THE JOURNAL OF FINANCE • VOL. XLI, NO. 3 • JULY 1986

Does the Stock Market Rationally Reflect Fundamental Values?

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ABSTRACT

This paper examines the power of statistical tests commonly used to evaluate the efficiency of speculative markets. It shows that these tests have very low power. Market valuations can differ substantially and persistently from the rational expectation of the present value of cash flows without leaving statistically discernible traces in the pattern of ex-post returns. This observation implies that speculation is unlikely to ensure rational valuations, since similar problems of identification plague both financial economists and would be speculators.

THE PROPOSITION THAT securities markets are efficient forms the basis for most research in financial economics. A voluminous literature has developed supporting this hypothesis. Jensen [10] calls it the best established empirical fact in economics.[1] Indeed, apparent anomalies such as the discounts on closed end mutual funds and the success of trading rules based on earnings announcements are treated as indications of the failures of models specifying equilibrium returns, rather than as evidence against the hypothesis of market efficiency.[2] Recently the Efficient Markets Hypothesis and the notions connected with it have provided the basis for a great deal of research in macroeconomics. This research has typically assumed that asset prices are in some sense rationally related to economic realities.

Despite the widespread allegiance to the notion of market efficiency, a number of authors have suggested that certain asset prices are not rationally related to economic realities. Modigliani and Cohn [14] suggest that the stock market is very substantially undervalued because of inflation illusion. A similar claim regarding bond prices is put forward in Summers [20]. Brainard, Shoven and Weiss [4] find that the currently low level of the stock market could not be rationally related to economic realities. Shiller [16, 17] concludes that both bond and stock prices are far more volatile than can be justified on the basis of real economic events. Arrow [2] has suggested that psychological models of "irrational decision making" of the type suggested by Tversky and Kahneman [22] can help to explain behavior in speculative markets. These types of claims are frequently

* Harvard University and NBER. I am grateful to Fischer Black, Zvi Griliches, Jim Pesando, Andrei Shleifer and Jim Poterba for clarifying discussions, but remain responsible for any errors. This paper repeats and recasts much of the analysis in Summers.

[1] Similar assertions are very common in the finance literature. While doubts along the lines of the discussion here, appear to be part of an oral tradition, the only reference I could find is Shiller [17].

[2] For examples, see the issue of the *Journal of Financial Economics* devoted to anomalies in the Efficient Market Hypothesis [15].

dismissed because they are premised on inefficiencies and hence imply the presence of exploitable excess profit opportunities.

This paper argues that existing evidence does not establish that financial markets are efficient in the sense of rationally reflecting fundamentals. It demonstrates that the types of statistical tests which have been used to date have essentially no power against at least one interesting alternative hypothesis to market efficiency. Thus the inability of these tests to reject the hypothesis of market efficiency does not mean that they provide evidence in favor of its acceptance. In particular, the data in conjunction with current methods provide no evidence against the view that financial market prices deviate widely and frequently from rational valuations. The same considerations which make deviations from efficiency difficult to isolate statistically make it unlikely that they will be arbitraged away or eliminated by speculative trading. Thus the results here call into question the theoretical as well as empirical underpinnings of the Efficient Markets Hypothesis. The absence of compelling theoretical or empirical arguments in favor of the proposition that financial market valuations are efficient is significant in light of a number of types of evidence suggesting that large valuation errors are common in speculative markets.

The first section distinguishes alternative concepts of market efficiency and lays out the formulation used here. Tests of market efficiency in its weak and strong forms are considered in the second and third sections, along with other evidence often adduced to suggest that stock market valuations are rational. The implications of the results for our understanding of speculative markets are discussed in the fourth and final section.

