How Rational Investors Deal With Uncertainty
(or, Reports of the Death of Efficient Markets Theory Are Greatly Exaggerated)

by Keith C. Brown,
University of Texas at Austin,

W. V. Harlow,
Salomon Brothers Inc., and

Seba M. Tinic,
University of Texas at Austin
Much academic research in finance in the past quarter century has been devoted to examining the proposition that corporate securities are priced by “rational” investors in an “efficient market.” Stated most simply, the proposition says that the intensive pursuit of large returns by stock market investors ensures that, for the vast majority, only modest ones will be had. This argument, which has been refined and tested as the “efficient markets hypothesis” (EMH), could well be described as the foundation of modern financial theory.

*This article is based on our paper, “Risk Aversion, Uncertain Information, and Market Efficiency,” Journal of Financial Economics 22 (1988), 355-385. The opinions and analyses presented herein are those of the authors and do not necessarily represent the views of Salomon Brothers Inc.
In the 1960s and 1970s, finance scholars amassed a large body of empirical evidence attesting to the efficiency of capital markets. So extensive was this research, and so consistently supportive in its findings, that Professor Michael Jensen of the Harvard Business School has called the EMH the best-documented proposition in all of the social sciences. And, besides dominating academic research for two decades, the EMH and valuation models like the Capital Asset Pricing Model have made significant inroads into Wall Street thinking and practice. Currently, for example, over $150 billion is invested in “index” funds—those which deliberately refrain from active investment strategies and instead attempt simply to mimic the broad market.

Professional money managers, needless to say, have never looked kindly on the EMH. Among many top corporate executives, too—especially those who would like to attribute the bulk of corporate raiders’ profits to systematic market undervaluation—the idea of investor rationality arouses skepticism. And when you add to these more or less predictable sources of resistance the heightened political concern about stock market volatility, especially in the wake of the October ‘87 Crash, proponents of the EMH seem to find themselves in an increasingly defensive position these days.

Much of the criticism, however, stems from a faulty understanding of what the theory really claims for itself. We will begin here by trying to dispel some of the misconception by explaining what economists mean when they speak of an “efficient market.”

Efficient markets theory is, at bottom, simply an extension to capital markets of the “zero profits theorem” that economists have long applied to competitive goods markets. Briefly stated, the EMH holds that competition among investors for information ensures that the current prices of widely traded financial assets are “unbiased” predictors of the future values of those securities. The EMH thus does not say that today’s price is the “right” price, but only that it is an “unbiased” indicator of future value—that is, neither too high nor too low on average. And, therefore, a company’s future stock price (adjusted for risk and for general market movements which affect all stocks) is equally likely to be higher or lower than today’s price.

For corporate management, then, today’s stock price can be understood as the market’s collective estimate—although a “noisy” estimate, to be sure—of the present value of the company’s future risky cash flows (or, more precisely, the “certainty equivalents” of those flows). And unless one has significant inside information (or can confidently predict the the future direction of the market as a whole), the current price may well be the most reliable estimate of the value of the company as it is currently being run.

For investors contemplating purchase of a company’s stock, the theory implies that they should expect to earn a “normal” rate of return—nothing more, nothing less—at any given time they choose to invest. And, in fact, the well—documented failure of the vast majority of professional fund managers to outperform market-wide averages consistently is one of the strongest pieces of testimony to the efficiency of our financial markets.

**RECENT ACADEMIC CHALLENGES: THE OVERREACTION HYPOTHESIS**

Over the last few years, however, in addition to the natural skepticism of practitioners, the EMH has begun to face stronger challenges from within the academic community. In the late 1970s, to be sure, a number of “anomalies” were detected that appeared to provide investors with “trading rules” that would allow them to earn consistently above-average returns. For example, one could buy a portfolio of stocks with low P/E ratios or buy a portfolio of small capitalization stocks in December to take advantage of the “January effect.” But most of these anomalies may have little bearing on the validity of the EMH. They may instead be the result of flawed models of the relationship between risk and expected returns.

More serious charges against the EMH, however, have arisen from fairly recent studies claiming to have discovered two distinct, but related forms of investor irrationality: (1) “excessive” long-run stock price volatility and (2) short-term investor “overreaction” to the news of dramatic financial events. Because our own research concerns the second of these two issues, we concentrate our attention largely on the question of investor overreaction. (The research on long-run market volatility is summarized very briefly in footnote 6 below.)

