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STOCK SELECTION AND TIMING — A NEW LOOK AT MARKET EFFICIENCY

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INTRODUCTION

In this paper it is shown that stock returns do not conform to a random walk model, nor to the more general martingale model, but nevertheless the stock market is weak-form efficient. This result is not surprising when we recall that risk-averse investors are typically concerned with more than the first moment of a security return's distribution, and market efficiency is appropriately determined in terms of (expected) utility — not profits alone. Extant tests of market efficiency have ignored this point.

By examining the first two moments of return distributions, and by not assuming any form of equilibrium pricing model, we provide tests of weak-form market efficiency which are more powerful than prior studies.

A market is considered informationally efficient if market prices 'fully reflect' information. The (sub)set of information presumed to be reflected determines the particular form of market efficiency. The market is said to be efficient in the weak-forms if market prices fully reflect the past realizations of market prices. Extant tests of the weak-form of market efficiency (e.g., Fama, 1970; Fama and Blume, 1966; and Mandelbrot, 1966) examine whether information on past price movements can be exploited to enhance *profits*. These tests assume that investors looking to profit from 'trend' data are risk-neutral. However, the normative theory of portfolio selection due to Markowitz (1952), and positive theories of capital asset pricing (e.g., Sharpe, 1964) are developed assuming that investors are risk-averse.

This paper fills a gap in the literature by testing the informational efficiency of the stock market by exploring whether or not gains in *expected utility* are attainable by utilizing the time series of past stock prices. In particular, since Sharpe (1963), a simple algorithm has been available for risk-averse investors to use in selecting optimal portfolios. Normative Portfolio Theory of Markowitz (1952) (*NPT*) suggests the use of historical data to obtain estimates of expected return and risk, and then apply a mathematical programming algorithm to build Mean-Variance (*E-V*) efficient portfolios. Surprisingly, studies that have tackled the timing question have done so in a vacuum vis-à-vis optimal (*E-V*) portfolio selection.

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In the next section of this paper we present a review of Martingales, Random Walks, Market Efficiency and Market Equilibrium. The subsequent section describes the data and methodology of the present study. The next section contains the Results and Interpretations. The final section concludes and summarizes the paper.

MARTINGALES, RANDOM WALKS AND MARKET EFFICIENCY

Martingales

The notion that the stochastic process that generates stock prices is a martingale is now generally accepted by financial economists. (See for example: Alchian, 1974; Fama, 1965; Mandelbrot, 1966; and LeRoy and LaCivita, 1981.) A martingale is a stochastic process (X_i), where, for all $i = 1, 2, \ldots$:

1. $E|X_i| < \infty$: and (1)
2. $E(X_{i+1}| X_1, \ldots, X_i) = X_i$. (2)

(See, e.g. Karlin and Taylor, 1975, p. 238.) This is often called a 'fair game' since the expected future value of the variable is equal to its most recent realization. To deal with either or both of:

1. The fact that stocks are risky assets and investors are risk averse; and
2. The notion of time preference (i.e., the 'time value of money,') in a risk neutral environment,

The martingale model is modified. The appropriate modification is known as a submartingale. In a submartingale, the expected value of the variable is at least its most recent realization.

In a market characterized by risk-neutral, price-taking investors, the (sub)martingale model is appropriate if arbitrage profits are eliminated. A proof of this proposition is found in LeRoy (1973). Samuelson (1965 and 1971) shows that when investors (even risk-averse investors) have an exogenously determined positive required rate of return, the (sub)martingale model must describe the stock price generating process. But LeRoy (1973) points out that in a general case, when investors are risk averse, there is no theoretical justification of the (sub)martingale property for stock returns or prices. Arbitrage arguments in this case would imply that investors cannot exploit the series of historical returns (or prices) to enhance utility, regardless of 'profit', or expected return.

Environments characterized by the absence of arbitrage profits are generally accepted in the state-of-the-art finance literature. If arbitrage were possible (and the gains exceed transactions costs), someone (or many) would take advantage of the situation to make a riskless profit, thereby eliminating the opportunity. This type of argument underlies the paradigms of finance (e.g., the Modigliani and Miller irrelevancy propositions, Option Pricing Theory, and the positive models of capital asset pricing). If economic agents are risk averse, the appropriate arbitrage arguments deal not with 'profits' or expected return, but rather with expected utility.

