and then returning are said to be *mean reverting*.

Implications

In contrast to an efficient stock market, an inefficient stock market does not direct investment funds to their best use because prices do

not necessarily reflect fundamental values. For example, feedback traders may irrationally drive the stock prices of companies with low fundamental values too high. Conversely, stock prices of companies with high fundamental values may be too low. As a result, companies with low fundamental values may be able to raise a lot of capital, while companies with high fundamental values may find it difficult to raise capital.

A second implication of an inefficient stock market is that mean reverting prices cause expected returns to vary. For example, although the average return in Figure 3 from the end of period one to the end of period five is 10 percent, the return is far from constant. As the price rises above the fundamental value, the return is 30 percent. But as the price reverts to the fundamental value, the average return is just 4 percent. Thus, greater than average returns are followed by less than average returns, while less than average returns are followed by greater than average returns.

A third implication is that prices are excessively volatile in the short run. Stock prices are volatile in an efficient market because new information causes unexpected changes in prices. However, prices are even more volatile in an inefficient market because prices will change by more than the value of the new information. In the long run, though, prices are not excessively volatile because they eventually revert to their fundamental trend. In other words, as shown in Figure 3, the long-run change in stock prices in an inefficient market is the same as in an efficient market.

Is the Stock Market Efficient?

The evidence is mixed on whether the stock market is efficient. Some recent studies have found that stock prices are mean reverting, leading some analysts to conclude that the stock market is inefficient. Other studies cast doubt on this conclusion.

Evidence that stock prices are mean reverting

After years of testing the efficient market hypothesis, financial economists have generally agreed that the stock market is efficient. In recent years, however, new research strategies have shown that stock prices are mean reverting over long investment horizons. The strategies rely on new statistical techniques that are potentially better able to detect regularities in stock prices. In addition, some researchers have begun to pay more attention to the long-run behavior of stock prices.

Variance-ratio tests. In the long run, stock price volatilities are the same whether or not prices are mean reverting. Short-run volatilities, however, are greater if prices are mean reverting than if they are not. As a result, the ratio of long-run volatility to short-run volatility is smaller if prices are mean reverting. The new statistical techniques use ratios of long-run volatilities to short-run volatilities to determine whether stock prices are mean reverting.

An example may help clarify this point. Suppose a stock's price will either rise 20 percent a year or fall 10 percent a year (solid lines in Figure 4). One measure of the volatility of this stock is the difference between the best and worst possible returns over the investment horizon. For a one-year investment, the best return is a 20 percent gain and the worst a 10 percent loss, so the volatility is 30 percent (20 percent less a negative 10 percent). For a two-year investment, the best return is 40 percent— 20 percent in each of the two years—and the worst is a negative 20 percent, so the volatility is 60 percent. Thus, the volatility of the two-year investment is twice that of the one-year investment. More generally, the volatility of a