Recent studies by Werner DeBondt and Richard Thaler purport to demonstrate that both the market-wide responses to general economic news and the

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stock price reactions to individual company “events” tend to overshoot their “equilibrium” levels—and then only gradually find their way back to those levels. That is, the market as a whole (and the price of individual stocks as well) systematically exaggerates the economic consequences of major events by raising prices too high when the news is good and cutting prices too sharply when the news is bad. In so doing, the studies argue, capital markets are providing investors with consistently exploitable opportunities for abnormal profits.2

In an efficient market, by contrast, prices are expected to respond to major events by moving quickly (if not “instantly”) to their new equilibrium levels. How do we know that prices have moved to their proper levels? The answer is that future price movements from these new levels should turn out to be “randomly distributed” around these new levels. In such a market, although investors will certainly overreact in some cases, they learn from their mistakes—because such mistakes, after all, are costly to them. And thus the cases in which investors overreact should be balanced by others in which they “underreact,” such that subsequent adjustments, on average, should be roughly equal to zero. This, in effect, was what Eugene Fama found in his classic 1965 study, “The Behavior of Stock Market Prices.”3

The recent findings of DeBondt and Thaler seem to imply, however, that investors do not learn from their past mistakes and that they consistently misread new information. Formulated as the “Overreaction Hypothesis” (OH), their argument suggests that large movements in stock prices are followed, on average, by large adjustments in the opposite direction. The hypothesis also predicts that the larger the initial price change (that is, the bigger the “surprise” to the market), the larger will be the amount of the initial overreaction, and hence the greater the subsequent price adjustment.

Our Findings

Over the past several years, we have studied this issue of market overreaction and come to a different conclusion. We too observed one of the findings that DeBondt and Thaler reported—the tendency of large stock price declines to be followed by a series of small upward adjustments. But we also made a discovery that contradicts their Overreaction Hypothesis: namely, that large stock price increases are also accompanied by small positive (or at least non—negative) adjustments, and not by the negative adjustments predicted by DeBondt and Thaler.4

In this article, we present a modified version of the EMH that we call the Uncertain Information Hypothesis (UIH). As noted above, the EMH, at least in its traditional form, starts with the assumption that investors have “complete” information and are thus able to move stock prices quickly to their new proper levels. Our UIH model attempts to extend efficient markets theory by showing how investors would respond “rationally” in situations of major uncertainty—those in which the assumption of complete information clearly does not hold.

As we will argue in the pages that follow, great uncertainty among investors leads, at least initially, to heightened price volatility and thus greater risk for investors. Because investors require higher returns for bearing greater risks, they respond to favorable as well as unfavorable surprise events by setting stock prices, on average, below their expected values. As the uncertainty over the eventual outcome is gradually clarified, subsequent price changes will tend to be positive, on average, regardless whether the initial event was good or bad. In this sense, positive price adjustments following major shocks are better understood as rational responses to increased risk than as chronic overreactions by the investing public.5

THE UNCERTAIN INFORMATION HYPOTHESIS

The standard version of the EMH is based on the clearly unrealistic assumption that investors have immediate access to all of the information they need to revise security prices in a definitive, once—and-for-all manner. In the real world, of course, some events are so little anticipated and of such consequence that

their ultimate effect on stock prices cannot be immediately determined. In the face of such uncertainty, our theory says, investors effectively form what economists refer to as "conditional probability distributions." Such distributions can be visualized as decision-tree-like diagrams that lay out a number of possible outcomes and assign probabilities to each. By multiplying the value of each possible outcome by its probability, one arrives at an "expected value" for the company’s shares. (In the Appendix, we provide a detailed illustration of this process.)

But, as our version of the EMH goes on to say, because of the increased uncertainty and thus greater risk attending such events, investors also immediately discount the value of the firm below the expected value of this probability distribution. This discount on the shares then disappears gradually, along with the uncertainty that gave rise to it.

For example, upon the unexpected death of a company’s talented CEO, the stockholders will quickly mark down the value of the company’s shares. But a more precise assessment of the consequences will not be possible until the market learns more about the company’s plans for a successor. So, in the immediate aftermath of the announcement, the best that investors will be able to do is to reset stock prices based on a subjective “guess” (or, more precisely, a probability distribution of guesses) about the longer-range effect. And, given investors’ aversion to risk, this first guess is more likely to fall below than above the eventual value.

The point of this example is that the unanticipated information affects investors in two ways. First, as the bad news is initially received, projections of the fortunes of the firm in question are immediately revised downward. Second, the level of uncertainty facing investors in this company increases, causing a further reduction in the value of the firm’s shares. Thus, even if this increase in uncertainty is not permanent, it nevertheless represents a potential source of risk for which investors will demand to be compensated (at least until the source of the risk is removed).