Random Walks

A less general process than the martingale model is the random walk. If successive returns are independent, identically, distributed (*iid*), the return generating process is some form of random walk, (cf. Karlin and Taylor, 1975). Retaining the notation of equations 1 and 2, in a random walk model: for all $i = 1, 2, \ldots,$

$$f(X_{i+1}) = f(X_i) \tag{3}$$

Thus, the martingale (which places restrictions on the first moment of the distribution only) is a special case of the random walk, (all random walks are martingales, but not vice-versa). Naturally, if the return generating process of stock returns is either (parametrically) Gaussian, or general stable Pareto-Levy, stock returns follow a random walk. This is so, since the application of these models to stock returns requires the assumption that stock returns are indeed *iid* random variables.

Samuelson (1982), however, is not willing to accept the hypothesis that stock returns conform to a random walk. His reasoning is that all assets (e.g., a share of stock) have an intrinsic value dictated by 'economic law'. The random walk model implies that there is a positive probability of large deviations in price from that value.

Efficient Markets

Fama (1970) describes an 'efficient market' as one in which prices 'fully reflect' all information. Three degrees of market efficiency are delineated with respect to the information set which is assumed — or posited — to be reflected in the price. In the context of timing, where the issue is the ability to exploit past trends in the data, the Weak Form of Market Efficiency is pertinent. The market is said to be efficient in the weak form if present prices 'fully reflect' the historical return series. This implies that no arbitrage opportunities exist vis-à-vis the trends of the data. The semi-strong form of market efficiency describes a market where all publicly available information is 'reflected' in asset prices. The strong form of market efficiency requires all information to be 'reflected' in asset prices.

Despite its intuitive appeal, the notion of 'fully reflecting' is void of empirical content. Any test of market efficiency contains a test of (at least) two distinct hypotheses:

1. That the market is efficient; and
2. The manner by which assets are (efficiently) priced.

Most of the testing of the weak form of market efficiency has focused on the martingale model: Can investors *profit* by exploiting the trend in prices or returns? 'Profit' in this context involves the ability to achieve a higher return over time than one would attain without building trends into his selection model. Technical Analysts (or Chartists) on Wall Street convince some investors that they can do just that.

An example of empirical work which tests weak form market efficiency is the filter rule approach. Alexander (1964) reports that by using a filter enhanced profits are possible. A filter in this context works as follows: If it is true that returns are positively serially correlated, a large return last period is a good indication of a large return this period. An $x\%$ filter rule would have the investor buy those stocks subsequent to periods when their returns exceed $x\%$. Hold these stocks until their return falls by $x\%$. Most of the studies involving filter rules involve daily stock return data. As Fama and Blume (1966, p. 228) explain, Alexander's filter rule is designed to 'test the belief, widely held among market professionals, that prices adjust gradually to new information'.

> The professional analysts operate in the belief that there exist certain trend generating facts, knowable today, that will guide a speculator to profit if only he can read them correctly. These facts are assumed to generate trends rather than instantaneous jumps because most of those trading in speculative markets have imperfect knowledge of these facts, and the future trend of price will result from a gradual spread of awareness of these facts throughout the market (Alexander, 1964, p. 7)

Mandelbrot (1963, pp. 417–418) explains that Alexander's results are spurious since Alexander assumes that orders can be implemented continuously and he does not consider the effects of transaction costs. When these factors are taken into consideration, the trading rule approaches yield lower returns than a simple buy and hold strategy. In subsequent work, Fama and Blume (1966) show that the only ones who could prosper from filter rules are brokers. This is taken as evidence in support of the martingale model of stock returns and weak form market efficiency.

Another test of the martingale model is Granger and Morgenstern's (1963) application of spectral analysis to stock prices. They obtain the result that trends in stock prices do not exist. Spectral analysis is a fairly weak tool though and only yields the specified results in the special case of normally distributed variates (i.e., the limiting case when no correlation implies independence, or where all martingales are random walks). (See Mandelbrot, 1966, p. 245, fn. 3.)