Figure 4
Investment Risk
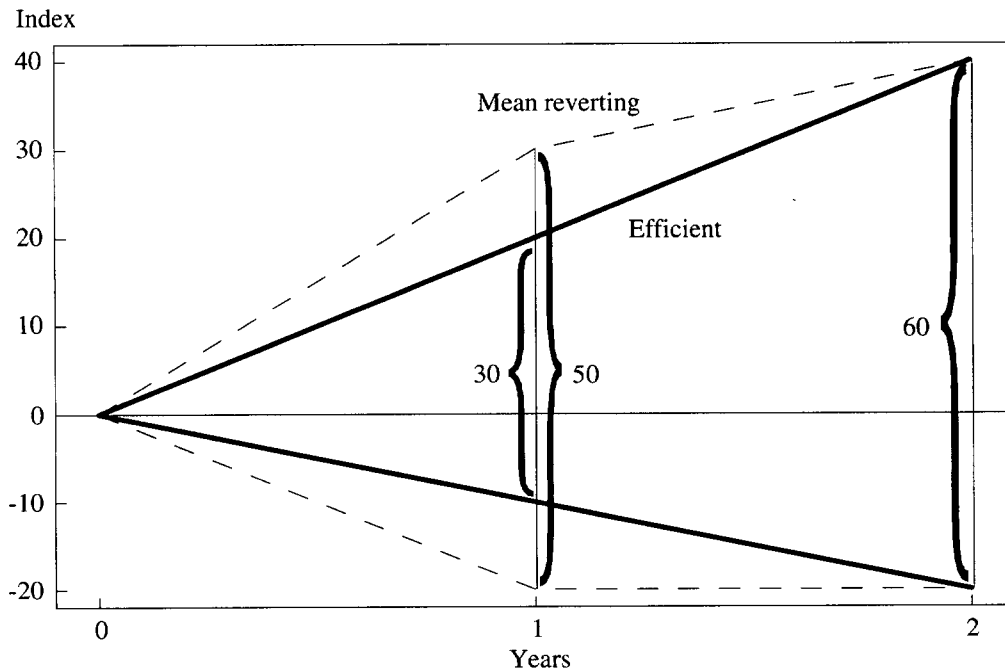
k-year investment will be k times the volatility of a one-year investment if the market is efficient.[6]

The volatility of a k-year investment will be less than k times the volatility of a one-year investment, however, if prices are mean reverting. Because prices overshoot fundamental values in the short run but not the long run, prices are excessively volatile only in the short run. For example, prices might either rise 30 percent or fall 20 percent so that the volatility is 50 percent in the first year (dashed lines in Figure 4). If the price returns to its fundamental value by the second period, the best two-year return is 40 percent and the worst is a negative 20 percent, so that the volatility is 60 percent— just as in the efficient market. Thus, the volatility of the two-year investment is much

less than twice the volatility of the one-year investment.[7]

Poterba and Summers have argued that the efficient market theory can be tested by looking at whether volatility rises proportionally to the investment horizon. They measured volatility by the variance of stock returns. If the market is efficient, the variance of k-year returns (r_k) should equal k times the variance of one-year returns (r_1).

$$Variance(r_k) = k \times Variance(r_1)$$

or   (2)

$$\frac{Variance(r_k)}{k \times Variance(r_1)} = 1$$

Thus, the ratio of the variances at all investment horizons should equal one if the market is efficient, but should be less than one if prices are

mean reverting.

Poterba and Summers concluded that the stock market is inefficient because prices are mean reverting. They calculated variance ratios for investment horizons of two to eight years. The data were excess returns on the New York Stock Exchange (NYSE) from 1926 to 1985, measured as monthly NYSE returns less U.S. Treasury bill returns. The variance ratios were less than one for all investment horizons greater than two years. For example, eight-year returns should be eight times more variable than one-year returns if the stock market is efficient. Poterba and Summers found, however, that eight-year returns are only three-and-a-half times more variable than one-year returns. In addition, the eight-year variance ratio is significantly less than one in a statistical sense. Finally, Poterba and Summers showed that mean reversion is stronger for stocks of small firms than of large firms.[8]

Regression tests. Another way to test the efficient market theory is to regress stock returns on past stock returns. If stock prices rise at a constant rate as suggested by the efficient market theory, returns should be constant over time and, therefore, unrelated to past returns. That is, in a regression of stock returns on a constant term and past returns, the constant term should be positive, but the slope coefficient on past returns should be zero. On the other hand, if prices grow faster than trend initially but slower as they return to trend, returns should be above and then below normal. Thus, if prices are mean reverting, the slope coefficient should be negative.

Many researchers have regressed stock returns on past returns to test the efficient market theory. Most of the studies used returns over very short investment horizons, such as daily or weekly returns. Although the slope coefficients were generally found to be statistically significant, they were not economically significant because they were so close to zero. Thus, in a review of many of the early studies, Fama concluded that the stock market is efficient.