A similar market reaction can be envisioned in the case of unexpectedly good news. Suppose that a company announces it has developed a new technology that promises to reduce its production costs significantly. As in the previous example, to the extent that this information takes investors by surprise, any immediate adjustments to the firm’s stock price will be based on a crude forecast of the ultimate consequences of the event. While such an announcement should cause an overall increase in the value of the firm, it might also raise the level of uncertainty about its future performance—which would cause the stock price increase to be less than otherwise.

Of course, we could also have constructed other examples where an event might actually reduce uncertainty. In fact, it is entirely reasonable to suggest that certain news releases—such as the announcement of the jury’s verdict in a closely contested trial—might have the effect of decreasing the riskiness of holding corporate shares. Our UIH model simply assumes that major surprises will typically increase the variability and risk of stock returns.

**Contrast with the Overreaction Hypothesis**

In cases of bad news, then, the pattern of investors’ responses predicted by our Uncertain Information Hypothesis will be indistinguishable from that predicted by the Overreaction Hypothesis. That is, the initial decline in stock prices will be followed, on average, by a price increase. The difference between the two theories becomes apparent only in the case of good news. In contrast to the Overreaction Hypothesis, our model predicts what would appear to be an underreaction; that is, an initial price increase followed, on average, by a further increase.

These propositions are demonstrated graphically in Figure 1. For purposes of comparison, Panel A shows the adjustment of stock prices to bad news under the traditional EMH. The arrival of bad news drives the value of the security down from its previous level, $P$, to $P_B$; and there is no further adjustment after the initial response. In this case, the stock price moves immediately to its new “intrinsic” value.

In contrast, Panel B shows the pattern of price changes that would accompany unfavorable surprises under the Uncertain Information Hypothesis (and under the Overreaction Hypothesis as well). According to our UIH model, the arrival of bad news would not only decrease the expected cash flows of the security but also increase their systematic risk. With this additional uncertainty, the present value of the “certainty equivalents” of the risky cash flows is $P^*_B$ which could be significantly less than $P_B$ in a stock market dominated by risk-averse investors. But, as the uncertainty is resolved, the price increases to $P_B$ from $P^*_B$ to reflect the associated reduction of investor risk.
The effect of favorable surprises on stock prices is shown in Panels C, D, and E. In the standard EMH, in which the consequences of the news are immediately and clearly known, the price of the stock increases quickly from \( P \) to \( P_G \); and there is no adjustment thereafter. The Overreaction Hypothesis (illustrated in Panel D) predicts that the price will overshoot the mark, rising to \( P^* \) and then falling back to \( P_G \).

Our UIH model, in contrast to both the standard EMH and the OH, suggests that if the good news also increases the uncertainty about the stock’s future cash flows, then the price will initially rise only to \( P^*_G \), and then gradually adjust further up to \( P_G \) as the uncertainty is dispelled. As in the case of bad news, this delayed price adjustment is caused by investors’ rational demand for higher expected returns to compensate them for the heightened uncertainty.

Although the preceding discussion is couched in terms of favorable and unfavorable surprises affecting the systematic risks of individual stocks, our UIH model is equally relevant to market-wide surprises that affect the values of broad-based stock indexes. The UIH claims that major favorable and unfavorable surprises about the economy will typically increase the risk of holding common stocks in general. Thus, the returns on market portfolios following major shocks would also be expected to exhibit the same “asymmetric” pattern (i.e., apparent overreaction to bad news, under-reaction to good) shown in Panels B and E in Figure 1. Moreover, the UIH also suggests that, to the extent investors’ risk aversion decreases with higher levels of stock prices, the subsequent upward price adjustments after major unfavorable surprises are expected to be greater than the adjustments following favorable events.

The heart of our UIH theory, then, can be summarized by the following propositions: (1) on average, stock return variability will increase following the announcements of major unanticipated events; (2) the average price adjustments following the initial market reactions to both “negative” and “positive” events will be positive (or, in the case of the latter, at least non-negative); and (3) to the extent the market’s risk-aversion decreases as the level of stock prices increase, post-event price increases will be larger for negative events than for positive ones. The important point here is that the portfolios are priced rationally in both situations, and there are no \textit{ex ante} opportunities for investors to earn riskless profits by “arbitraging” price overreactions or under-reactions. Under this scenario, one only has the \textit{illusion} that investors consistently overreact to bad new and underreact to good.6

The general conclusion that has been drawn from the evidence amassed to date is that there appear to be “predictable” return components in security prices. More precisely, it has been shown that from 25 to 45 percent of the variability of stock returns over a three- to five-year time horizon can be predicted from returns in previous periods.