Market Equilibrium

If investors are risk averse, expected utility maximizers, it does not necessarily follow that stock returns conform to a martingale model. Only if risk averse investors have an exogenously determined positive required rate of return does this result follow a fortiori. Further, if investors are expected utility maximizers with an exogenously determined rate of return, absence of arbitrage opportunities implies that a random walk must hold — at least as concerns the distributional moments of relevance to investors. However, there is no justification to pre-suppose the martingale model. All that the arbitrage proof requires is that investors not be able to enhance utility by exploiting trends of past data. In other words, it is possible to imagine an environment where trends do exist in stock returns, but this trend is not erased by arbitrage as riskiness also increases along a similar trend. Only in the case where investors are risk neutral will such a trend be eliminated by arbitrage.

This is of course consistent with the Markowitz (1952) portfolio selection framework. In the Markowitz context, the investor enhances (expected) utility by exploiting historical data. He uses this information to make inferences about the various return generating processes. Presumably, if the processes are stationary over time, the investor need not be concerned about the timeliness of the data. His concern is with the richness of the data and his ability to estimate the nature of the return generating process. In the Markowitz framework, there is no question of timing or portfolio revision. The only changes a Markowitz investor need make over time would be due to increased insight provided by additional data.

With the notable exception of LeRoy (1973) and LeRoy and LaCivita (1981), the scientific exploration of the nature of stock return series and market efficiency has been done outside of the Markowitz portfolio selection context. As evidence mounts as to the general validity of the Markowitz algorithm (cf. Frankfurter and Lamoureux, 1987; and Kroll, Levy and Markowitz, 1984), it becomes imperative to judge the efficiency of the market in the Markowitz context.

We wish to examine whether the market is Markowitz-efficient. That is, can investors beat — in expected utility terms — the Markowitz buy and hold strategy by exploiting trends in the data — through a superimposed filter rule. This test makes no assumption about the nature of equilibrium asset pricing. We allow the data to speak for themselves. Thus we are *not* jointly testing market efficiency along with some pricing model.

As an example of an environment which is inconsistent with a Markowitz efficient market, Mandelbrot (1963, pp. 418–419) states that large changes of price, of random sign, tend to be serially correlated. This phenomenon is used as part justification of the stable Pareto-Levy model with respect to speculative price changes. If this observation were, in fact true, then the stock return generating process would be a martingale — not a random walk — with serially correlated $|\tilde{r}|$.

Merton (1981) also addresses the question of 'market timing'. Several empirical studies (e.g., Henrikkson, 1984; Henrikkson and Merton, 1981; and Kon, 1983) have been based on Merton's model. This approach, however, is very different from what has generally been classified under the rubric of 'market timing', and is also different from the approach taken herein. Merton derives the equilibrium value of a portfolio manager's ability to predict those time periods in which fixed income securities will outperform stocks and vice-versa. Of course, the idea that bond returns will outperform stock returns 'ex-ante' is inconsistent with the joint hypotheses of risk aversion and equilibrium (or the absence of arbitrage opportunities). Merton's model and subsequent studies based thereupon, are mentioned only as a point of reference.

METHODOLOGY AND DATA

The Data

The data for this study consists of 906 stocks' monthly returns for the period May, 1963—December, 1981 taken from the CRSP tape. Only those stocks with 224 (contiguous) legitimate returns are selected. The three estimators to Sharpe's diagonal selection algorithm (linear slope, intercept, and conditional variance), are estimated using the entire 224 months of data. The diagonal model, i.e.,

$$\tilde{r}_i = \alpha_i + \beta_i \tilde{r}_I \tag{1}$$

is estimated by ordinary least squares (*OLS*):

$$r_{it} = \hat{\alpha}_i + \hat{\beta}_i r_{It} + e_{it} \tag{2}$$

where:

$\tilde{r}_i$ = the random variable representing the rate-of-return on security i,
r_{it} = return on security i in period t,
$\hat{\alpha}_i$ = the (*OLS*) linear intercept term,
$\hat{\beta}_i$ = the (*OLS*) linear slope,
$\tilde{r}_I$ = random rate of return on the index (here: CRSP equal weighted index),
e_{it} = *OLS* error term of security i in period t, and
the caret represents *OLS* estimators.

