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Capital Market Efficiency: An Update*

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Statistical evidence accumulated in the 20 years following Eugene Fama's (1970) survey raises questions about his conclusion that capital markets are efficient. Stock price volatility has been shown to exceed the volatility consistent with capital market efficiency. Other evidence —for example, the small-firm effect, the January effect, and other calendar-based anomalies of stock prices— points in the same direction. Finally, analysts find it difficult to explain stock prices even after the fact using realized values of variables which, according to efficient capital markets theory, should account for stock price changes.

Economist 1: *"That looks like a $100 bill over there on the sidewalk."*

Economist 2: *"Don't bother going over to check it out. If it were genuine, someone would have picked it up already."*

The theory of efficient capital markets says, most simply, that the prices of financial assets equal the discounted value of the expected cash flows these assets generate. In the context of the stock market, efficiency implies that stock prices equal the discounted value of expected future dividends. Investors are not assumed to form perfectly accurate forecasts of future dividends, but they are assumed to make effective use of whatever information they have. If capital markets are efficient in this sense, changes in stock prices should be associated exclusively with new information leading to revisions in expected future dividends: when dividend prospects improve, stock prices rise, and conversely.

Moreover, since all relevant, publicly available information is discounted in asset prices as soon as it becomes available, investors cannot construct systematically profitable trading rules based only on this information. Thus, in an efficient market there is no motive to buy stock based on favorable information; if the information is in fact favorable, the market already has discounted it. In other words, the $100 bill above could not be genuine; otherwise, it would have been picked up already.

These observations suggest that factors not identifiable with future profitability—fads, nonrational speculative bubbles, investor psychology—should not affect stock prices. In this regard, the stock market selloff on October 19, 1987, offers dramatic evidence that capital markets may not be efficient. On that single day, stock values declined by approximately a half trillion dollars, a magnitude unprecedented in absolute terms. In relative terms the selloff was comparable only to the stock market panic of October 1929 which heralded the Great Depression.

According to the efficient markets theory, the selloff could have been caused only by information made available that day (or over the preceding weekend since October 19, 1987, was a Monday) that justified a downward revision on the order of 22 percent in the present discounted value of expected future dividends. However, no economic information of an even mildly unusual nature was made public that day, let alone information that would drastically increase investors' estimates of the probability of an impending economic cataclysm. It is true that investors were worried about recession, but no more than they usually are. In any event, whatever fears of recession investors had subsequently proved unfounded, as the economy showed virtually no ill effects following the stock market collapse.

Moreover, the partial recovery of stock prices in the days following the selloff can only be reconciled with the efficient markets model if the recovery could be associated with economic news inducing investors to believe that the impending recession would, after all, not be as severe as the news that led to the selloff had indicated. Again, however, no economic news of the requisite importance was reported during the week of October 19.

This is not to say that stock price changes on the order of ten or twenty percent, even over a period as short as several days, are never associated with changes of commensurate magnitude in fundamentals. Following the June 1989 suppression of student protests in China, stock prices in Hong Kong dropped by a magnitude comparable in relative terms to the U.S. selloff in October 1987. The connection between political conditions in China and the role of Hong Kong firms in the Chinese economy is so strong that a stock price change on the order of twenty percent is not an obviously disproportionate response to the news that the Chinese government opted to suppress rather than accommodate the liberalization that the students were advocating. Therefore, there is no clear conflict between market efficiency and the selloff that occurred on the Hong Kong exchange in June 1989.

A single dramatic event like the October 19, 1987, selloff, however, does not invalidate the most important prediction of the efficient markets theory, which is that there should not exist trading rules that allow investors systematically to outperform the market. Research conducted in the 1960s and reported in Fama (1970) generally supported this implication, leading financial economists to conclude that capital market efficiency was corroborated empirically.

The more recent evidence, however, does not substantiate Fama's verdict. Detailed analysis using financial data bases developed in the 1970s, and drawing on a more extensive understanding of the empirical implications of market efficiency than was available in 1970, suggests that the October 19, 1987, selloff was not an isolated episode (although, of course, it was virtually unprecedented in magnitude). Instead, the evidence now suggests that most fluctuations in stock prices cannot be traced to changes in rational forecasts of future dividends, contrary to the prediction of the efficient markets model.

The new evidence arises from two areas of research which developed largely independently. First, analysts realized about fifteen years ago that market efficiency implied an upper bound on the volatility of stock prices. Empirical tests suggest that this bound is violated, indicating that stock prices are more variable than is consistent with market efficiency. Second, beginning about the same time analysts came to realize that stock returns display a variety of systematic patterns that are difficult to explain within a framework of rational optimization. The "variance-bounds" and "anomalies" literatures are surveyed in this paper.