As intriguing as these results are, they can still be “explained” in two different ways: (1) investors are irrational and thus prices often depart from fundamental values in a way that should provide the opportunity for abnormal profits; or (2) both the risks borne and the risk premiums demanded by rational investors change significantly over time in ways as not yet fully understood. Of course, the OH is consistent with the former explanation while the UIH is consistent with the latter.

\[ \text{FIGURE 1} \]

**STOCK PRICE CHANGES IN RESPONSE TO UNFAVORABLE AND FAVORABLE UNCERTAIN INFORMATION**

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<tbody>
<tr>
<td>[ \Delta P ]</td>
<td>[ \Delta P^* ]</td>
<td>[ \Delta P ]</td>
<td>[ \Delta P^* ]</td>
<td>[ \Delta P ]</td>
</tr>
<tr>
<td>( t=0 ) Event Day</td>
<td>( t=0 ) Event Day</td>
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<td>( t=0 ) Event Day</td>
<td>( t=0 ) Event Day</td>
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6. It should be noted that the debate between the OH and the UIH is related to another class of market efficiency tests that focus on what is known as “mean reversion” in security prices. The mean reversion hypothesis can be visualized by showing a path of stock prices that swing wildly (“excessively”) back and forth across some “trend line” measure of “intrinsic” value. In effect, it suggests a long-run pattern of overreactions followed regularly by “corrections.”

TESTING THE UIH

Defining Unexpected Events

As we have outlined the theory, the UIH attempts to explain investor reactions to major unanticipated events. In devising a test of our theory, the first question that arises is, how do we know when a “major” event has occurred? To avoid introducing any subjective bias on the part of the researcher, we defined “events” using strictly quantitative criteria.

In the case of general market reactions, all daily price movements greater than one percent of a broad market index were considered as events.7 Over the 24-year period from 1962 through 1985, we found 75 such events: 36 positive and 39 negative.

In the case of individual companies, we deemed as events all daily percentage returns (adjusted for risk and expected return) greater than 2.5 percent by the 200 largest companies in the S&P 500.8 As expected, there were far more company-specific than market-wide events, even with the difference in the sample criterion. Over the same 24-year period, we found 9,105 events, of which 4,788 were positive and 4,317 were negative. (Table 1 summarizes the statistical characteristics of both samples of events.)

The Effect of Surprises on Volatility

Because the primary prediction of the UIH is that major surprises will tend to increase investor uncertainty, our first task was to compare the level of price volatility before and after the events. To allow for direct comparison of events that took place over a 24-year period, we defined the date of the event to be “Day 0” for all cases in both samples regardless of where it fell in calendar time. Then, a subsequent period running from Day +1 to Day +60 was examined in order to estimate the appropriate measure of “post-event” volatility.

In measuring pre-event (or “normal”) volatility, we used different measures for the two different samples. For the sample of market-wide surprises, risk was measured as the variance of the observed stock price returns. We compared the level of post-event variance to the same measure calculated by using all “non-event” days; that is, all days during the 1962-1985 sample period that did not fall in one of the 60-day periods that followed the 75 surprises.

For the sample of individual companies, we measured the stock price “betas” (or covariances) over the period two hundred days prior to the event (Day –200 to Day –1), and then compared those to the betas calculated over the sixty-day period following the event (Day +1 to Day +60).

General Market Volatility. In Panel A of Table 2, we report the results of the return variance analysis on our market-wide sample in the form of three different sets of data: (1) all non-event days; (2) all post-event days following favorable surprises; and (3) all post-event days following unfavorable surprises. As shown there, major surprises appear to affect investor risk precisely as the UIH predicts. The “F-statistics” are measures of the statistical significance of the difference

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7. More precisely, we determined that an “event” had occurred if the market return on any given day departed from its “expected value” by more than one percent. The expected return to the market index was estimated by the average daily return of an equally-weighted index of all NYSE and ASE companies over the 60 days immediately preceding the event. We chose such a seemingly small number as one percent on the assumption that, because of the natural diversification within the market portfolio, deviations from the expected daily return would not have to be extremely large to be considered a bona fide surprise.