More recent studies have extended the early research by using multiyear returns in the regressions. Fama and French (1988a) tested for mean reversion by regressing multiyear returns on past multiyear returns for investment horizons of one to ten years. They used monthly data adjusted for inflation from the NYSE and various industry groups over the period from 1926 to 1985. For example, for a four-year horizon, the return from March 1935 to March 1939 was regressed on the return from March 1931 to March 1935.

Fama and French concluded that stock prices are mean reverting. They found that the coefficients on past returns became negative for two-year returns, reached a minimum for three-to-five-year returns, and then approached zero as the investment horizon increased to eight years. For example, the coefficient on past NYSE returns for the four-year horizon was -0.36 and statistically significant. Thus, for example, if returns were 10 percent above average over the past four years, they are likely to be 3.6 percent below average over the next four years. Finally, like Poterba and Summers, Fama and French found that mean reversion is stronger for stocks of small firms than of large firms.[9]

Another way to use regressions to test for efficient markets is to regress stock returns on the difference between stock prices and a measure of fundamental values.[10] If stock prices are mean reverting, returns should be negatively related to past differences between prices and fundamental values. For example, if a stock price is above its fundamental value, future returns should be small as the price returns to the fundamental value.

Fama and French (1988b) found that stock prices are mean reverting when dividends are used to measure fundamental values. Dividends

are a measure of fundamental values because stock prices should be proportional to dividends in an efficient market (see equation 1). Thus, if prices are mean reverting, returns should be negatively related to the difference between prices and dividends. Using inflation-adjusted NYSE returns from 1926 to 1986, Fama and French found that two-year to four-year returns are negatively related to the difference between stock prices and dividends.[11]

Campbell and Shiller found that prices are mean reverting using dividends and earnings to measure fundamental values. Because dividends ultimately depend on earnings, earnings can also be used to measure fundamental values. Using excess returns and inflation-adjusted returns on the Standard and Poor's 500 stock index from 1871 to 1987, they found that prices are mean reverting over one-year, three-year, and ten-year horizons.

Why the stock market might still be efficient

Despite the evidence that stock prices are mean reverting, the stock market might still be efficient for two reasons. First, some critics argue the evidence for mean reversion is weak, either because the data samples are too small or because the evidence depends entirely on the behavior of stock prices before World War II. Second, some critics argue that mean reverting stock prices are, in fact, simply a characteristic of more sophisticated versions of the efficient market theory.

Small sample size. Some researchers argue there are not enough data to conclude that stock prices are mean reverting. In general, the tests used to determine whether a statistic is sig-. nificant assume that the statistic is calculated from an infinite number of observations. Because a finite number of observations are actually used in any test, the tests are only an

approximation. The larger the number of observations, however, the better the approximation. The problem with mean reversion tests is that the data sets are very small. For example, from 1925 to 1985, there are only 12 independent observations of five-year returns (60 years divided by five).

Using statistical tests that account for the relatively small number of observations, several studies have found that previous work overstated the statistical significance of the mean reversion evidence (Mankiw, Romer, and Shapiro; Nelson and Kim; Kim, Nelson, and Startz; and McQueen). In general, these studies have found that the evidence on mean reversion is only marginally, if at all, statistically significant. Thus, while the evidence is suggestive, it is not strong enough to conclude that stock prices are mean reverting.

Mean reversion is due to pre-World War II data. Some researchers argue that stock prices may have been mean reverting in the past, but not anymore. According to these critics, stock prices were mean reverting only before World War II—stock returns were high in the late 1920s, low after the 1929 Crash and during the Great Depression, and then high during and right after the war. Since the war, however, they argue that such regularities in stock returns have largely disappeared.