I. Defining Market Efficiency

The notion of market efficiency has been defined in many ways. Fama [5] presents a thorough discussion of both theoretical issues and empirical tests of this proposition. In the development below, I shall consider the evolution of the price of a single security. It can easily be taken to represent an entire portfolio. It is assumed that the required expected rate of return on the security is equal to a constant, r, which is known with certainty. As has frequently been observed, standard tests of market efficiency are really joint tests of efficiency and a model specifying expected returns. The assumption made here that the ex ante return is known and constant makes it possible to focus only on the test of market efficiency.[3]

Assume that the security in question yields a sequence of cash flows, D_t. These may be thought of as dividends if the security is a stock, or coupons if the security is a bond. If the security has a finite maturity, T, then D_T may be taken to represent its liquidation value, and all subsequent values of D_t may be taken to

[3] Since the discussion here assumes that the model generating expected returns is known with certainty, it will overestimate the power of available statistical tests. Recent theoretical work suggests that the particular model of ex-ante returns considered here cannot be derived rigorously. This is immaterial for the points at issue here. What is crucial is that the discussion is carried on assuming full knowledge of the model characterizing ex-ante returns.

equal zero. One statement of the hypothesis of market efficiency holds that:

$$P_t = P_t^* = E\left[\left(\sum_{s=t}^{\infty} \frac{D_s}{(1+r)^{s-t}}\right)\middle|\Omega_t\right] \tag{1}$$

where Ω_t represents the set of information available to market participants at time t. This is not the form in which the hypothesis is usually tested. Equation (1) is mathematically equivalent to the statement that, for all t:

$$P_t = E\left(\frac{P_{t+1}}{1+r}\right) + E(D_t) \tag{2}$$

or the equivalent statement that

$$E(R_t) = E\left(\frac{P_{t+1}}{P_t} - 1 + \frac{(1+r)_t}{P_t}\right) = r \tag{3}$$

where the information set in equations (2) and (3) is taken to be Ω_t. Note that once a transversality condition is imposed on the difference equation (3), it implies equation (1).[4]

Equation (3) also implies that:

$$R_t = r + e_t \tag{4}$$

where e_t is serially uncorrelated and orthogonal to any element of Ω_t. Market efficiency is normally tested by adding regressors drawn from Ω_t to (4) and testing the hypothesis that their coefficients equal zero, or by testing the hypothesis that e_t follows a white noise process.[5] The former represent tests of "semi-strong" efficiency while the latter are tests of "weak" efficiency. A vast literature, summarized in Fama [5], has with few exceptions been unable to reject the hypothesis of market efficiency, at least for common stocks. The body of evidence supporting the hypothesis of market efficiency has been used to support two different conclusions. First, almost tautologously, failures to reject the hypothesis of market efficiency have been taken as evidence that portfolio managers cannot outperform the market to an important extent by trading using publicly available information. Second, evidence of market efficiency is often viewed as establishing that financial market prices represent rational assessments of fundamental values. The large event study literature rests on this premise.

II. Tests of Market Efficiency

The inability of a body of data to reject a scientific theory does not mean that the tests prove, demonstrate or even support its validity. As students of elementary statistics are constantly reminded, failure to reject a hypothesis is not equivalent to its acceptance. This principle applies to all scientific theories, not just those that are stated statistically. Experiments can falsify a theory by

[4] The transversality condition serves to rule out speculative bubbles.

[5] Abel and Mishkin [1] and Jones and Roley [10] show that other standard tests of efficiency are essentially equivalent to those described in this paragraph.

contradicting one of its implications. But the verification of one of its predictions cannot be taken to prove or establish a theory.[6]

How then do we evaluate the strength of the evidence supporting a hypothesis? Clearly we do not simply count the number of implications of a hypothesis which are validated. We give more weight to the verification of some implications than to the verification of others. For example, almost everyone would agree that findings that excess returns cannot be predicted using past data on sunspots provides less support for the hypothesis of market efficiency than do demonstrations that excess returns are not serially correlated. This is because we find it much easier to imagine alternative models in which returns are serially correlated than we do alternative models in which sunspots can help predict returns. The usefulness of any test of a hypothesis depends on its ability to discriminate between it and other plausible formulations. Below I examine the usefulness of standard tests of market efficiency according to this criterion.

Evaluation of any test of a theory requires specification of an alternative hypothesis. A natural specification of an alternative hypothesis to market efficiency holds that:

$$P_t = P_t^* + u_t$$

$$u_t = \alpha u_{t-1} + v_t \tag{5}$$

where lower-case letters indicate logarithms and u_t and v_t represent random shocks. This hypothesis implies that market valuations differ from the rational expectation of the present value of future cash flows by a multiplicative factor approximately equal to $(1 + \mu_t)$. The deviations are assumed to follow a first-order autoregressive process. It seems reasonable to suppose that deviations tend to persist but not grow forever so that $0 \leq \alpha \leq 1$. The assumption that u_t follows an AR process is made for ease of exposition and does not affect any of the substantive points at issue. For simplicity, it is assumed that u_t and v_t are uncorrelated with e_t at all frequencies.