The $\hat{\alpha}_i$, $\hat{\beta}_i$, and $\hat{\sigma}^2(\tilde{e}_i)$ from (2) of the stocks in the selection universe, along with $E(\tilde{r}_I)$ and $\sigma^2(\tilde{r}_I)$, are used as inputs to the Sharpe (1963) optimal portfolio selection algorithm which generates the appropriate *E-V* frontier of efficiency in each case.[1]

The experiments involve revision of the universe from which the investor selects the optimal portfolio. Those stocks which are desirable (in a timing context) are included in the selection sub-universe; alternatively, those stocks which are undesirable are excluded. Portfolios are selected at the beginning of each of the 201st through 224th periods according to the Markowitz—Sharpe criterion — from the stocks qualifying in each period. Thus, an investor would select a security using the superimposed filter rule, only if it is desirable in both an *E-V* context and a timing context. Earlier filters forced a timing desirable stock on the investor.

Now, in ex-ante terms it is clear that no rule which excludes securities from the selection set can generate portfolios which are superior in Mean-Variance space to those selected from the entire universe. Evaluation of the various techniques is therefore in ex-post terms. The actual portfolio returns are generated for each of the 24 periods and in this fashion the techniques are comparable. The ex-post return used is the geometric mean return of the 24 actual returns in each period. The ex-post risk measure is the sum of the squared deviations between the actual return in each period and the expected return in that period. This is adjusted for sampling by dividing it by the number of periods minus one. Risk is an ex-ante concept. Ex-post a certain return was realized with probability one. This method is consistent with the portfolio evaluation literature (e.g., Jensen, 1969; and Sharpe, 1966) — where realized returns are adjusted according to 'ex-ante' risk. The measure of risk used here is an indication of performance versus expectation in each period.

There is no theory which assures — nor is there any reason to assume — that Markowitz selected portfolios, which are ex-ante efficient, will dominate all other portfolios, ex-post. Accordingly, no conclusions could be drawn by looking at the results from a single period. The 24 month period is considered long enough to average out deviations from expected values. For comparison purposes the ratio of return to risk is used. Once again, this is consistent with the portfolio evaluation literature.

To make the comparisons manageable three portfolios from the Mean-Variance Efficient Frontier are evaluated. The three are chosen in each instance based upon the shadow price — or dual value — from the Markowitz–Sharpe algorithm. The dual value (or λ) represents the marginal gain in (expected) return from risk reduction. It is thus a measure of investors' relative aversions to risk. The NE corner portfolio (when return is on the ordinate and risk on the abscissa) has a dual value of zero, since no more gain in expected return is possible. The SW corner portfolio has a dual value of infinity since no further risk reduction is possible. Portfolios with common dual values would be chosen by the same investor under the various regimes and thus can be directly compared.[2] The dual values chosen in this study are from the middle range of the Efficient Frontier. Portfolio 1 has 38 stocks in the no-exclusion case (λ of 5.7). Portfolio 2 has 55 stocks in the universal case (λ of 12.6). Portfolio 3 has 62 stocks in the no-exclusions case (λ of 18.0). By avoiding the two extremes of the Efficient Frontier the sampling error problems discussed by Frankfurter and Lamoureux (1988) are neutralized.

Estimation

There is an estimation factor accompanied with timing *which is held constant in this analysis*. After each period's realization, there is another observation to facilitate estimation. The three inputs to the Sharpe–Markowitz algorithm should be revised using all available data — portfolios revised accordingly. In the present study these three values are estimated using the entire 224 month period. These values are thus treated as parameters, enabling 'ceteris to be paribus' in this study of market efficiency. This particular aspect of portfolio theory — optimal revision — is treated by Bloomfield, Leftwich and Long (1977) who show that frequent portfolio revisions provide inferior results versus a buy-and-hold strategy, especially when transactions costs are considered.

RESULTS AND INTERPRETATION

Benchmark

The ex-ante and ex-post return, risk and return-to-risk ratio (performance measure) for the universal, no-timing selection for each of our three efficient portfolios are shown in Table 1. Panel A presents the 'ex-ante' return and risk characteristics of portfolios selected from the entire universe for each of the three levels of λ. Panel B, of Table 1 shows the 'ex-post' results over the twenty-four months for these three portfolios. This is the benchmark against which the portfolios obtained by applying the timing filters are to be compared.