8. Expected returns were estimated differently for the individual firm events than for the market index events. Remember that investors’ expected (or, alternatively, “required”) returns are a function of risk. And because major surprises change the level of risk, they can be expected to change expected returns as well. Consequently, before calculating the set of abnormal post-event price changes, we first re-estimated expected returns for both the general market index and the individual companies using data from a time period not affected by the event.
THESE FINDINGS ABOUT VOLATILITY ARE CONSISTENT WITH THE PRIMARY PREDICTION OF THE UIH: NAMELY, A LARGE INCREASE IN UNCERTAINTY (AS REFLECTED IN PRICE VOLATILITY) FOLLOWED BY A GRADUAL RESOLUTION OF THAT UNCERTAINTY.

### TABLE 2
CHANGES IN RISK INDUCED BY UNANTICIPATED EVENTS

<table>
<thead>
<tr>
<th>Panel A. Marketwide Events</th>
<th>Panel B. Individual Firm Events</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sample</strong></td>
<td><strong>Number of Observations</strong></td>
</tr>
<tr>
<td>(i) Nonevent Days</td>
<td>1,936</td>
</tr>
<tr>
<td>(ii) Postevent Days: Positive Events</td>
<td>2,160</td>
</tr>
<tr>
<td>(ii) Postevent Days: Negative Events</td>
<td>2,340</td>
</tr>
</tbody>
</table>

*** denotes significance at the 1% critical level

between the non-event risk level and the two post-event risk levels; and they suggest that we can be quite confident in concluding that the events in question are consistently followed by a measurable increase in general market volatility. Our analysis also suggests that, although negative events had a somewhat larger impact on risk than positive ones, the difference was not statistically significant.

**Company-Specific Volatility.** For the sample of individual company events, the results listed in Panel B of Table 2 are equally striking. As mentioned above, for each of 9,105 events we compared the firm’s beta before and after the event. Also, in order to get a better sense of whether these company-specific volatility changes were permanent, we computed a third beta for each event over a time period judged to be well beyond the event itself (from Day +61 to Day +260).

Two conclusions can be drawn from these findings. First, as with the market-wide sample, unanticipated events result in a sharp increase in the systematic risk of individual firms. The increases averaged 5.2 percent (1.056/1.004) for favorable surprises and 6.3 percent (1.073/1.009) for negative ones. Second, it is also clear that much of this risk increase is temporary. As shown in the column labeled “Subsequent Days,” the average betas for both positive and negative events trend back toward their pre-event levels. Nevertheless, they continue to remain somewhat above their values prior to the surprise. Thus, it appears that unanticipated events have both a permanent and a temporary effect on investors’ perception of company risk.

**The Effect of Surprises on Prices**

Having established that major surprises increase price volatility, we then calculated the daily “abnor-
Table 3 displays a representative portion of the post-event CARs along with their associated significance tests. The complete set of CARs over the 60-day post-event period for each subsample is illustrated in Figure 3. What both exhibits make clear is that, on average, investors did indeed receive additional compensation in the wake of major surprises both favorable and unfavorable. And this point is reinforced by the statistical observation that only the positive CARs in Table 3 (as well as those not listed there) were statistically significant.

What is also clear, however, is that the positive price adjustments were considerably higher after bad news than good. In the cases of good news about individual companies, the CARs pictured in Figure 3 seem to suggest that the uncertainty is resolved very quickly (in as short a period as 5 days), and that stock returns fluctuate randomly around zero thereafter (in a pattern much like the one predicted by the standard EMH).

### The Relationship Between Risk and Return

Having established that major surprises increase both risk and return in the stock market, the final goal of our study was to investigate the strength of the relationship between the two. All models of rational investor behavior assume that investors require greater returns for bearing risk. Consequently, in evaluating the initial price shocks and subsequent adjustments in our samples of events, we would expect to find that the level of increase in the CARs is positively related to the level of increase in volatility.

To test the relationship between risk and return in this case with any degree of precision would have required the use of a formal model of the risk-return relationship—a source of controversy that we wanted to steer clear of. So, we chose instead to run two relatively informal tests that examine certain aspects of this risk-return relationship.

The first of these tests focused on the market-wide surprises. In constructing this experiment, we reasoned that if investors exhibit what is known as “constant relative risk aversion”—that is, if the amount of additional return needed to compensate an added unit of risk remains roughly the same...
FIGURE 2
STOCK RETURN VOLATILITY BEFORE AND AFTER MAJOR UNANTICIPATED EVENTS

Panel A. Positive Events

Panel B. Negative Events

FIGURE 3
CUMULATIVE ABNORMAL RETURNS FOLLOWING UNEXPECTED PRICE-CHANGE EVENTS

Panel A. Marketwide Events

Panel B. Individual Firm Events

regardless of the relative level of stock prices—then the expected risk premium on the market index should be directly proportional to the variance of market returns. This, in turn, implies that the percentage increase in post-event expected returns should be roughly equal to the percentage increase in post-event risk.