Some economists view the updated evidence on market efficiency as demonstrating that the theory of efficient capital markets is wrong, and that investors are simply not as rational as efficient markets theory assumes. If so, it follows that capital markets are probably not doing a good job of resource allocation. Most economists, however, start out with a strong commitment to the assumption that people act rationally, and these economists will not reject the efficient markets model—and with it, the presumption that capital markets are doing a reasonably good job of allocating capital—unless confronted with absolutely airtight evidence against efficiency. None of the evidence reported in this paper meets such an exacting standard. Therefore those who start out with a strong predisposition in favor of capital market efficiency interpret the recent evidence as perhaps raising questions about the theory and suggesting topics for future research, but not as justifying definitive rejection.

I. The Efficient Markets Model

Contrary to the impression given above, the efficient markets model does not start out assuming that asset values equal the present value of expected future cash flows. Rather, the present-value representation is derived from the more primitive assumption that the rate of return r_{jt} on the j-th stock (more generally, the j-th asset) satisfies:

$$E(r_{jt} \mid I_t) = \rho \tag{1}$$

Here I_t comprises investors' information at t; $E(.|I_t)$ denotes the mathematical expectation of (.) conditional on I_t; ρ, the expected rate of return on stock, is a positive constant, on the assumption that capital markets are perfect and investors are risk-neutral. Equation (1) says that an investor with information I_t will predict an expected rate of return equal to ρ for any asset. Since this is the same prediction that an uninformed investor would make, the efficient markets model implies that the information set I_t is useless in predicting expected rates of return. In this sense information I_t is "fully reflected" in securities prices.

For example, suppose that I_t contains the history of dividends, earnings, sales, advertising outlay, and costs for firm j up to date t, and possibly also macroeconomic variables like GNP, interest rates, commodity prices, and the money stock. Equation (1) says that no matter what values the variables in I_t take on, asset prices will depend on these values in such a way that the expected rate of return on the j-th asset is always ρ. If so, an investor who knows dividends, earnings, and so on is no better off than an investor who does not know the past history of these variables since the uninformed investor can always predict an expected rate of return of ρ without knowing I_t and is assured that his prediction will coincide with that of the informed investor, who predicts an expected rate of return of ρ for all values of I_t.

If at each date the expected rate of return on each asset is ρ, it follows that the expected rate of return on any portfolio is also ρ, since the expected rate of return on a portfolio is just a weighted average of the expected rates of return on its component securities. Accordingly, no trading rules based on information I_t can generate an expected rate of return greater than ρ. Of course, an investor in possession of information better than "the market's" information I_t could use this information to detect differentials in expected rates of return among the various assets, and consequently could construct profitable trading rules. However, efficient markets theory postulates that there do not exist investors with information better than the market's information, or more realistically, that if such investors exist, they do not affect prices.

Fama (1970) distinguished three versions of market efficiency depending on the specification of the information set I_t. Markets are "weak-form efficient" if I_t comprises past returns alone, "semi-strong-form efficient" if I_t comprises all publicly available information, and "strong-form efficient" if I_t includes insider information as well as publicly-available information.[1] It is clear that strong-form efficiency implies semi-strong form efficiency, which in turn implies weak-form efficiency, since expected returns that cannot be predicted based on a large information set surely cannot be predicted based on a small information set that is contained in the large information set. However, the reverse implications do not follow; a capital market easily could be weak-form efficient but not semi-strong-form efficient, or semi-strong-form efficient but not strong-form efficient.

The efficient markets model (1) says that rates of return on stock are unpredictable. It might appear to follow that the efficient markets model implies that stock prices are completely without structure, but that is not the case. In fact, the efficient markets model turns out to be exactly the same model as the present-value relation with which the efficient capital markets model was identified in the introduction. The derivation of this equivalence follows. Because (one plus) the rate of return is by definition equal to the sum of the dividend yield (d_t/p_t) and the rate of capital gain (p_{t+1}/p_t), (1) can be rewritten as:

$$p_t = \frac{E(d_{t+1} + p_{t+1} \mid I_t)}{1 + \rho} \tag{2}$$

Substituting $t+1$ for t, (2) becomes:

$$p_{t+1} = \frac{E(d_{t+2} + p_{t+2} \mid I_{t+1})}{1 + \rho} \tag{3}$$

Using (3) to eliminate p_{t+1} in (2), the price of stock can be written:[2]

$$p_t = \frac{E_t(d_{t+1})}{1 + \rho} + \frac{E_t(d_{t+2} + p_{t+2})}{(1 + \rho)^2} \tag{4}$$

Here E_t (.) is used as an abbreviated notation for $E(.|I_t)$. Proceeding similarly $n-1$ times, there results:

$$p_t = \frac{E_t(d_{t+1})}{1 + \rho} + \frac{E_t(d_{t+2})}{(1+\rho)^2} + \ldots + \frac{E_t(d_{t+n-1})}{(1 + \rho)^{n-1}} + \frac{E_t(p_{t+n} + d_{t+n})}{(1 + \rho)^n} \tag{5}$$

Assuming that $(1 + \rho)^{-n} E_t(p_{t+n})$ converges to zero as n approaches infinity, (5) becomes the familiar present-value equation:

$$p_t = \frac{E_t(d_{t+1})}{1+\rho} + \frac{E_t(d_{t+2})}{(1+\rho)^2} + \frac{E_t(d_{t+3})}{(1+\rho)^3} + \ldots . \qquad (6)$$

Further, the proof is completely reversible, implying that if the present-value relation (6) is satisfied, so is the efficient markets model (1). Samuelson (1965, 1973) and Mandelbrot (1966) were the first to state this result and to point out its relevance to efficient-markets theory.

