INVESTMENT FINANCE V

LECTURE 4

Market Efficiency

Essentially all market efficiency tests focus on the speed with which stock prices adjust to new information.

Nobody claims that the information itself is worthless. But once it is publicly available, it is already reflected in the stock price and no ordinary investor can profit from it.

The alternative definitions of market efficiency relate to the type of information that is regarded as relevant and reflected in the current stock price.

Weak-form Efficiency

All the information regarding past price movements is reflected in the stock price. No amount of charts or analysis based solely on past prices can help to obtain normal profit).

Semi-strong-form Efficiency

All publicly available information is reflected in the stock price. (One cannot make an abnormal profit by looking at any of the publicly available information, such as stock price movements, volume of trade, volume of short sales, the firm's income statements, etc.).

Strong-form Efficiency

All information, including non-public information, is reflected in the stock price. (The three definitions of marked efficiency are due to Harry Roberts "Statistical versus clinical prediction of the stock market", unpublished paper, Chicago 1967.

Weak-form Efficiency and the Random Walk

The first to apply the notion of a random walk to security price movements was L Bachelier, "Théorie de la Spéculation", Paris, Gauthier-Villars 1900.

Market Efficiency

In 1953, Maurice Kendall presented a paper to a meeting of the Royal Statistical Society in London which dealt with the price behaviour of Stocks and Commodities. The purpose of the paper was to analyse price cycles but Kendall couldn't find any.

M G Kendall, "The Analysis of Economic Time Series, Part 1, Prices", Part 1, Prices", *Journal of the Royal Statistical Society* (1953). Each series was just like a set of prices drawn from a table of random numbers, hence the name "random walk".

The random walk approach to security markets asserts that the period-to-period price changes of a security are statistically independent, or very nearly so. If this hypothesis holds, the price movements of securities will follow what statisticians call a "random walk".

Random Walk theorists usually take as their starting point the model of a perfect securities market with a large number of competing investors. If current information relevant to security pricing is available at little or no cost, then at any given point in time stock prices should reflect the market's evaluation of currently available information. Price changes would be a function of new information which would occur in a randomly unpredictable fashion. Price movements in such a perfect market would be statistically independent of one another.

The analysis of current or past prices would tell us nothing about the future. Prices cannot tell us anything about the future. Prices cannot be forecast on the basis of a historical time series of price movements. Stock prices have no memory.

If the random walk hypothesis is empirically confirmed, we may assert that the stock market is weak form efficient.

Market Efficiency

E F Fama "The Behaviour of Stock Market Prices", *The Journal of Business* (1965).

"In statistical terms, the theory (random walk) says that successive price changes are independent, identically distributed random variables".

The theory of random walks in stock prices is based on two hypotheses:

1. Successive price changes in an individual security are independent.

2. The price changes conform to some probability distribution.

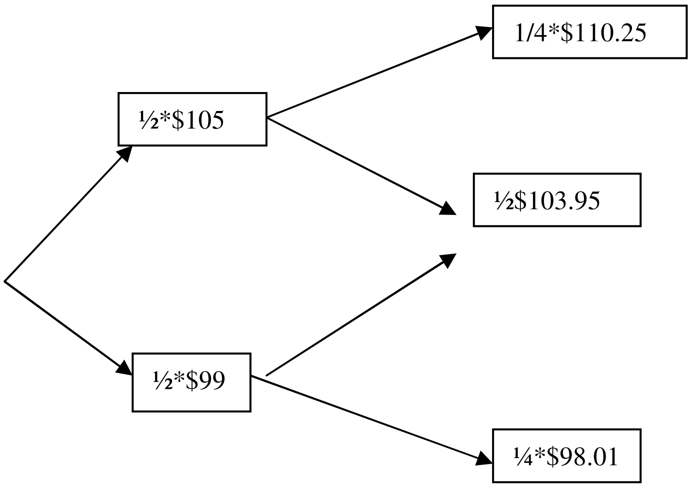
Does this mean that on average stock price changes have a zero mean? Not necessarily, Martingale, and sub martingale.

Various models have been used in the literature - *See *Fama's classification*.