Many, though not all, of the plausible senses in which markets might fail to rationally reflect fundamental values are captured by this specification. It clearly captures Keynes's [12] notion that markets are sometimes driven by animal spirits unrelated to economic realities. It also is consistent with the experimental evidence of Tversky and Kahneman [22] that subjects overreact to new information in making probabilistic judgements. The formulation considered here captures Robert Shiller's [16, 17, 18] suggestion that financial markets display excess volatility and overreact to new information. One deviation from standard notions of market efficiency which does not take this form is Blanchard and Watson's [3] suggestion of intermittent rational speculative bubbles.[7]

Adopting the approximation that $\log(1 + u_t) = u_t$, and that $\frac{\text{Div}_t}{P_t} \simeq \frac{\text{Div}_t}{P_t^*}$,

[6] A discussion of what it means to establish evidence in favor of a scientific hypothesis may be found in Hempel [8].

[7] Olivier Blanchard has pointed out to me that if $\alpha = 1 + r$, equation (5) will characterize a speculative bubble. In this case however, market valuations will come to diverge arbitrarily far from fundamental valuations.

Table 1

Theoretical Autocorrelation of Excess Return
Assuming Market Inefficiency

$\frac{\sigma_e^2}{\sigma_u^2}$	α				
	.75	.90	.95	.99	.995
1.0	−0.042	−0.008	−0.003	0.000	0.000
0.5	−0.062	−0.014	−0.004	0.000	0.000
0.25	−0.083	−0.022	−0.007	0.000	0.000
0.1	−0.104	−0.033	−0.012	−0.001	0.000
0.05	−0.113	−0.040	−0.017	−0.001	0.000
0.01	−0.122	−0.048	−0.023	−0.003	−0.001

Note: Calculations are based on Equation (8).

equations (3), (4) and (5) imply that excess returns $Z_t = (R_t - r)$ follow an ARMA (1, 1) process.[8] That is:[9]

$$Z_t = \alpha Z_{t-1} + e_t - \alpha e_{t-1} + v_t - v_{t-1}. \tag{6}$$

Granger and Newbold [7] show that since Z_t can be expressed as the sum of an ARMA (1, 1) process and white noise, ARMA (0, 0), it can be represented as an ARMA (1, 1) process. Equation (6) can be used to calculate the variance and the autocorrelations of Z_t. These calculations yield:

$$\sigma_z^2 = 2(1 - \alpha)\sigma_u^2 + \sigma_e^2 \tag{7}$$

$$\rho_k = \frac{-\alpha^{k-1}(1 - \alpha)^2\sigma_u^2}{1(1 - \alpha)\sigma_u^2 + \sigma_e^2} \tag{8}$$

where ρ_k denotes the kth-order autocorrelation. Note that the model predicts that the Z_t should display negative serial correlation. When excess returns are positive, some part is on average spurious, due to a shock, v_t. As prices revert to fundamental values, negative excess returns result.

A. Weak Form Tests of Market Efficiency

At this point the power of "weak form tests" of market efficiency can be evaluated. These tests involve evaluating the hypothesis that the $\rho_k = 0$. Table I presents the theoretical first order autocorrelation for various parameter combinations. In all cases, the parameters are chosen to accord with the observed variance in stock market returns. Note that (8) implies that all subsequent autocorrelations are smaller in absolute value. In order to get a feeling for the

[8] These approximations are necessary in order to obtain simple analytic expressions. Monte-Carlo results confirm that these approximations are innocuous. Shiller [18] presents an example similar to the one here in his defense of volatility tests.