Table 1

Universal Case

Panel A 'Ex-Ante'			
	Expected Return	*Variance*	*E/V*
Portfolio 1	0.02212	0.00123	17.98
Portfolio 2	0.01955	0.00061	32.00
Portfolio 3	0.01724	0.00045	38.31
Panel B 'Ex-Post'			
	Geometric Mean Return	*Variance*	*E/V*
Portfolio 1	0.00864	0.00047	18.21
Portfolio 2	0.01055	0.00051	20.52
Portfolio 3	0.01017	0.00045	22.52

Violation of Random Walk Property

If stock returns do follow a martingale, (whether or not a random walk), it may be possible for an investor to enhance utility by studying trend data. To test Mandelbrot's proposition that large changes in price of random sign are serially correlated, the absolute value of a stock's monthly return $|r_{it}|$ is regressed against its two period lag, $|r_{i,t-2}|$, using *OLS*. This is an instrumental variable for the one period lag which provides consistent regression estimators of the one month lag. Of the 906 stocks in the sample, 200 appear to have serially correlated absolute values of monthly returns at the five percent level of significance. All 200 of these serial correlations are positive. (With daily returns, all of the 906 stocks have serially correlated absolute value returns at the one percent level of significance. With weekly returns, 314 stocks have serially correlated absolute value of returns at the one percent significance level.)

As far as 'market efficiency tests' are concerned, in this study the statistical question of serial correlation is not particularly relevant. The question is: can investors exploit any correlation (be it 'statistically significant' or not).

Other things being equal, a risk averse investor would choose to avoid large price changes of random sign. With this in mind, the filter rule is applied to the relevant set:

1. The entire universe of 906 stocks; or
2. The subset of 200 stocks which violate the serial independence of $|\tilde{r}_i|$,

such that stocks with large $|r_{t-1}|$ are excluded from the selection sub-universe in period t.

To quantify 'large' in this application, the $|\tilde{r}_i|$ are ranked in ascending order for each stock, and quantile values are obtained. These quantile values are used as the appropriate filter. In this fashion risk is distinguished from the trend of $|\tilde{r}_i|$ (as stocks with a higher variance of returns would tend to be generally excluded if a simple $x\%$ filter rule were applied).

Table 2 shows the realized geometric mean returns, the dispersion between realized and expected returns, and the performance measure for the three portfolios when the first application of the filter rule is applied. As an example, in Panel A, a stock i is rejected from the selection sub-universe in period t if its absolute value return in period t–1 exceeds the 20th quantile of the series $|\tilde{r}_{it}|$.

We report in Table 3 the realized values for portfolios selected by first applying the filter rule to the absolute value of last period's return only to those 200 stocks with serially correlated absolute value returns. As an example, in Panel A the three portfolios were selected by applying the Markowitz–Sharpe algorithm to the sub-universe consisting of all 706 stocks with nonserially correlated absolute value returns and those stocks from amongst the other 200 stocks whose last period's absolute value return was less than the 10th quantile of that series.

When the filter is applied to all stocks, no reductions in 'realized risk' are achievable. Slight reductions in risk are attained when the rule is applied to the 200 stock subset. The 10th and 20th quantile rules accomplish this risk reduction the best. There is no justification, therefore, to support the random walk model (at least as applies to the 200 stocks in the 'violation subset'). The reductions in risk are achieved only at a high opportunity cost in realized return, which would be severely enlarged by transactions costs. Comparing Tables