Since investors are risk averse and stocks are risky, we would expect to find a positive mean change in stock prices. For example, suppose you invest $100 in a stock. Flip a coin to win. If a head comes up you lose 1% and if tail shows, you gain 5%. If you gamble only once your average return is:

1/2 x $99 + 1/2 x $105 = $102

Random Walk with Positive Drift (two-period case)



Suppose you gamble again, say invest for another week. The expected terminal value is

1/4 x 98.01 + 1/4 x 103.95 + 1/4 x 103.95 + 1/4 x 110.25 = $104.04

Price changes are independent in each period - there is an equal probability of a rise or fall. But on average, we earn 2% if we invest for one week and 4.04% if we invest for two weeks. We have a random walk with "positive drift". In our example, the drift is equal to 2%, which implies that on average the investment terminal value increases every period by 2%.

Tests of Weak-form Efficiency

The random walk hypothesis is usually tested by looking for association between stock price changes on consecutive days. The tests fall into two broad groups:

Parametric tests (i.e., regression analysis)

Non-Parametric tests (i.e., runs tests)

(a) Regression Analysis

The simplest way to test the random walk theory is by calculating the stock price change ΔPt for everyday t, and then regressing today's price change ΔP+ on yesterday's price change ΔPt-1.

$$\Delta Pt = a + b\ \Delta Pt\text{-}1$$

Such regressions may produce one of the three general patterns shown in the diagram. The intercept term a measures the expected price change, unrelated to previous price changes. This is the "positive drift" of the random walk process.

If prices behave like the first two diagrams, then past price changes are important and trading rules developed on the form of past pale data may have economic worth.

However, if prices conform to the last diagram, this is consistent with random walk theory, as future price changes are independent of past price changes. Most empirical studies have found that the last diagram tends to be the best description of the data.

Tests of Weak-form Efficiency

Fama (1965) found that the correlation between ΔPt and ΔPt-1 is very low and in most cases is not significant different from zero. The table gives details of Fama's results. *

TABLE 5.1

Sample Autocorrelations of Daily Return on the Dow-Jones Industrials for Lags $\tau = 1, 2, \ldots, 10$

STOCK	LAG (τ)										
	1	2	3	4	5	6	7	8	9	10	T
Allied Chemical	.017	−.042	.007	−.001	.027	.004	−.017	−.026	−.017	−.007	1223
Alcoa	.118*	.038	−.014	.022	−.022	.009	.017	.007	−.001	−.033	1190
American Can	−.087*	−.024	.034	−.065*	−.017	−.006	.015	.025	−.047	−.040	1219
AT&T	−.039	−.097*	.000	.026	.005	−.005	.002	.027	−.014	.007	1219
American Tobacco	.111*	−.109*	−.060*	−.065*	.007	−.010	.011	.046	.039	.041	1283
Anaconda	.067*	−.061*	−.047	−.002	.000	−.038	.009	.016	−.014	−.056	1193
Bethlehem Steel	.013	−.065*	.009	.021	−.053	−.098*	−.010	.004	−.002	−.021	1200
Chrysler	.012	−.066*	−.016	−.007	−.015	.009	.037	.056*	−.044	.021	1692
Du Pont	.013	−.033	.060*	.027	−.002	−.047	.020	.011	−.034	.001	1243
Eastman Kodak	.025	.014	−.031	.005	−.022	.012	.007	.006	.008	.002	1238
General Electric	.011	−.038	−.021	.031	−.001	.000	−.008	.014	−.002	.010	1693
General Foods	.061*	−.003	.045	.002	−.015	−.052	−.006	−.014	−.024	−.017	1408
General Motors	−.004	−.056*	−.037	−.008	−.038	−.006	.019	.006	−.016	.009	1446
Goodyear	−.123*	.017	−.044	.043	−.002	−.003	.035	.014	−.015	.007	1162
International Harvester	−.017	−.029	−.031	.037	−.052	−.021	−.001	.003	−.046	−.016	1200
International Nickel	.096*	−.033	−.019	.020	.027	.059*	−.038	−.008	−.016	.034	1243
International Paper	.046	−.011	−.058*	.053*	.049	−.003	−.025	−.019	−.003	−.021	1447
Johns Manville	.006	−.038	−.027	−.023	−.029	−.080*	.040	.018	−.037	.029	1205
Owens Illinois	−.021	−.084*	−.047	.068*	.086*	−.040	.011	−.040	.067*	−.043	1237
Procter and Gamble	.099*	−.009	−.008	.009	−.015	.022	.012	−.012	−.022	−.021	1447
Sears	.097*	.026	.028	.025	.005	−.054	−.006	−.010	−.008	−.009	1236
Standard Oil (Calif.)	.025	−.030	−.051*	−.025	−.047	−.034	−.010	.072*	−.049*	−.035	1693
Standard Oil (N. J.)	.008	−.116*	.016	.014	−.047	−.018	−.022	−.026	−.073*	.081*	1156
Swift and Co.	−.004	−.015	−.010	.012	.057*	.012	−.043	.014	.012	.001	1446
Texaco	.094*	−.049	−.024	−.018	−.017	−.009	.031	.032	−.013	.008	1159
Union Carbide	.107*	−.012	.040	.046	−.036	−.034	.003	−.008	−.054	−.037	1118
United Aircraft	.014	−.033	−.022	−.047	−.067*	−.053	.046	.037	.015	−.019	1200
U.S. Steel	.040	−.074*	.014	.011	−.012	−.021	.041	.037	−.021	−.044	1200
Westinghouse	−.027	−.022	−.036	−.003	.000	−.054*	−.020	.013	−.014	.008	1448
Woolworth	.028	−.016	.015	.014	.007	−.039	.013	.003	−.088*	−.008	1445