[9] This can be seen as follows. With the approximations assumed here, $R_t = \frac{\text{Div}_t}{P_t^*} + p_{t+1} - p_t = \frac{\text{Div}_t}{P_t^*} + P_{t+1}^* - p_t^* + u_{t+1} - u_t$, where the last equality is implied by equation (5). This can be written, using (3) and (4) as $R_t = r + e_t + u_{t+1} - u_t$. Combining this last equation with equation (5) yields equation (6).

magnitudes involved, it is useful to consider a concrete example. Suppose one is interested in testing market efficiency using aggregate data on monthly stock market returns over a 50-year period. With 600 observations, the estimated autocorrelations have a standard error of $1/\sqrt{597} \simeq .042$ on the null hypothesis of zero autocorrelation. This calculation leads to an overstatement of the power of tests because it counterfactually assumes a constant variance of excess returns and the normality of e_t. Suppose that $\sigma_u^2 = .08$ so that the standard deviation of the market's error in valuation is close to 30 percent, and that $\alpha = .98$. This implies that it takes about three years for the market to eliminate half of any valuation error, u_t. These assumptions, along with the observation that $\sigma_z^2 \simeq .004$, imply, using (7), that $\sigma_e^2 \simeq .001$.[10] Equation (8) implies that the theoretically expected value of ρ_1 is $-.008$. Thus, in this example, the data lack the power to reject the hypothesis of market efficiency even though market valuations frequently differ from the rational expectation of the present value of future cash flows by more than 30 percent.[11] In order to have a 50 percent chance of rejecting the null hypothesis it would be necessary to have data for just over 5000 years. Note also that in this example three-fourths of variance in excess returns is due to valuation errors, u_t, rather than genuine information, e_t. Even if $\sigma_u^2 = .10$, so that all the variance in market returns is spurious, and $\sigma_e^2 = 0$, the theoretical value of ρ_1 is only $-.01$, so that deviations from efficiency could not be detected. If, as is plausible, the serial correlation in valuation errors is greater, the power of standard tests is even lower.[12]

B. Announcement-Based Tests

These results have implications for tests of market efficiency which go beyond the examination of serial correlation and excess returns. One of the major pieces of evidence that is often adduced in favor of the hypothesis of market efficiency is the prompt response of stock prices to news. Countless studies have demonstrated that stock prices respond almost instantaneously to new information, and that no predictable excess returns can be earned by trading after information has been released. This finding has no power in distinguishing the traditional market efficiency hypothesis from the alternative considered here. Under the alternative hypothesis considered here, the market responds immediately to news about fundamentals, e_t. And no abnormal patterns in returns are generated subsequent to major news announcements. The "fads" hypothesis considered here and the market efficiency hypothesis make exactly the same prediction

[10] This estimate for σ_z^2 is consistent with the 20 percent annual standard deviation of market returns reported by Ibbotsen and Sinquefield [9].

[11] A more formal procedure would calculate the distribution of the test statistic $\left(\frac{\rho_k}{\sigma_k}\right)$ under the alternative hypothesis. It should be obvious that carrying out this procedure would support the assertions in the text. Note that these calculations overstate the power of the tests actually performed by assuming that variances are constant and ignoring the special problem surrounding tests for unit roots.

[12] Summers [20] shows that using daily rather than monthly data or testing autocorrelations at many lags does not alter the conclusions reached here.

about true news and so announcement tests do not provide any basis for distinguishing between them.

III. Tests of Semi-Strong Efficiency

In closing the last section on weak-form tests we considered one type of test for semi-strong efficiency—examining the profitability of strategies of buying or selling following certain types of announcements. Here we consider a different type of test. Equation (5) implies that expected excess returns should be negative when $p_t > p_t^*$ and positive when $p_t < p_t^*$. This reflects the assumed tendency of market prices to return towards the rational expectation of the present value of future cash flows. The key question is whether these expected excess returns are large enough to be detectable.

In practice any effort used to test efficiency in this way runs into the problems that p_t^* is unobservable. This problem is assumed away so that the hypothetical tests considered here have far more power than any test which could actually be devised. Under the assumptions that have been made so far, it is easy to see that:

$$E(z_t) = -(1 - \alpha)u_{t-1} = (1 - \alpha)(p_t^* - p_t) \tag{9}$$

In the example considered above with $\alpha = .98$, and $\sigma_u = .28$, (9) implies that when the market was undervalued by one standard deviation, the expected excess monthly return would be $(.02) \cdot (.28) = .0056$. This contrasts with a standard deviation of monthly returns of .06.