In fact, as reported in Panel A of Table 4, the increases in post-event returns tended to be somewhat larger than the increases in risk (the “elasticity coefficient” for the whole sample was 1.58). Without a more precisely formulated model of risk and return, however, it is difficult to say whether this represents “excessive” compensation for increased

Our findings demonstrate rather convincingly that, regardless of the risk measure used, post-event certainty is an increasing function of the size of the initial price change. The larger the initial market reaction to a surprise, the greater the subsequent level of investor uncertainty and thus the higher the measure of risk.

### Table 4
The Relationship Between Postevent Risk and Return

<table>
<thead>
<tr>
<th>Panel A. Risk and Expected Return Changes for Marketwide Events</th>
<th>Panel B. Event Magnitudes and Risk Changes for Individual Firm Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample</td>
<td>% Change In Expected Return</td>
</tr>
<tr>
<td>--------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>All Events</td>
<td>41.838%</td>
</tr>
<tr>
<td>N = 4,788</td>
<td></td>
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<tr>
<td>Positive Events Only</td>
<td>49.393</td>
</tr>
<tr>
<td>N = 4,317</td>
<td></td>
</tr>
<tr>
<td>Negative Events Only</td>
<td>46.538</td>
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*** indicates significance at the 1% critical level

Risk. What is important for our purposes is that the findings in Panel A are consistent with the direction of the relationship that would be expected in an efficient market.

In the case of company-specific surprises, we used regression analysis to determine whether the size of the initial price change was highly correlated with the subsequent increase in risk. Two measures of risk were tested, systematic risk (as measured by a company’s beta) and total risk (as measured by total variance).

As reported in Panel B of Table 4, our findings demonstrate rather convincingly that, regardless of the risk measure used, post-event uncertainty is an increasing function of the size of the initial price change. The larger the initial market reaction to a surprise, the greater the subsequent level of investor uncertainty and thus the higher the measure of risk.

In sum, the findings of these two tests, together with the earlier results, provide strong support for our claim that investors “rationally” increase their expected returns to compensate for the increased risk attending major unanticipated events. Now, we attempt to apply our model of investor behavior to the biggest “surprise” in recent stock market history, the October '87 Crash, to see how the claim of investor rationality stands up under extreme uncertainty.

**The UIH and the Market Crash of 1987**

On Monday, October 19, 1987, the stock market suffered its largest one-day loss in history, with the S&P 500 losing more than 20 percent of its value. Explanations for this stunning decline have been many and varied, with blame being cast on everything from order execution procedures on the exchanges and NASDAQ to program trading and portfolio insurance. While we don’t presume to be able to shed light on the underlying causes of “Black Monday,” we can attempt to use the Uncertain Information Hypothesis to deduce what should have been expected to happen on the days following the crash.\(^{13}\)

Given the magnitude of the price shock of October 19, the UIH would have predicted the following: (1) volatility in the stock market should increase dramatically; and (2) overall market values should trend upward as the volatility gradually falls toward more normal levels and the general uncertainty disappears. And this is indeed what happened in the wake of the Crash. As shown in Figure 4, the volatility of the S&P 500 market index increased dramatically after October 19, reflecting the substantial increase in the level of investor uncertainty about the market.

The measures of market volatility presented in Figure 4 are not based on direct observations. Traditional estimates of volatility (such as the standard deviations of stock returns) could not be directly calculated in this case because there is only one observation surrounding the event. For this reason we were forced to derive a substitute measure of volatility from changes in other variables. Our surrogate measure of general market volatility was the daily implied standard deviation (ISD) of stock price movements using the closest-to-the-money call option on the actual index (that is, the SPX option).\(^{14}\)

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\(^{13}\) Because the Crash occurred after the sample period of our original study, an alternative set of data must be considered. Additionally, inasmuch as Black Monday represents a single unanticipated event, the depth of the statistical analysis is obviously quite limited.

THE STOCK MARKET RATIONALLY RESPONDS TO ANY EVENT WHICH
CREASES STOCK RISK BY LOWERING THE CURRENT PRICE, AND THEREBY
CREASING THE LEVEL OF EXPECTED RETURN FOR NEW INVESTORS.
COVERSELY, WHEN THE PERCEIVED RISK AND VOLATILITY FALL, THEN
INVESTORS LOWER THEIR REQUIRED RATES OF RETURN
AND STOCK PRICES RISE.

**CONCLUDING COMMENTS**

The efficient markets hypothesis (EMH) is based, in part, on the assumption that reliable information is
artificial world of relative certainty, prices are expected
to adjust to major events quickly and accurately (or, at
shooting nor undershooting the mark).