What is striking here is that even though dividend changes in (6) can be partly forecast, the generating equation (1) implies that rates of return cannot be forecast. For example, if "the market" expects dividends to rise, the price of stock will be high relative to dividends now, so that when dividends do rise, no extra-normal return will be generated. Stockholders will earn extra-normal (sub-normal) returns only if dividends increase more (less) than had been expected. Thus if capital markets are efficient, a general expectation of a dividend increase does not imply that stocks should be bought (or, for that matter, sold), since the expected increase is already reflected in market prices.

This similarity between the efficient markets model and the "fundamentalist" model means that the much-publicized feud between Wall Streeters, who analyze stocks by computing discounted cash flows, and efficient marketers, who believe that rates of return cannot be forecast, is largely based on misunderstanding. The fundamentalist model focuses on the predictable part of prices, whereas the efficient markets model focuses on unpredictable returns, but the mathematical equivalence between the two models guarantees that there is no inconsistency.

However, the dispute is not entirely without substance: fundamentalists do not assert that prices are exactly equal to the discounted value of future dividends, but rather that prices fluctuate around the discounted value of future dividends. This apparently trivial difference is essential, since only in the latter case can profits be made by buying stocks that are priced lower than fundamentals justify, and selling stocks that appear to be overpriced. If underpriced and overpriced securities do not exist, as advocates of the efficient markets model maintain, then such trading strategies cannot succeed.

In deriving the expected present-value equation (6) from the efficient capital markets model (1), it was necessary to assume that $(1 + \rho)^{-n} E_t(p_{t+n})$ converges to zero as n approaches infinity. This convergence assumption means that price is expected to grow more slowly than the rate at which future returns are discounted. Violation of the convergence assumption would mean that there exist speculative bubbles: even though price exceeds the discounted value of expected dividends, investors are willing to hold stocks because they anticipate that price will exceed expected dividends by an even wider margin in the future.

It is known that, in theory, speculative bubbles can exist even in simple models in which agents are assumed to be rational and to have identical preferences and endowments, and in which there is no uncertainty (Gilles-LeRoy 1989). In such countries as Japan, where stocks routinely trade at prices 50 times earnings (although such figures are difficult to interpret because accounting practices are different in Japan from those in the U.S.), it is plausible that speculative bubbles are an important determinant of stock prices. However, the same is probably not true of the U.S., where stocks trade at price-earnings multiples on the order of 10 or 15. It is not easy to devise empirical tests which can reliably detect the presence of bubbles. However, one particularly simple kind of bubble would, if it occurred, result in a sustained downward trend in the dividend-price ratio as stock prices rose without limit. Data for the dividend-price ratio in the U.S. do not display any downward trend. The absence of trend in the dividend-price ratio led West (1988a), for example, to conclude that speculative bubbles are probably not an important component of U.S. stock values.

The expected present-value model often strikes people as highly implausible. Many investors do not even consider dividend levels in their investment decisions. Instead they buy stocks that are believed likely to appreciate. Further, the stocks of many firms which do not pay, and have never paid, dividends command high prices. The proposition that rates of return cannot be forecast, on the other hand, is very appealing: the negation of (1) has the unattractive implication that there exists some information variable known to investors which they can use to construct systematically profitable trading rules. Yet the mathematical equivalence of (1) and (6) (granted the convergence condition just discussed) means that it is logically inconsistent to reject the expected present-value model while at the same time accepting the unpredictability of rates of return.

If the reasonableness of (1) is accepted, it follows that the objections to the logically equivalent (6) cannot be as compelling as they appear at first. It is perfectly natural that investors might exhibit greater awareness of capital gains than dividends, given the greater variability and unpredictability of capital gains. Although most investors do not think much about dividend yields, the hypothesis that capital gains reflect changes in dividend prospects nonetheless still holds. Also, whether a given firm has paid dividends in the past is irrelevant. What is relevant is the firm's capacity to pay dividends in the future, which is governed by the firm's earnings prospects. The expected present-value equation (6) says only that the value of a firm that investors were absolutely certain would never pay dividends in the future (even a liquidating dividend if the firm were to disband or merge into another firm) would be zero.