How much data would it take for these excess returns to be statistically discernible? Suppose that the regression equation

$$Z_t = a + b(p_t^* - p_t) + \eta_t \tag{10}$$

is estimated. Equation (9) implies that $E(\hat{b}) = (1 - \alpha)$. The standard errror of $\hat{b}$ can be calculated from the expression:

$$\sigma_{\hat{b}}^2 = \frac{\sigma_\eta^2}{n\sigma_u^2} \tag{11}$$

In the example considered above, one can calculate that $\sigma_b \simeq .01$. This implies that the hypothesis of market efficiency would not be rejected at the five percent level, with probability of one-half.[13] If $\alpha = .99$, the probability of rejecting the null hypothesis is less than one-sixth. Of course this discussion vastly overstates the power of any test that could actually be performed. In addition to the problem of measuring p_t^*, there are the problems of non-normality in the residuals, and the problem of measuring expected returns. These factors combine to suggest that tests of semi-strong efficiency do not have much more power against the type of inefficiency considered here than do tests on serial correlation properties of excess returns.

As Merton [13] stresses, a major piece of evidence in favor of the market

[13] There is one-half chance that $\hat{b} < E(\hat{b}) = .02$. In these cases the null hypothesis of efficiency will be accepted.

efficiency hypothesis is the repeated finding that professional money managers do not consistently outperform the market. Professional managers do not outperform the market as a class, and convincing evidence that any individuals have the ability to outperform the market has yet to be presented. Merton argues that this finding indicates that no "hidden models" with market forecasting ability are in use. The power calculations reported above suggest that even if some individuals have the ability to identify periods of market over- and undervaluation, they would not be able to prove it during the relatively short horizons over which performance evaluations are usually undertaken.

IV. Implications and Conclusions

The preceding analysis suggests that certain types of inefficiency in market valuations are not likely to be detected using standard methods. This means the evidence found in many studies that the hypothesis of efficiency cannot be rejected should not lead us to conclude that market prices represent rational assessments of fundamentals valuations. Rather, we must face the fact that most of our tests have relatively little power against certain types of market inefficiency. In particular, the hypothesis that market valuations include large persistent errors is as consistent with the available empirical evidence as is the hypothesis of market efficiency. These are exactly the sort of errors in valuation one would expect to see if market valuations involved inflation illusion or were moved by fads as some have suggested.

The weakness of the empirical evidence verifying the hypothesis that securities markets are efficient in assessing fundamental values would not be bothersome if the hypothesis rested on firm theoretical foundations, and if there were no contrary empirical evidence. Unfortunately, neither of these conditions is satisfied in practice.

A. Will Speculation Eliminate Valuation Errors?

The standard theoretical argument for market efficiency is that unless securities are priced efficiently, there will be opportunities to earn excess returns. Speculators will take advantage of these opportunities by arbitraging away any inefficiencies in the pricing of securities. This argument does not explain how speculators become aware of profit opportunities. The same problems of identification described here as confronting financial economists also plague "would be" speculators. If the large persistent valuations errors considered here leave no statistically discernible trace in the historical patterns of returns, it is hard to see how speculators could become aware of them. Moreover, cautious speculators may be persuaded by the same arguments used by economists to suggest that apparent inefficiencies are not present.[14]

There is another logically separate point to be made here as well. Even if inefficiencies of the type considered here could be conclusively identified, the excess returns to trying to exploit them would be small and uncertain. The same

[14] A more extensive discussion of the reasons why speculators are unlikely to eliminate miscalculations of fundamentals may be found in Summers [20].

noise which confounds statistical tests for inefficiencies makes exploiting valuation errors risky. Risk-averse speculators will only be willing to take limited positions when they perceive valuation errors. Hence errors will not be eliminated unless they are widely noticed.

An example provided by Schaefer [15] highlights one of the points being made here—that asset values can diverge significantly from fundamentals without leaving a statistically discernible trace in the pattern of returns. The example is somewhat specialized because fundamentals cannot be valued directly in the case of most assets. But the inability to detect predictable excess returns here suggests that failure elsewhere should not be taken as conclusive evidence of rational valuation. Schaefer consider the case of British gilts. He shows that some gilts are priced in such a way that they were dominated securities for investors in all tax situations. Nonetheless, he concludes that (p. 155)

> In an economic sense the result for the Electricity 3% is 'highly significant': the bond is dominated over the period with probability one. On the other hand, the period to period returns on the bond and its dominating portfolio are imperfectly correlated, and thus we cannot achieve statistical significance when we analyze mean period by period returns.