Table 2

Violation of Random Walk?
Filter Rule Applied to All Stocks

Panel A: 20th Quantile			
	Geo.Mn.Ret.	*Dispersion*	*Per.Msr.*
Portfolio 1	0.0090265	0.0044714	2.08
Portfolio 2	0.0090828	0.0028400	3.20
Portfolio 3	0.0071430	0.0025656	2.78
Panel B: 30th Quantile			
	Geo.Mn.Ret.	*Dispersion*	*Per.Msr.*
Portfolio 1	0.0097456	0.0046550	2.09
Portfolio 2	0.0115366	0.0036042	3.20
Portfolio 3	0.0060720	0.0033629	1.81
Panel C: 50th Quantile			
	Geo.Mn.Ret.	*Dispersion*	*Per.Msr.*
Portfolio 1	0.0048599	0.0018144	2.68
Portfolio 2	0.0069609	0.0014039	4.96
Portfolio 3	0.0055810	0.0012155	4.59
Panel D: 60th Quantile			
	Geo.Mn.Ret.	*Dispersion*	*Per.Msr.*
Portfolio 1	0.0056381	0.0017660	3.19
Portfolio 2	0.0054426	0.0014497	3.75
Portfolio 3	0.0068941	0.0014469	4.75
Panel E: 70th Quantile			
	Geo.Mn.Ret.	*Dispersion*	*Per.Msr.*
Portfolio 1	0.0044303	0.0018553	2.39
Portfolio 2	0.0098240	0.0016198	5.85
Portfolio 3	0.0062008	0.0015527	3.99
Panel F: 75th Quantile			
	Geo.Mn.Ret.	*Dispersion*	*Per.Msr.*
Portfolio 1	0.0014238	0.0011650	1.23
Portfolio 2	0.0016508	0.0010084	1.64
Portfolio 3	0.0018501	0.0006936	2.67
Panel G: 85th Quantile			
	Geo.Mn.Ret.	*Dispersion*	*Per.Msr.*
Portfolio 1	0.0008860	0.0011849	0.75
Portfolio 2	0.0015697	0.0010727	1.46
Portfolio 3	0.0013752	0.0008688	1.58
Panel H: 95th Quantile			
	Geo.Mn.Ret.	*Dispersion*	*Per.Msr.*
Portfolio 1	0.008154	0.0011879	0.69
Portfolio 2	0.0021868	0.0011368	1.92
Portfolio 3	0.0019741	0.0009716	2.03

Table 3

Violation of Random Walk?
Filter Rule Applied to 200 Stock Subset Only

	Geo.Mn.Ret.	*Dispersion*	*Per.Msr.*
Panel A: 10th Quantile			
Portfolio 1	0.0034752	0.0005212	6.67
Portfolio 2	0.0026636	0.0003687	7.22
Portfolio 3	0.0025835	0.0002750	9.39
Panel B: 20th Quantile			
Portfolio 1	0.0033951	0.0005239	6.48
Portfolio 2	0.0026312	0.0003700	7.11
Portfolio 3	0.0027647	0.0002765	10.08
Panel C: 30th Quantile			
Portfolio 1	0.0033789	0.0005346	6.41
Portfolio 2	0.0026417	0.0003695	7.15
Portfolio 3	0.0027304	0.0002750	9.93
Panel D: 50th Quantile			
Portfolio 1	0.0033369	0.0005318	6.27
Portfolio 2	0.0025988	0.0003738	6.95
Portfolio 3	0.0032988	0.0005348	6.17
Panel E: 60th Quantile			
Portfolio 1	0.0032988	0.0005348	6.17
Portfolio 2	0.0025845	0.0003750	6.89
Portfolio 3	0.0026798	0.0002785	9.62
Panel F: 70th Quantile			
Portfolio 1	0.0032320	0.0005348	6.04
Portfolio 2	0.0025663	0.0003766	6.81
Portfolio 3	0.0024500	0.0002900	8.45
Panel G: 75th Quantile			
Portfolio 1	0.0032663	0.0005346	6.11
Portfolio 2	0.0025921	0.0003769	6.88
Portfolio 3	0.0025463	0.0002777	9.17
Panel H: 85th Quantile			
Portfolio 1	0.0032244	0.0005371	6.08
Portfolio 2	0.0025587	0.0003814	6.71
Portfolio 3	0.0027218	0.0002813	9.68
Panel I: 95th Quantile			
Portfolio 1	0.0032692	0.0005374	6.08
Portfolio 2	0.0025558	0.0003839	6.66
Portfolio 3	0.0026522	0.0002933	9.04

2 and 3 with Table 1 shows that the no-exclusion case performance measures exceed the performance measures under the filter rules. There is no reason, therefore, to reject the hypothesis that the stock market is weak form efficient.