II. Market Efficiency and Its Implications for Volatility

The October 19, 1987, episode was not the first time stock prices had dropped sharply in the apparent absence of news of commensurate importance bearing on dividend prospects. October 19 was typical of major stock price changes in this respect, not exceptional: most stock price changes, major or minor, cannot convincingly be associated with contemporaneous changes in investors' expectations of future corporate profits (Cutler, Poterba, and Summers, 1987). To the extent that stock prices frequently fluctuate in response to variables unrelated to dividend prospects, stock prices in some sense should be more volatile than is consistent with market efficiency. This consideration led analysts to ask whether market efficiency could be shown formally to have the implication that stock price volatility should be lower than the volatility of dividends, and if so how this prediction could be tested.

Proponents of market efficiency were skeptical of this approach. They argued that since efficiency implies that prices respond instantaneously to new information, stock price volatility cannot be deemed in any sense "excessive." However, because market efficiency has been shown to imply that stock prices equal the discounted sum of expected future dividends, stock prices will behave like a weighted average of dividends over time, and an average is always less volatile than its components.[3] There is no contradiction, then, between the requirement that stock prices respond quickly to new information and the implication that the volatility of prices is related to that of the underlying dividends stream.

Results of tests of the implications of market efficiency for stock price volatility were circulated in 1975 in my paper with Richard Porter (published in 1981). The timing, incidentally, was not coincidental—our thinking on this topic was prompted by the 1974-1975 stock market drop, the most pronounced in the postwar U.S. economy up to that time. Robert Shiller reported similar volatility results in his 1979 and 1981 papers. These papers used different analytical methods, but the results were the same: stock price volatility is too great to be consistent with market efficiency.

These papers alleging excess volatility of asset prices were well-received by economists sympathetic to the idea that asset price changes are not closely linked to changes in the expected discounted value of the cash flows to which these assets give title. However, defenders of the efficient markets model were motivated to search for statistical problems with the specific econometric procedures used in the initial papers. They found several serious biases, all of which predisposed the tests to reject market efficiency. The most important papers here are Flavin (1983) and Kleidon (1986). At the same time, new volatility tests were being devised which were free of the biases that attended the initial tests (West, 1988; Mankiw, Romer, and Shapiro, 1985; Campbell and Shiller, 1988a, 1988b; and LeRoy and Parke, 1990). These new tests continued to indicate that asset prices are excessively volatile, although perhaps not by as great a margin as the initial tests suggested.

Lawrence Summers has likened the findings of the volatility tests to that of the statistical tests for a link between smoking and lung disease. Early tests indicating the presence of such a link were found to be contaminated by statistical problems which biased the outcome toward that finding. Nevertheless, subsequent tests, which were free of statistical bias, continued to support the original conclusion of a statistically significant link, although the link was shown not to be as strong as had first been thought.

The volatility test reported below, which is very simple and yet appears econometrically sound, is drawn from LeRoy and Parke (1990). Recall that the efficient markets model says that stock price equals the discounted value of expected dividends:

$$p_t = \frac{E_t(d_{t+1})}{1+\rho} + \frac{E_t(d_{t+2})}{(1+\rho)^2} + \frac{E_t(d_{t+3})}{(1+\rho)^3} + \ldots . \quad (6)$$

Because there is no direct way to measure investors' information, direct observation of $E_t(d_{t+1})$, $E_t(d_{t+2})$, . . . , is not possible. This greatly complicates the derivation of the implications of market efficiency for price volatility. However, it is possible to show that the less information investors have, the higher will be the variance of the rate of return (LeRoy, 1989). Consequently, assuming markets are at least weak-form efficient, so that investors' information includes at least past returns, puts a lower bound on the amount of information investors have, therefore implying an upper bound on the variance of the rate of return.[4]

To derive the upper bound on the variance of the rate of return, it is necessary to evaluate this variance when investors predict future dividends using no information other than past returns. It is assumed that dividends follow a geometric random walk:

$$d_{t+1} = d_t \epsilon_{t+1} \tag{7}$$

where the ϵs are constant-mean random variables distributed independently over time. Analysts disagree about the accuracy of the geometric random walk specification. Some evidence shows it to be surprisingly accurate for such a simple specification, while other evidence suggests that in some contexts the geometric random walk specification can be misleading. For the present purpose the most attractive feature of the geometric random walk is its simplicity, which allows a very intuitive development of the variance-bounds relations. More complex characterization of dividend behavior, while allowing greater accuracy, would necessarily complicate the discussion by requiring use of more general analytical methods (Campbell-Shiller, 1988, 1988a).