*Sample autocorrelation is at least two standard deviations to the left or to the right of its expected value under the hypothesis that the true autocorrelation is zero.

SOURCE: Eugene F. Fama, "The Behavior of Stock Market Prices," *Journal of Business* 38 (January 1965): 72.

TABLE 5.2

Autocorrelations of Monthly Returns on the Dow-Jones Industrials for July 1963–June 1968

COMPANY	$r(R_{jt}, R_{j,t-1})$	$r(R_{jt}, R_{j,t-2})$	$r(R_{jt}, R_{j,t-3})$
Allied Chemical	.017	−.236	.144
Alcoa	−.306*	.076	.172
American Can	−.061	.003	.162
AT&T	−.117	.096	.173
American Tobacco	−.282*	−.058	.156
Anaconda	−.097	−.170	.156
Bethlehem Steel	−.034	−.044	−.101
Chrysler	.207	−.020	−.093
Du Pont	−.076	−.023	.234
Eastman Kodak	.098	−.175	.088
General Electric	−.028	−.093	−.006
General Foods	−.001	−.023	.070
General Motors	−.091	−.060	.254
Goodyear	−.034	−.294*	−.114
International Harvester	−.050	.236	.140
International Nickel	−.196	−.043	−.058
International Paper	−.010	−.367*	.089
Johns Manville	.060	−.128	−.113
Owens Illinois	.139	−.176	−.288*
Procter and Gamble	−.193	.193	−.077
Sears	−.105	−.020	.253
Standard Oil (Calif.)	−.111	.093	.207
Standard Oil (N. J.)	−.025	−.032	.242
Swift and Co.	.020	.005	−.020
Texaco	.076	−.148	.004
Union Carbide	−.080	.022	.047
United Aircraft	−.143	.136	.159
U.S. Steel	−.113	.023	.067
Westinghouse	.099	−.005	−.094
Woolworth	.078	.062	.098
Averages	−.044	−.016	.065

*Sample autocorrelation is at least two standard deviations to the left or to the right of its expected value under the hypothesis that the true autocorrelation is zero.

For the one day lag regression, Fama obtains that 22 out of 30 correlation co-efficient are positive, and 9 out of the 22 positive numbers are significantly different form 0. However, from an economic point of view, the magnitudes are very small. On average, for all 30 stocks, less than 1% of the variation in stock price changes in period 1 can be explained by stock price changes in period t-1.

(b) Runs Tests

Regression analysis may be distributed by the presence of outliers. This bias can be avoided by the use of the non-parametric runs test which takes into account only the signs of $\Delta Pt-1$ and ΔPt and not their magnitude.