Even where valuation errors are detectable, and the existence of excess returns can be documented, the errors may not be eliminated. An excellent example is provided by the case of stock market futures. When held to maturity, they yield a return which is perfectly correlated with the market portfolio. Yet they have frequently been priced so that the return from holding them exceeds the return from holding the underlying market portfolio by several percentage points. At one level this can be explained by pointing to the difficulty of achieving an arbitrage by shorting the whole market portfolio. But this does not resolve the issue. The fact remains that two assets are available for purchase with essentially perfectly correlated but unequal returns. The differences in expected returns are no larger than in the examples presented above where fads created valuation errors of thirty percent or more.

B. Are There Valuation Errors?

The analysis presented so far suggests that valuation errors, if present, will be difficult to detect by looking at observed returns. But this does not prove their existence. However, both theoretical and empirical considerations suggest the likelihood that market valuations differ frequently and substantially from fundamental values. Shleifer and Summers [19] examine the likelihood that market forces will eventually eliminate irrational traders. We argue that this is unlikely. To the extent that risk is rewarded, irrational investors who plunge into particular securities may even come to dominate the market. And even a cursory examination suggests that there are many traders pursuing strategies not closely related to fundamental valuations. There are no grounds for assuming either that irrational traders will be eliminated, or that they will be unable to move market prices.

Indirect empirical evidence suggests the importance of valuation errors. Perhaps most striking is direct evidence of divergences between the market and

fundamental valuations. A classic example is the discounts on closed end funds. Even though the underlying assets are easily valued, market values do not accurately reflect fundamentals. Schaefer [15] suggests a similar pattern for British gilts. For most securities, fundamental values are hard to measure. But the large takeover premiums that are frequently paid even in cases where there are no obvious economic advantages to combination, suggests that valuation errors are being made in the market either ex ante or ex post.

The results of French and Roll [6] can also be interpreted as suggesting market valuations diverge from fundamental values. They find that much of the volatility in the market is in some sense self-generating. Market prices move much more over intervals when the market is continuously open, than over otherwise similar intervals when the market is not continuously open. The "extra" movements in prices associated with the markets being open seem likely to lead to valuation errors. The evident difficulty economists have in explaining any significant amount of the variations in speculative prices on the basis of "news" about fundamentals also suggests that valuation errors are being made continuously.

C. Implications

The central message of the huge literature on market efficiency is the supreme difficulty of earning abnormal returns making use only of publicly available information. This paper has not disputed this conclusion. Rather it has taken issue with the corollary implication of the efficient market view that market prices represent rational assessments of fundamental values. While this does not call into question prescriptions about portfolio management derived from the efficient market hypothesis, it does suggest caution in treating stock prices or their changes as rational reflections of fundamental values. This point is important for both corporate financial policy and for event study research. It is even more important for macroeconomic theories such as the q investment theory which presume that asset prices can be used to reflect the present value of the rents an asset will generate.

This analysis suggests that a more catholic approach should be taken to explaining the behavior of speculative prices. It may be possible to model the process by which errors are incorporated into asset prices. The rich literature on individual choice under uncertainty may provide guidance here. Such an approach seems preferable to insisting on the basis of very weak available evidence that market valuations are always rational.

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DISCUSSION

ROBERT F. STAMBAUGH*: This interesting paper by Professor Summers questions the power of common tests of market efficiency. The inefficiency entertained is one in which the deviation of the price from the rational market fundamental is persistent and potentially large. This deviation is similar to a speculative bubble, which can induce "excess" volatility and negative autocorrelation in returns (e.g., Tirole [1]). The major contribution of this paper lies in the observation that, while the pricing error can contribute substantially to the variance of returns, the negative autocorrrelation can be too small to detect using common techniques. Thus, Professor Summers argues that most tests of market efficiency have had little power to reject market efficiency against this alternative version of inefficiency.

Researchers often face the reality that a statistical test has power to reject the null against only certain classes of alternatives—a uniformly powerful test is the

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