When markets are at least weak-form efficient the upper bound on the variance of the rate of return on stock is the variance that would occur if investors based their dividend forecasts on past dividend behavior and nothing else. In this case the geometric random walk model implies that the best guess about future dividends is that they equal current dividends, multiplied by a trend term which depends on the mean value of ϵ. Therefore price will be given by a constant markup applied to current dividends:

$$p_t = k\, d_t \tag{8}$$

If price is proportional to dividends, the rate of return will equal the dividend growth rate multiplied by a constant which is very near one. To see this, recall the definition of the rate of return r_t as the dividend yield plus the rate of capital gain:

$$r_t = \frac{d_{t+1} + p_{t+1}}{p_t}\ . \tag{9}$$

Substituting $p = k\, d_t$ and $p_{t+1} = kd_{t+1}$ into (9) and using (7), we have

$$r_t = \left(\frac{k+1}{k}\right)(1 + \epsilon_{t+1}) - 1. \tag{10}$$

Because k, the price-dividend ratio, is on the order of 25, the multiplicative constant $(k+1)/k$ is not far from one, and therefore can be ignored. Thus the rate of return approximately equals the dividend growth rate, and the variances of these variables are approximately equal also.

In sum, this decreasing relation between investors' information and return volatility implies that if capital markets are at least weak-form efficient (and if dividends follow a random walk) the variance of the rate of return on stock cannot be greater than the variance of the dividend growth rate.

III. Empirical Results

Chart 1 shows the Standard & Poor's stock price index from 1926 to 1985, adjusted for inflation in commodity prices using the producers' price index. As expected, real stock prices display a pronounced upward trend over time, reflecting corporate retained earnings and, to a lesser extent, new equity issues. A very striking observation from Chart 1 is that stock price volatility has decreased between the 1930s and the 1980s. The decline from 1929 to 1932, the rise in the mid-1930s, and the decline in the years just before World War II were much more pronounced than any change occurring between World War II and the mid-1970s. This decreasing volatility of stock prices goes contrary to a common impression that stock market volatility has increased in recent decades. Another observation is that the October 19, 1987, selloff appears in Chart 1 as only a minor drop at the end of the period, rather than as the cataclysm it in fact was. The reason is that it came after nine months of rapid gains in stock prices, so that annual data show only a small drop from 1986 to 1987.

Chart 1
Standard And Poor's Stock Price Index

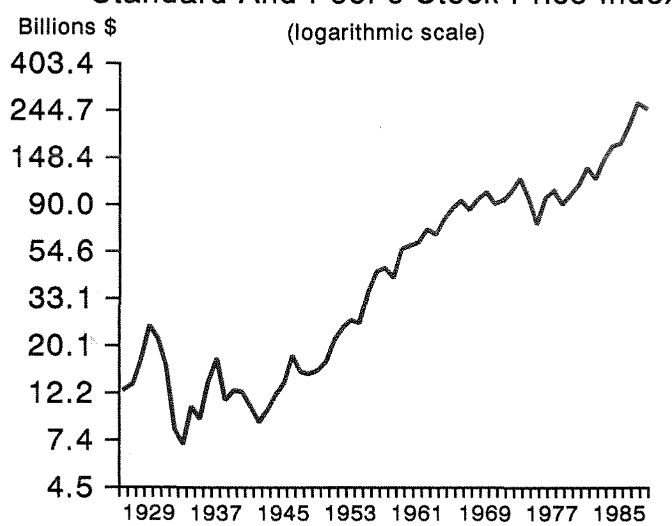


Chart 2 displays a simulated rate of return series that is representative of the pattern that would be expected under weak-form market efficiency. To generate the artificial stock prices on which the returns in Chart 2 were based, investors were arbitrarily assumed to be able to forecast dividends with perfect accuracy five years into the future. Beyond that horizon, however, they were assumed to have no information at all. Therefore they were assumed to extrapolate dividends using a constant growth rate, as implied by the geometric random walk. As would be expected in an efficient market, rates of return were higher than normal in years preceding dividend growth that was higher than normal, and lower than normal in years preceding low dividend growth. However, the relevant observation is that the rate of return has lower volatility than the dividend growth rate, conforming to the implication of market efficiency outlined above.

Chart 3 is similar to Chart 2 except that the actual rate of return on stock, rather than the simulated return based on market efficiency, is shown. Several aspects of this diagram are surprising. Most striking is the decrease in the volatility of both the rate of return on stock and the dividend growth rate from the 1930s to the 1980s. This decline in stock price volatility was noted in the discussion of Chart 1. Chart 3 makes clear that the decline in the volatility of dividend growth is even more pronounced than that in return volatility. However, for the purpose of testing the volatility implications of market efficiency, the relevant observation is that over the postwar period the rate of return on stock was much more variable than the dividend growth rate (in the prewar period the difference is not nearly as great). This result is inconsistent with the stock market being weak-form efficient.