In a modification of the EMH called the Uncer-
assumption of “complete information” and attempt
to show how the introduction of uncertainty changes
contrast to the EMH, the UIH suggests that in
response to surprise events that add greatly to uncer-
individual company), both the risk and the required
return to stockholders are expected to increase. And
will immediately trade at a level below their ex-
pected value equivalents to reflect the temporary
disappears over time, required returns should
stock prices should rise to reflect the decrease in risk.

The evidence of our recent study of the market’s

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15. A far more detailed development of these arguments is given in K. French,
W. Schwert, and R. Stambaugh, “Expected Stock Returns and Volatility”, *Journal of
SUCH APPARENT OVERREACTION COULD EQUALLY WELL BE VIEWED AS REFLECTING A LARGE INCREASE IN INVESTORS REQUIRED RETURNS AND THUS ARGUABLY, IN THE MARKET-WIDE RISK PREMIUM.

FIGURE 5
RISK AND RETURN AFTER THE STOCK MARKET CRASH OF OCTOBER 1987

Cumulative Daily Returns

Volatility

Cumulative Returns

Volatility

Event Day

market-wide daily (unexpected) price swings greater than 1 percent and over 9,000 company-specific price movements greater than 2.5 percent over the period 1962-1985—provides strong support for our argument. Our findings demonstrate that regardless of whether the news was good or bad, the average pattern of price adjustments after the initial reaction was significantly positive. Because the volatility of prices was also shown to rise significantly after both good and bad surprises—and then to fall gradually back toward normal levels—these incremental returns to stockholders are interpreted by us as compensating investors for bearing the added risk associated with uncertainty.

While we did find results that could be construed as evidence of market overreaction to large negative shocks, we argue that such apparent overreaction could equally well be viewed as reflecting a large increase in investors’ required returns and, thus arguably, in the market-wide risk premium. In fact, we showed that the level of volatility after major surprises is composed of a small permanent as well as a larger transitory component.

What is the import of our findings for efficient markets theory? The main prediction of market efficiency is that the stock market should provide no consistent opportunities for investors to earn more than normal rates of returns (again, adjusted for risk). For this principle to hold, any apparently predictable trend in stock prices—that is, any “trading rule” based on a systematic market “overreaction” to bad news or “underreaction” to good—must turn out, on closer inspection, to be an illusion.

In this case, the illusion is created by the process of averaging the responses by investors (many of which overshoot, while others undershoot their expected stock values) to a large number of events. It is true that if you bought all the individual stocks on the day following a daily price movement of more than 2.5 percent, you would earn what appears to be an “excess” rate of return over a very few days. But, if you then adjusted that rate of return for the increased risk of this investment strategy by taking account of the increased price volatility, you would likely discover that you had earned what finally amounts to nothing more than a normal rate of return.

Thus, while we have little doubt that the debate over market efficiency will continue for some time, our research suggests that abandoning the assumptions of investor rationality and market efficiency in favor of loosely formulated alternatives may be premature.
APPENDIX ■ THE UNCERTAIN INFORMATION HYPOTHESIS: AN EXAMPLE

We begin by assuming that the stock market is comprised of risk-averse investors whose preferences can be characterized by logarithmic utility function over the terminal value of their wealth. We also assume, for simplicity, that the stock market represents the entire source for investor wealth and that prior to the arrival of any new information (t = –1) the level of a broadly based index of stock is 100. Now, supposing that investors make rational judgments about new information, Figure 6 gives a probability distribution summarizing investors’ beliefs about future payoffs to their investments.

The first thing to notice in this display is that investors have allowed for the possible occurrence of four distinct outcomes. Two of these events can be regarded as “normal” in the sense that their impact will be immediately assimilated into market prices (i.e., 102.000 or 96.292). The other two potential outcomes represent “uncertain” surprises. Both of these unexpected events have been structured so that investors can immediately establish: (i) whether they represent good or bad news, and (ii) what the possible eventual effect of the event will be. While these latter two events are treated as being quite unlikely (as evidenced by their assigned probabilities of 0.001), they nonetheless present a practical difficulty for investors trying to evaluate the market at time t = –1 since their resolution, if they do occur, will not be immediate.

To see this, observe from Figure 6 that in the wake of the unexpected good news announcement, investors know only that the ultimate payoff will either be 140.000 (with a 35% probability) or 103.905 (with a 65% probability). Similarly, the unfavorable surprise offers eventual payoffs of 62.694 or 94.641 with 20% and 80% likelihoods, respectively. The challenge that investors face is to establish an economically justifiable value for the market in the face of an uncertain information event.