Violation of Martingale Property

It is possible that stock returns violate the random walk property, but conform to the martingale property. To ascertain whether stocks' monthly price realizations violate the martingale property, we test whether r_t and r_{t-1} are correlated. Towards this end the monthly returns of each of the 906 stocks over the 20 year period are regressed against the two month lagged return. The two month lag return is used as an instrumental variable for the one month lag. Under the null hypothesis, this provides a consistent estimator of the coefficient of the one period lag. Of the 906 stocks, 106 appear to have serially correlated returns at a five per cent level of significance. All but five of these 106 stocks have an inverse correlation between r_t and r_{t-1}.

As before, our concern is not with the statistical mask of the data rather with the ability of investors to exploit trends, regardless of their statistical significance. To test whether utility enhancement is possible by utilizing this type of trend data, filter rules are applied to define the selection sub-universe in two fashions:

1. The rule is applied to the entire universe of 906 stocks; and
2. The rule is applied only to the subset of the 106 stocks which appear to violate the martingale property.

Table 4 shows the ex-post realizations over the 24 months period for the three portfolios for various filter rules (indicated inside each panel) as applied in Method 1 above. In this application all stocks are subjected to the same filter rule in each period. As an example, Table 2, Panel A shows the case whereby if a stock's return in period $t-1$ were greater than zero, that stock is excluded from the selection sub-universe in period t (as indicated by the table heading. 'r_{t-1} . . . Include').

In Table 5, the filter rule is applied only to the 106 stocks which appear (statistically) to violate the martingale property. For the five stocks which have positively correlated monthly returns, the filter rule is inverted. As an example, in Table 3, Panel A, all sub-universes include the 800 stocks whose monthly price realizations conform to the martingale model. The 106 stocks with negative serial correlation of monthly returns are subjected to the following filter: if last period's return were less than −5 percent include that stock in this period's sub-universe. For the five stocks with positively serially correlated monthly returns, the corresponding filter rule is: if last period's return were greater than 5 percent, include that stock in the selection universe for this period.

Out of the numerous experiments we performed, the above tables present a sample only. None of the many filter rules applied did better than those reported. Note that by using the filter rules, it is possible to realize a greater

Table 4

Potential Martingale Violation Filter Rule Applied to Entire Universe

Panel A: r_{t-1} < 0.0 Include			
	Geo.Mn.Ret.	*Dispersion*	*Per.Msr.*
Portfolio 1	0.0024767	0.0019860	1.25
Portfolio 2	0.0001392	0.0022713	0.06
Portfolio 3	0.0076942	0.0005225	14.73
Panel B: r_{t-1} < -0.04 Include			
	Geo.Mn.Ret.	*Dispersion*	*Per.Msr.*
Portfolio 1	0.0043783	0.0005103	8.58
Portfolio 2	0.0005128	0.0002975	17.24
Portfolio 3	0.0052853	0.0002662	19.86
Panel C: r_{t-1} < -0.08 Include			
	Geo.Mn.Ret.	*Dispersion*	*Per.Msr.*
Portfolio 1	0.0118504	0.0012970	14.27
Portfolio 2	0.0110531	0.0010724	10.31
Portfolio 3	0.0140800	0.0010020	14.05
Panel D: r_{t-1} < -0.12 Include			
	Geo.Mn.Ret.	*Dispersion*	*Per.Msr.*
Portfolio 1	-0.0133600	0.0016837	7.94
Portfolio 2	-0.0111470	0.0013278	8.39
Portfolio 3	0.01260000	0.0018548	6.79
Panel E: r_{t-1} < -0.16 Include			
	Geo.Mn.Ret.	*Dispersion*	*Per.Msr.*
Portfolio 1	-0.0172000	0.0027600	-6.23
Portfolio 2	-0.0081000	0.0013700	-5.91
Portfolio 3	0.00141900	0.0011880	1.19

return than in the case where no such rule is applied. A comparison of Panel C of Table 4 with Panel B of Table 1, shows that by applying a −8 percent filter rule gains in realized return are achieved in Portfolios 2 and 3. The gain in Portfolio 3's return is rather dramatic. A return of 1.4 percent per month with the filter rule, versus only 1.0 percent without it. This gain in realized return is more than offset, however, by increased realized 'risk'. This is apparent by comparing the performance measures under each regime. Under no case does any 'filtered' portfolio have a higher performance measure than in the no filter case. It is also surprising that treating stocks differently based on their statistical serial correlation does generally worse than the case where all securities are subjected to the filter.