The volatility test just presented was chosen because it is easy to motivate intuitively. Because the test depends on strong simplifying assumptions, it may be that the finding of excess volatility arises from a violation of these assumptions rather than of market inefficiency. For example, without the simplifying random walk assumption, it is not necessarily true that the variance of the growth rate of dividends is an upper bound for the variance of the rate of return. Equally important, the version of the expected present-value model used to derive the volatility test incorporated the assumption that the discount rate is constant at ρ. Changing real interest rates over time are therefore a conceivable alternative to market inefficiency as a cause of the apparent excess volatility. However, both of these possibilities have been explored extensively in the variance-bounds literature, and so far, it appears that allowing for these more general specifications does not help explain the excess volatility. Thus, the conclusion that volatility is excessive can be justified in much more general settings than assumed here. The volatility test just reported then should be regarded as a sample from the volatility literature in which simplicity of exposition is purchased at the expense of restrictive specifications.

There are two possible sources of excess volatility in stock prices. First, investors could be overreacting to relevant information; second, they could be reacting to information which is irrelevant according to the efficient markets model. Although there do not appear to exist studies which attempt formally to apportion the excess

Chart 2
Simulated Rate Of Return
And Dividend Growth Rate

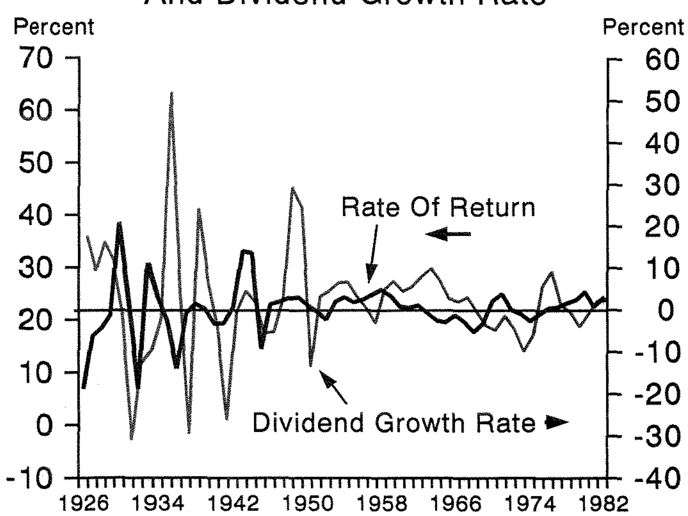
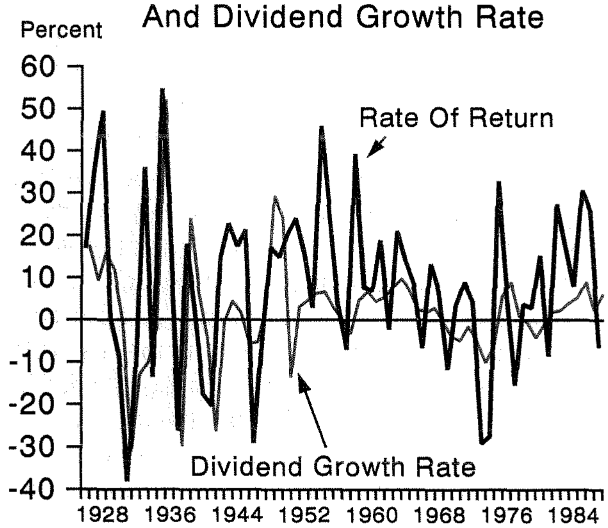


Chart 3
Actual Rate Of Return
And Dividend Growth Rate



volatility between these two sources, it seems likely that both are important.

That investors react to irrelevant information, at least, has been well established. For example, Roll (1984) documented the importance of irrelevant information in determining orange juice futures prices. Efficient markets theory implies that changes in the futures price of orange juice concentrate will reflect changes in the spot price which market participants expect will prevail at the date of the expiration of the futures contract. Roll argued persuasively that the only variable that can plausibly be viewed as giving relevant information about spot prices is weather—specifically, weather forecasts leading market participants to change their estimates of the probability of a freeze in Florida, since a freeze would adversely affect the orange crop.

Other variables which could in principle be relevant, Roll argued, would be expected to have only minor effect in the context of orange juice futures prices since current changes in supply induced by factors other than weather are of secondary importance, inasmuch as these factors do not change abruptly. For example, the number of trees bearing oranges at any time reflects planting decisions made several years earlier. Similarly, it appears unlikely that consumers' income and the prices of such substitutes as apple juice or tomato juice figure in an important way. Thus the efficient markets model predicts that weather should exert a dominant influence on futures prices. Roll verified that low temperatures in Florida were in fact associated with increases in orange juice futures prices, as expected. However, only a few percent of the total variation in futures prices can be explained in this way. In fact, Roll was unable to find any variable at all which correlated significantly with futures prices.

In his Presidential address to the American Finance Association, Roll (1988) reported the results of tests of whether the efficient markets model provides accurate *ex post* explanations for stock prices. He found that, again, irrelevant information appears to be of dominant importance. Even using such data as industry average prices and aggregate stock market indexes, Roll was able to explain *ex post* only a small fraction of the variation in prices of individual stocks.