Denote a price increase $\Delta Pt>0$ by "+" and a price decrease by "-". Check the daily price changes and construct a series of "+" and "-" which describes the past behaviour, e.g., suppose that one observed the following prices on consecutive days:

Stock price	\$100	\$101	\$95	\$94	\$93	\$120
Stock price change		+1	-6	-1	-1	+27

Thus, we have the following series of price change signs:

+ - - - - +

Tests of Weak-form Efficiency

In the above example, we have three runs. If stock prices are positively associated, we would expect to have long runs of "+" and long runs of negative "-" signs. Thus, any series of observations would be expected to break into a few long runs if stock prices are negatively associated, we would expect to find + - + -, i.e., many reversals - thus we will have many short runs. If, in fact, price changes are independent, we can calculate the expected number of runs for any given observations from a standard statistical formula.

$$\sigma_m = \left(\frac{\sum_{i=1}^{3} n_i^2 \left[\sum_{i=1}^{3} n_i^2 + N(N+1) \right] - 2N \sum_{i=1}^{3} n_i^3 - N^3}{N^2(N-1)} \right)^{1/2}, \qquad (14)$$

TABLE 12

TOTAL ACTUAL AND EXPECTED NUMBERS OF RUNS FOR ONE-, FOUR-, NINE-, AND SIXTEEN-DAY DIFFERENCING INTERVALS

Stock	Daily		Four-Day		Nine-Day		Sixteen-Day	
	Actual	Expected	Actual	Expected	Actual	Expected	Actual	Expected
Allied Chemical	683	713.4	160	162.1	71	71.3	39	38.6
Alcoa	601	670.7	151	153.7	61	66.9	41	39.0
American Can	730	755.5	169	172.4	71	73.2	48	43.9
A.T.&T.	657	688.4	165	155.9	66	70.3	34	37.1
American Tobacco	700	747.4	178	172.5	69	72.9	41	40.6
Anaconda	635	680.1	166	160.4	68	66.0	36	37.8
Bethlehem Steel	709	719.7	163	159.3	80	71.8	41	42.2
Chrysler	927	932.1	223	221.6	100	96.9	54	53.5
Du Pont	672	694.7	160	161.9	78	71.8	43	39.4
Eastman Kodak	678	679.0	154	160.1	70	70.1	43	40.3
General Electric	918	956.3	225	224.7	101	96.9	51	51.8
General Foods	799	825.1	185	191.4	81	75.8	43	40.5
General Motors	832	868.3	202	205.2	83	85.8	44	46.8
Goodyear	681	672.0	151	157.6	60	65.2	36	36.3
International Harvester	720	713.2	159	164.2	84	72.6	40	37.8
International Nickel	704	712.6	163	164.0	68	70.5	34	37.6
International Paper	762	826.0	190	193.9	80	82.8	51	46.9
Johns Manville	685	699.1	173	160.0	64	69.4	39	40.4
Owens Illinois	713	743.3	171	168.6	69	73.3	36	39.2
Procter & Gamble	826	858.9	180	190.6	66	81.2	40	42.9
Sears	700	748.1	167	172.8	66	70.6	40	34.8
Standard Oil (Calif.)	972	979.0	237	228.4	97	98.6	59	54.3
Standard Oil (N.J.)	688	704.0	159	159.2	69	68.7	29	37.0
Swift & Co.	878	877.6	209	197.2	85	83.8	50	47.8
Texaco	600	654.2	143	155.2	57	63.4	29	35.6
Union Carbide	595	620.9	142	150.5	67	66.7	36	35.1
United Aircraft	661	699.3	172	161.4	77	68.2	45	39.5
U.S. Steel	651	662.0	162	158.3	65	70.3	37	41.2
Westinghouse	829	825.5	198	193.3	87	84.4	41	45.8
Woolworth	847	868.4	193	198.9	78	80.9	48	47.7
Averages	735.1	759.8	175.7	175.8	74.6	75.3	41.6	41.7

*The table shows Fama's (1965) results.

The actual number of runs is very close to the expected number under the random walk hypothesis. For the one-day lag, the actual number is slightly less than the expected number.