Stated differently, what will be the prices set immediately after the announcement of a favorable (i.e., Price/Good) and an unfavorable (i.e., Price/Bad) news? The Uncertain Information Hypothesis predicts that rational investors will initially react to the occurrence of these unlikely events decreasing absolute risk aversion, and (ii) constant relative risk aversion. For a more detailed explanation, see K. Arrow, *Essays in the Theory of Risk Bearing*, Chicago: Markham Publishing, 1971.
by setting prices so as to maximize the expected utility of their terminal wealth. As indicated at the bottom of the display, these values are equal to 114.211 and 85.888, respectively. Establishing this result has two important consequences. First, since all of the probabilities and potential outcomes (regardless of when they are resolved) are known at time \( t = -1 \), investors are able to make the following unconditional forecast of the expected return of their stock investment before any event occurs:

\[
E(R) = [\.662)(102.000/100) + (.336)(96.292/100) + (.001)(114.211/100) + (.001)(85.888/100)]^{-1} = .078\%
\]

Using this value, it is also easily confirmed that an unconditional forecast of the standard deviation (i.e., risk) of the stock market is:

\[
\sigma = 2.768\%
\]

The second consequence of our assumption about investor reaction to uncertain information is apparent upon calculation of revised estimates of \( E(R) \) and \( \sigma \) when an unexpected event actually occurs. Specifically, the arrival of the unexpected good news event will prompt investors to initially revalue the index to 114.211 and then compute the following conditional forecasts of expected return and risk in the stock market:

\[
E(R/Good) = [(.650)(103.905/114.211) + (.350)(140.000/114.211)]^{-1} = 2.038\%
\]

\[
\sigma_{Good} = 15.074\%.
\]

In the same fashion, following an unfavorable surprise which initially pushes the value of the market index down to 85.888, forecasts of the subsequent return characteristics conditioned on the attendant uncertainty are:

\[
E(R/Bad) = [(.800)(94.641/85.888) + (.200)(62.694/85.888)]^{-1} = 2.752\%
\]

\[
\sigma_{Bad} = 14.878\%.
\]

The critical aspect of this example—indeed, the main point of the UIH—is that the arrival of unanticipated information has caused the riskiness and, hence, the expected return of the stock investment to increase. This was seen to be true whether the uncertain informational event had a negative (i.e., bad news) or positive (i.e., good news) initial impact. Thus, in the aftermath of such surprises one should expect that market will increase in value. On average, then, the observed pattern of stock prices following unanticipated bad news will superficially resemble the corrections necessitated by the actions of overreactive, irrational investors.

From the above example, however, this interpretation—which is the central prediction of the OH—is clearly incorrect since the initial level of \([Price/Bad]\) was set in rational anticipation of a subsequent stock price movement either up to 94.641 (with 80% probability) or down to 62.694 (with 20% probability). Thus, the illusion of overreaction is solely a mathematical artifact caused by averaging realized returns over a large number of negative events. Further, after a favorable surprise, the UIH would predict that the observed pattern of stock returns should, on average, resemble an underreaction to the initial event. In any case, the principal point of the example is that seemingly predictable postevent price adjustments need not imply irrationality on the part of investors, particularly if the events increase uncertainty. Thus, empirical results that confirm an increase in risk following substantive unanticipated news events would be consistent with the predictions of the UIH.

17. Given the specification of the logarithmic utility function \( U = \log (P) \), marginal utility can be expressed as \( U' = 1/P \). The UIH predicts that investors will set \( P_0 \) equal to \( E[U'(P_1)E[U'(P_2)|xP_1]] \), or \( P_0 = E[1/P_1]^{-1} \) For simplicity, we assume here that the risk-free rate of return is 0.00%.

KEITH BROWN

is the Allied Bancshares Centennial Fellow and Assistant Professor of Finance at the University of Texas. He is a Chartered Financial Analyst and formerly worked as a Senior Consultant to the Corporate Professional Development Department at Manufacturers Hanover Trust Company.

VAN HARLOW

is Vice President, Equity Portfolio Analysis at Salomon Brothers Inc. Before assuming his present position, he was Assistant Professor of Finance at the University of Arizona. He is a Chartered Financial Analyst.

SEHA TINIC

is the James A. Elkins Professor at the University of Texas where he serves as the Chairman of the Department of Finance. He is a co-author of the book Investing in Securities; An Efficient Markets Approach and his research interests include topics in investments and investment banking.