IV. Asset Pricing Anomalies

There has always existed evidence at odds with the simplest models incorporating market efficiency. Prior to the 1970s, this conflict between theory and evidence usually was dismissed on the grounds that with relatively minor modifications, the efficient markets model could accommodate the contrary observations. For example, analysts identified trading rules that apparently could generate systematic profits, contrary to the efficient markets model. However, when these analysts allowed for brokerage charges, the profits usually evaporated.

More recently, however, analysts have recognized that there exists evidence that is not easy to square with the efficient markets model, even after making reasonable allowance for brokerage charges and other transactions costs. The "P-E anomaly" (Basu 1977, 1983) is the most prominent. It refers to the finding that stocks with low price-earnings ratios generate systematically higher rates of return than do stocks with high P-E ratios. This pattern is difficult to square with any recognizable version of the efficient markets model. In an efficient market, the stock price of successful firms should rise, but only by as much as is consistent with the firms earning normal returns in the future, and similarly with unsuccessful firms.

In contrast, it is easy to relate the P-E anomaly to the excess volatility of stock prices, at least informally. If investors overreact to news, then the stocks of successful firms will be bid to a higher multiple over earnings than is justified by the objective probability of this success continuing in the future. Subsequently the euphoria will wear off, generating low or even negative returns on average. Similarly, investors may be overeager to unburden their portfolios of losers, to the point where these stocks are discounted more than the facts justify. Subsequently such stocks on average generate higher returns than normal as their prospects improve. Correspondingly, this pattern of systematic overreaction to news would be expected to lead to price volatility in excess of that predicted by the efficient markets model. Therefore it is possible that the excess volatility of stock prices is the same thing as the P-E anomaly.

DeBondt and Thaler (1985, 1987) recently have documented a pattern similar to the P-E anomaly. They compared fictional portfolios of "winners"— stocks that had appreciated significantly in the recent past—with similar portfolios of "losers." They found that the losers strongly outperformed the market generally in subsequent years, while winners earned lower returns than the market averages. This result also suggests a pattern of overreaction, although the relation between DeBondt-Thaler's result and the P-E anomaly remains unclear.

Development of large data bases suitable for computerized study of stock prices have led to new anomalies.

Of these, the most striking is the "January effect" (Rozeff and Kinney, 1976; see Thaler, 1987, for a survey). Rozeff and Kinney found that rates of return on stock averaged 3.5 percent in January, whereas in other months returns averaged only 0.5 per cent. Several explanations involving tax-related purchases and sales of stocks have been investigated, but these explanations are not entirely convincing.

Another anomaly is the "small-firm" effect (Banz, 1981) in which small firms appear to earn higher returns than large firms, even when allowance is made for differences in riskiness. A subsequent study (Keim, 1983) showed that the January effect and the small-firm effect may be the same thing: the January effect appears only in samples that give equal weight to large and small firms. Value-weighted samples, in which small firms have much less importance relative to their role in equal-weighted samples, show little evidence of a January effect. This is exactly the pattern that would be expected if small firms account for the January effect.

Still other calendar-based anomalies have surfaced in recent years. Cross (1973), French (1980), and Keim and Stambaugh (1984), among others, have analyzed the "weekend effect," which refers to the observation that stock returns are on average negative from the close of trading on Fridays to the opening of trading on Mondays. Gibbons and Hess (1981) showed that a similar effect exists for bonds. Further, we have the "Wednesday effect": in 1968 the New York Stock Exchange was closed on Wednesdays in order to allow the back offices of brokerage houses to catch up with paperwork. Roll (1986) found that the volatility of stock prices was lower from Tuesday to Thursday when the market was closed on Wednesdays than over two-day periods over which the Exchange was not closed. This puzzle is difficult (although not impossible; see Slezak, 1988) to reconcile with market efficiency, given that as much news about corporate dividends presumably was arriving when the market was closed on Wednesdays as on other weekdays. The implication is that to some extent the trading process itself generates price volatility, a phenomenon clearly inconsistent with market efficiency. Finally, there exists a day-of-the-month effect: stock returns are positive in the days surrounding the turn of the month, but are zero on average for the rest of the month (Ariel, 1985).

Finally, Tinic and West (1984) investigated the seasonal pattern in the risk-return tradeoff. Fama and MacBeth's (1973) paper earlier had verified the prediction from finance theory that high-risk firms earn higher average rates of return than low-risk firms. Motivated by the results on the January effect, Tinic and West investigated the seasonal pattern in the correlation between risk and return which Fama-MacBeth had estimated. They found that this correlation is due entirely to the data for January. Given Keim's result that small firms earn high returns in January, and given the obvious fact that small firms are riskier than large firms, it is not surprising that the correlation between risk and expected return is strongest in January. What is surprising, however, is that the correlation between risk and return is essentially zero for the other eleven months of the year. Inasmuch as investors are risk-averse, this lack of compensation for risk in eleven of the twelve months of the year is not easy to reconcile with market efficiency.