Based on these experiments, the martingale model as fits security price realizations must be rejected. Gains in realized returns are possible by exploiting the trend in the data — even with monthly returns! There is no cause, however, to reject the weak form hypothesis of market efficiency, as gains in utility (as

Table 5

Apply Martingale — Type Filter to 106 Stock Subset Only

	Geo.Mn.Ret.	Dispersion	Per.Msr.
Panel A: 5% Rule			
Portfolio 1	0.0031996	0.0053300	6.23
Portfolio 2	0.0026188	0.0003899	6.72
Portfolio 3	0.0024290	0.0002858	8.50
Panel B: 5.5% Rule			
	Geo.Mn.Ret.	*Dispersion*	*Per.Msr.*
Portfolio 1	0.0032015	0.0005324	6.01
Portfolio 2	0.0026178	0.0003900	6.71
Portfolio 3	0.0024719	0.0002830	8.73
Panel C: 6% Rule			
	Geo.Mn.Ret.	*Dispersion*	*Per.Msr.*
Portfolio 1	0.0031996	0.0005321	6.01
Portfolio 2	0.0026188	0.0003903	6.71
Portfolio 3	0.0023746	0.0002865	8.29
Panel D: 6.5% Rule			
	Geo.Mn.Ret.	*Dispersion*	*Per.Msr.*
Portfolio 1	0.0031996	0.0005321	6.01
Portfolio 2	0.0026159	0.0003908	6.69
Portfolio 3	0.0026159	0.0002804	9.00
Panel E: 7% Rule			
	Geo.Mn.Ret.	*Dispersion*	*Per.Msr.*
Portfolio 1	0.0031986	0.0005318	6.01
Portfolio 2	0.0026169	0.0003910	6.83
Portfolio 3	0.0025578	0.0002789	9.17
Panel F: 8.5% Rule			
	Geo.Mn.Ret.	*Dispersion*	*Per.Msr.*
Portfolio 1	0.0031986	0.0005318	6.01
Portfolio 2	0.0026121	0.0003916	6.67
Portfolio 3	0.0023727	0.0002901	8.18

measured 'ex-post' by the 'Performance Measure') are not possible by exploiting trends.

CONCLUSIONS

The results of these experiments may be simply stated: the filter techniques applied to the monthly data do not offer any benefits above a simple buy-and-hold strategy. For the theory of finance and the nature of stock returns, the results are not so simple and up-end almost all previous research on the behavior of stock returns. First, the theoretical distinction between market efficiency on the one hand, and the martingale and/or random walk nature of speculative price changes on the other hand is clarified. It is possible (and is done here) to reject both the random walk model and the martingale model as applied to stock prices and accept the weak-form market efficiency hypothesis.

Market efficiency is appropriately determined in (expected) utility terms. Ad-hoc theoretical restrictions on the nature of security returns will only necessarily imply weak-form market efficiency when coupled with specific assumptions about the nature of investors' (expected) utility functions. Thus, trends in a return series that might be exploited to increase profits are only necessarily inconsistent with weak-form market efficiency if investors are risk neutral.

The Markowitz model is the best (cf. Frankfurter and Lamoureux, 1987; and Kroll, Levy, and Markowitz, 1984) normative model of stock selection available. It is surprising that previous attempts to empirically explore the question of market efficiency do so in a vacuum. By tying the Markowitz model into such empirical explorations the ideas behind timing and selection are interwoven, and stronger support for the hypothesis of market efficiency is achieved.

NOTES

1 Applying the market model (or single-index model) in this context makes no assumption vis-à-vis the equilibrium risk-return relationship in the market. It is simply a means of parsimoniously approximating the inter-relationships among all of the securities (cf. Frankfurter, Phillips, and Seagle, 1976).

2 This direct comparison is theoretically only valid for an investor with homothetic preferences (i.e., for whom the income expansion path in E-V space is a ray, i.e., λ is not dependent upon wealth). The portfolios using the filter are dominated in E-V space by other portfolios along the standard frontier, making the efficiency conclusion general.

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