Some recent studies show that mean reversion does disappear when the early years are excluded. Using NYSE returns from 1947 to 1986, Kim, Nelson, and Startz found that stock prices are not mean reverting. Indeed, for large-firm stocks, prices move away from the mean at long horizons.[12] Fama and French (1988a) found that mean reversion disappears for all of their groups when returns from 1941 to 1985 are used.[13]

Critics of the studies of postwar data might argue that the studies omit the second half of the 1980s—a period in which stock prices appear

Chart 1

Variance Ratios
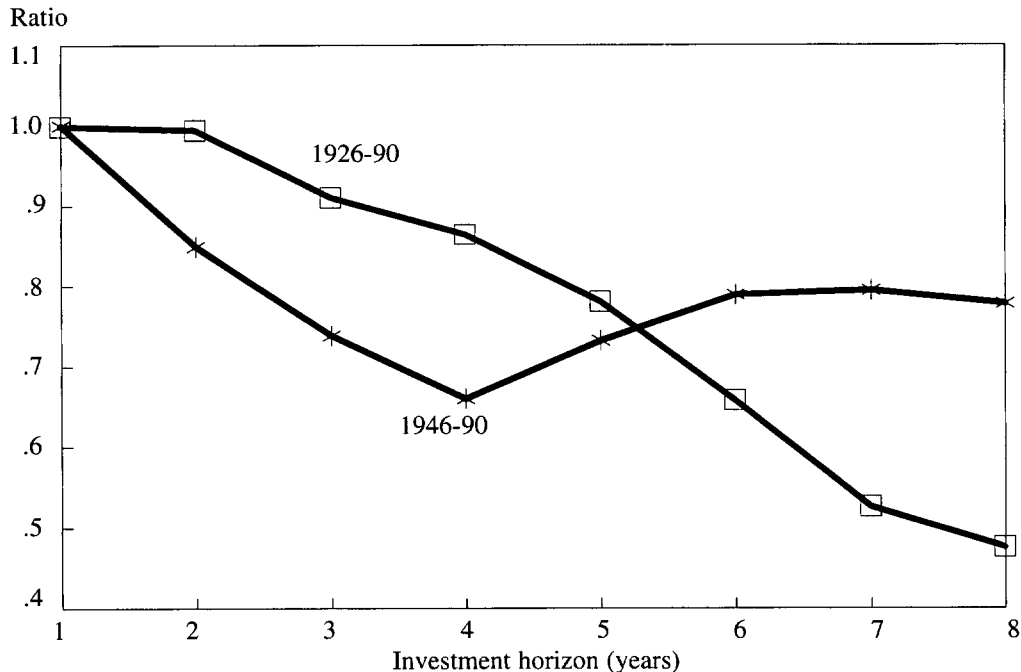
Ratio

Note: Returns are monthly returns on the equal-weighted New York Stock Exchange portfolio less monthly returns on U.S. Treasury bills from 1926 to 1990 and 1946 to 1990. The variance ratio for a k-year investment horizon is calculated as the variance of the k-year return divided by k times the variance of the one-year return. The variance ratios are adjusted for small-sample bias as discussed in Poterba and Summers.

Source: Center for Research in Security Prices.

to have been mean reverting. For example, the return on the Dow Jones Industrial Average over the three years prior to the October 1987 collapse was 112 percent, while the return over the three years after the collapse was just 30 percent.[14]

Updating the postwar sample through 1990 does not significantly affect the results, however. The effect of updating the data is shown by calculating variance ratios over the 1946-90 period and comparing them with variance ratios calculated over the 1926-90 period (Chart 1). Mean reversion at long horizons has been

weaker since 1946 than before 1946, although mean reversion at short horizons has been stronger over the postwar period. But because the sample is so small, these variance ratios are probably no more than marginally significant. Thus, overall, the postwar evidence casts doubt on the mean reversion evidence.