V. Conclusions

Several essentially unrelated types of evidence that capital markets are inefficient have been discussed in this paper. Since it is not easy to think of non-trivial predictions of the efficient markets model that are borne out empirically, the burden of the evidence is negative. (Of course, trivial predictions are borne out. For example, it is true that the sustained upward trend in dividends that has occurred in the U.S. economy is associated with sustained price appreciation, as the efficient markets model predicts.)

How important this conclusion is depends on what lies behind the contrary evidence. The version of capital market efficiency adopted in the variance-bounds test reported above is grossly over-simplified (for example, equation (1) does not allow that investors are risk-averse, and therefore will demand a higher rate of return on high-risk securities than on low-risk securities). If it were to turn out that minor modification of the efficient markets model were sufficient to dispose of the contrary evidence, then the violations of market efficiency would not be important. However, most of the obvious extensions of the efficient markets model have been tried already, largely without success so far. Although it is possible that these extensions of the efficient markets model will succeed in the future, it may at some point be necessary for economists to face the uncongenial task of thinking about a world in which asset prices do not behave according to the precepts of finance and economic theory.

Economists are accustomed to thinking of prices not simply as measuring the amount of wealth that is transferred from one person to another when goods change hands, but also as guiding resource allocation. This is true as much for asset prices as for the prices of consumption goods. To see how this works in the context of asset prices, think of the petroleum market. There exists a large but far from infinite supply of oil reserves in the Middle East and other parts of the world. Other sources of energy exist, but they are at present more expensive than petroleum, at least for such purposes as automobile transportation and heating. However, when the petroleum runs out at some point in the future, the price of petroleum must be high enough to induce energy-users to shift to other energy sources. In the simplest idealized case, the price of petroleum will rise to equality with the alternate energy source just as the last gallon of oil is extracted, so that energy users are induced to shift sources at exactly the right time. Before that day of reckoning, petroleum prices must be rising to guarantee to holders of petroleum reserves a competitive return.[5] In this stylized account, the price of petroleum gives exactly the right signals to users of petroleum: they have adequate incentive to conserve, but are not induced irrationally to squander other resources so as to save petroleum. It follows that a massive program to encourage conservation or reliance on alternative sources is likely to do more harm than good, inasmuch as such a program amounts to fixing a social mechanism that is not broken.

Evidence of capital market inefficiency means that it cannot be taken for granted that asset prices are doing as good a job of rationing resources among alternative users as the foregoing account implies. The existing price of petroleum may not, after all, fully reflect the best information about petroleum reserves, alternative energy technologies, and so forth. Accordingly, the price of petroleum may not be providing the right incentives for conservation and development of alternative technologies.

It is apparent that an extreme interpretation of the evidence against capital market efficiency has the effect of opening the door to a variety of schemes to alter economic institutions. Inasmuch as such schemes generally have met with various degrees of failure in the past, we should not be too quick to jettison capital market efficiency, and with it the idea that prices determined in competitive markets do a reasonably good job of allocating resources. The evidence reviewed here suggests, rather, that economists ought to be aware that the evidence in favor of their way of thinking about the economy is far from clear-cut.

NOTES

* A more detailed version of this paper is found in LeRoy (1989).

1. Although these verbal characterizations of market efficiency are drawn directly from Fama (1970), it is not unambiguously clear that Fama identified market efficiency with the fair-game model (1); see LeRoy (1976, 1989) for discussion.

2. Used here is the rule of iterated expectations, which says that $E(E(d_{t+2} \mid I_{t+1}) \mid I_t) = E(d_{t+2} \mid I_t)$, and similarly for p_{t+2}.

3. Even though future dividends are weighted differently from current dividends because of discounting, and future dividends are not known with certainty, price behaves like an average of dividends over time.

4. The test to be described is known as the "West test" (West, 1988), although the original version of the West test is formally equivalent to one of the volatility tests derived by LeRoy-Porter (1981). (See Gilles-LeRoy, 1988.) West's derivation was independent, and he was the first actually to conduct the test. Also, West was the first to realize that the return volatility test has certain econometric advantages over price volatility tests, particularly for diagrammatic presentation. These advantages justify adoption of the West test here.

In one respect the test reported here differs from that derived by LeRoy-Porter and West. The formal derivation of the West test assumes constant-variance linear processes, which is an unsatisfactory specification in light of the upward trend in stock prices over the past fifty years. In order to correct for scale, Chart 3 instead compares the rate of return with the dividends growth rate. Formal derivation of the validity of this comparison, which is based on the linearization procedure of Campbell-Shiller (1988), is found in LeRoy-Parke (1990).

5. The implication that the prices of exhaustible resources should rise at a rate approximately equal to the real interest rate has been studied by Schmidt (1988). Schmidt found no evidence of rising prices over time, implying that holders of wealth in the form of exhaustible resources earned a zero real rate of return.

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