Sophisticated efficient market theories. Even if stock prices are mean reverting, the stock market might still be efficient. Mean reversion implies that the simple efficient market theory described earlier—where the real interest rate is assumed to be constant over

Figure 5

Figure 5
Stock Prices in an Efficient Market: Change in Interest Rates

Stock price (ratio scale)
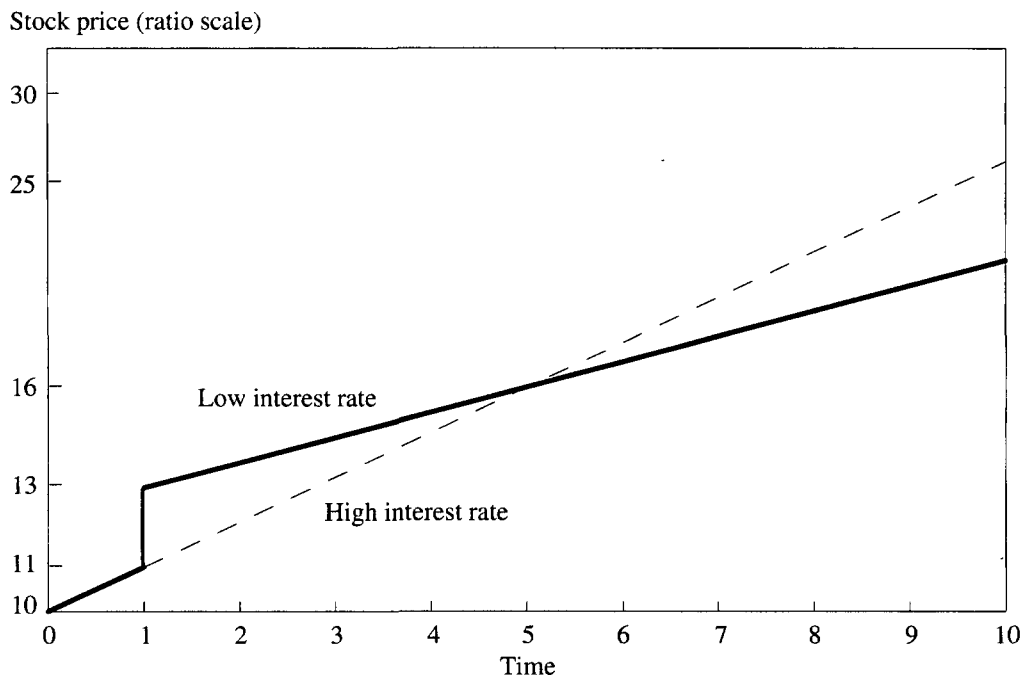
time—is incorrect. In the simple theory, expected real returns are constant over time because the real interest rate is assumed to remain constant. But if real interest rates vary over time, returns should also vary over time in an efficient market. Indeed, if real interest rates are mean reverting, stock prices will also be mean reverting.

Real interest rates could vary for a variety of reasons. For a given riskless interest rate, changes in the riskiness of stocks or in investors' tolerance for risk would cause the risk adjustment factor, and therefore the interest rate, to change. Alternatively, for a given risk-adjustment factor, the riskless interest rate may change over time. Several researchers have developed sophisticated examples in which

changes in risk tolerance and the riskiness of stocks cause interest rates, and therefore stock prices, to be mean reverting (Fama and French 1988b; Black; and Cecchetti, Lam, and Mark).

The basic idea underlying the sophisticated models is illustrated in Figure 5. Suppose that interest rates fall at the end of the first period. The decline could be due to a fall in the riskless interest rate, in the riskiness of stocks, or in the risk averseness of investors. According to equation 1, a decline in interest rates causes the current stock price to rise. At the same time, the lower interest rate implies that future prices will grow at a slower rate. As the figure shows, the stock price first jumps above the old trend and then slowly reverts to the old trend just as in the inefficient market theory.

Indeed, Figure 5 looks very similar to Figure 2. Thus, if interest rates are mean reverting, perhaps because they fall during recessions and rise during recoveries, stock prices may appear mean reverting even if the stock market is efficient.

Poterba and Summers argue, however, that changes in the riskiness of stocks or the risk tolerance of investors cannot explain the mean reversion found in the data for two reasons. First, the degree of mean reversion in stock price data implies changes in the riskiness of stocks or in risk tolerance that are implausibly large. Second, although the behavior of stock prices in the feedback trader model and sophisticated efficient market theories are similar, they are not exact. Specifically, prices should move away from trend in the short run if they are mean reverting. In other words, as shown in Figure 2; if prices grow faster than normal, feedback traders should cause them to continue to grow faster than normal in the short run. In the sophisticated models (Figure 5), however, prices should immediately begin to grow slower than normal after a fall in interest rates. Lo and MacKinlay, and Poterba and Summers find that prices move away from trend for investment horizons of two years or less, which supports the feedback trader model.

Conclusions

Analysts have traditionally regarded the stock market as an efficient market. More recently, some analysts have argued that feedback traders cause the market to be inefficient. The major problem for the economy of an inefficient market is that investment funds are not directed to where they are most useful.

This article reviewed the mean reversion evidence on stock market efficiency. Some studies of stock prices suggest prices are mean reverting. However, it is too early to conclude that the stock market is inefficient for two reasons. First, other studies indicate that stock prices are not mean reverting. Some show that the statistical tests are relatively inaccurate due to a lack of long-horizon stock returns, while others show that the evidence in favor of mean reversion is much weaker if pre-World War II data are excluded. Second, even if stock prices are mean reverting, it may be that one of the more sophisticated efficient market theories is correct.

Endnotes

[1] Investors cannot get higher than average returns by following simple investment strategies, however. In an efficient market, arbitragers work so quickly that investors cannot take advantage of any mispricing of securities.

[2] Because the real interest rate is used in equation 1, the price and dividend terms are also real values. Equation 1 would also hold if all values were expressed in nominal terms. Real terms are used to avoid changes in values induced by inflation. For expositional purposes, "real" will not be used as a modifier unless it is necessary for clarity.

[3] More formally, the efficient market theory says that the price of a stock should equal the present value of all future dividends.

$$P_0 = \sum_{i=1}^{\infty} \frac{ED_i}{(1+r)^i} = \frac{ED_1}{1+r} + \sum_{i=2}^{\infty} \frac{ED_i}{(1+r)^i}$$

The expected price of a stock one period in the future is just the present value of all dividends from that time on.

$$EP_1 = \sum_{i=2}^{\infty} \frac{ED_i}{(1+r)^{i-1}}$$

Dividing EP_1 by $1 + r$ gives

$$\frac{EP_1}{1+r} = \sum_{i=2}^{\infty} \frac{ED_i}{(1+r)^i},$$

which is just the summation term in the second line of the P_0 equation. Thus, substituting $EP_1/1+r$ into the P_0 equation gives equation 1 in the text.

[4] The dividend-inclusive price, q_t, is constructed so that the percentage change in price equals the total return from dividends and price appreciation. That is,

$$(q_t - q_{t-1})/q_{t-1} = (D_t + P_t - P_{t-1})/P_{t-1}.$$

One way to think of the dividend-inclusive price is that it is what the price of the stock would be if the stock did not pay dividends so that the total return comes from price appreciation.

[5] The slope of the line is the percentage change in price instead of just the change in price because the vertical scale of the figure is a ratio scale. The slope equals the risk-adjusted interest rate because the dividend-inclusive price is constructed such that the percentage change in price equals the total return including dividends (see endnote 4). That is,

$$slope = (q_t - q_{t-1})/q_{t-1} = (D_t + P_t - P_{t-1})/P_{t-1} = r,$$

and r is assumed to be constant over time in the simple efficient market theory described in the text. More sophis-

ticated efficient market theories allow r to vary over time. In those theories, expected returns will vary over time with r. These theories will be discussed later in the article.

[6] If risk is measured by the variance of returns, the variance of the return on a k-year investment is just k times the variance of the return on a one-year investment. For example, if p_t is the log of the dividend-inclusive price, the two-year return is

$$(p_t - p_{t-1}) + (p_{t-1} - p_{t-2}) = p_t - p_{t-2}.$$

The variance of the two-year return is

$$var(p_t - p_{t-2}) = var(p_t - p_{t-1}) + var(p_{t-1} - p_{t-2})$$
$$+ 2cov(p_t - p_{t-1}, p_{t-1} - p_{t-2}).$$

If the market is efficient, the covariance between the current one-year return and the lagged one-year return is zero. Assuming the variance of one-year returns is constant over time, the two-year variance becomes $2var(p_t - p_{t-1})$.

[7] If risk is measured by the variance of returns, the variance of the return on a k-year investment is less than k times the variance of the return on a one-year investment. For example, if p_t is the log of the dividend-inclusive price, the two-year return is

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$$+ 2cov(p_t - p_{t-1}, p_{t-1} - p_{t-2}).$$

If prices are mean reverting, the covariance between the current one-year return and the lagged one-year return is negative. Thus, assuming the variance of one-year returns is constant over time, the two-year variance is less than $2var(p_t - p_{t-1})$.

[8] Poterba and Summers report results for both value-weighted and equal-weighted NYSE returns. Value-weighted returns are calculated from a weighted-average price index for all stocks on the NYSE, where the weight on a stock's price is the market value of the firm's outstanding shares divided by the market value of all shares on the NYSE. Equal-weighted returns are calculated from a price index in which all stock prices have the same weight. The primary difference between the two measures of returns is that value-weighted returns are dominated by large-firm stocks.

The variance ratios for both types of returns are less than one for all horizons over two years. However, the equal-weighted statistics generally are smaller than the value-weighted statistics. For example, eight-year equal-

weighted returns are three-and-a-half times more variable than one-year returns, while eight-year value-weighted returns are five-and-a-half times more variable than one-year returns. Because smaller firms carry a larger weight in equal-weighted returns than in value-weighted returns, these results suggest mean reversion is more prominent for stocks of small firms than of large firms.

Poterba and Summers report Monte Carlo estimates of the standard errors of the variance ratios for all horizons, but they report the statistical significance only for the eight-year horizon. The eight-year variance ratio is statistically different from one at the 8 percent level for the value-weighted returns and at the 0.5 percent level for the equal-weighted returns. It should be noted, however, that none of the variance ratios are more than two standard deviations from one.

The data used by Poterba and Summers end before the October 1987 stock market collapse. Extending the data through 1990, however, does not change the results.

9 Fama and French report results for value-weighted and equal-weighted NYSE returns, equal-weighted returns for groups of NYSE firms of similar size, and equal-weighted returns for various industries. In general, the coefficients for the three-to-five-year horizons are the most negative for all groups. Moreover, for most of the groups, the coefficients are more than two standard errors from zero only for the three-to-five-year horizons. The exceptions are the large-firm portfolios and the value-weighted returns, which are not more than two standard errors from zero at any horizon. Thus, like the Poterba and Summers results, mean reversion is more prominent for stocks of small firms than of large firms.

10 If the stock market is efficient, any difference between prices and a measure of fundamental value must be due to errors in measuring fundamental values. Because the measurement errors should cancel each other out over time, however, returns should not be systematically related to such measurement errors.

11 Fama and French actually regress returns on the log of dividends minus the log of prices and find that the slope coefficients are positive. This implies that the coefficient on prices minus dividends should be negative as discussed in the text. They report results for value-weighted and equal-weighted real returns. In general, the slope coefficients are larger in the equal-weighted regressions than in value-weighted regressions. Thus, they also find that mean reversion is more prominent for stocks of small firms than of large firms.

12 Kim, Nelson, and Startz use the term "mean aversion" to describe the tendency of prices to move away from the mean. Like mean reversion, mean aversion is not consistent with the efficient market theory. However, no one has come up with a story that explains why prices should be mean averting over long horizons.

13 Poterba and Summers find that mean reversion does not disappear when returns from 1936 to 1985 are used. These results are apparently due to the fact that the sample still includes returns from the Great Depression.

14 The return over the three years prior to the 1987 collapse was calculated from monthly averages of the Dow Jones Industrial Average from September 1984 to September 1987. The return over the three years after the 1987 collapse was calculated from monthly averages of the Dow Jones Industrial Average from November 1987 to November 1990.

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