Testing Filter Rules

A popular trading rule based on past prices is the filter rule.

- "If the price of a security moves up at least 7%, buy the security and hold it until its price moves down at least 7% from the subsequent high, at which time sell the stock and go short; the short position is maintained until the price rises 7% above the subsequent low, at which time cover the short position and buy the stock. If the stock price changes by less than 7% up or down, simply do not make any transactions". Such trading rules are called 7% filters.

Tests of Weak-form Efficiency

. The effectiveness of a filter strategy is compared with a naive buy and hold policy. The table gives some details of Fama & Blume's (1966) results, E F Fama & M Blume "Filter Rules and Stock Market Trading", *Journal of Business* (1966). Only small filters before transactions costs seemed to provide a higher return, and transactions costs would wipe these out - filter rules do not provide any excess return.

TABLE 16

SUMMARY OF FILTER PROFITABILITY IN RELATION TO NAÏVE BUY-AND-HOLD TECHNIQUE*

Stock	Profits per Filter†		
	Without Commissions (1)	With Commissions (2)	Buy-and-Hold (3)
Allied Chemical	648.37	−10,289.33	2,205.00
Alcoa	3,207.40	− 3,929.42	− 305.00
American Can	− 844.32	− 5,892.85	1,387.50
A.T.&T.	16,577.26	4,912.84	20,005.00
American Tobacco	8,342.61	− 1,467.71	7,205.00
Anaconda	− 28.26	− 7,145.82	862.50
Bethlehem Steel	− 837.94	− 6,566.80	652.50
Chrysler	− 954.68	−12,258.61	− 1,500.00
Du Pont	6,564.21	− 465.35	9,550.00
Eastman Kodak	6,584.95	− 5,926.10	11,860.50
General Electric	− 107.06	− 8,601.28	2,100.00
General Foods	11,370.33	2,266.89	11,420.00
General Motors	− 1,099.40	− 8,440.42	2,025.00
Goodyear	− 2,241.28	−17,323.20	2,920.70
International Harvester	− 735.95	− 7,444.92	3,045.00
International Nickel	5,231.25	− 3,509.97	5,892.50
International Paper	2,266.82	− 7,976.68	− 278.10
Johns Manville	− 1,090.22	− 8,368.44	1,462.50
Owens Illinois	727.27	− 5,960.05	3,437.50
Procter & Gamble	12,202.83	4,561.52	8,550.00
Sears	4,871.36	408.65	5,195.00
Standard Oil (Calif.)	− 3,639.79	−21,055.08	5,326.50
Standard Oil (N.J.)	− 1,416.48	− 6,208.68	1,380.00
Swift & Co.	− 923.07	− 8,161.76	552.50
Texaco	2,803.98	− 5,626.11	6,546.50
Union Carbide	3,564.02	− 1,612.83	1,592.50
United Aircraft	− 1,190.10	− 8,369.88	562.50
U.S. Steel	1,068.23	− 5,650.03	475.00
Westinghouse	− 338.85	−12,034.56	745.00
Woolworth	4,190.78	− 2,403.34	3,225.00

* All figures are computed on the basis of 100 shares. Column (1) is total profits minus total losses on all filters, divided by the number of different filters tried on the security. Column (2) is the same as column (1) except that total profits and losses are computed net of commissions. Column (3) is last price plus any dividends paid during the period, minus the initial price for the period.

† The different filters are from 0.5 per cent to 5 per cent by steps of 0.5 per cent; from 6 per cent to 10 per cent by steps of 1 per cent; from 12 per cent to 20 per cent by steps of 2 per cent; and then 25 per cent, 30 per cent, 40 per cent and 50 per cent.

Semi-strong-form Efficiency

All public information should be reflected in the stock price. Publicly available information is so large and heterogeneous that it is impossible to test market efficiency relative to all sources of information. However, one can test several types of information which are conceived to have a major effect on stock prices.

Stock Splits

E F Fama, L Fisher, M Jensen and R Roll "The Adjustment of Stock Prices to New Information". *International Economic Review* (Feb 1969).

Fama, Fisher, Jensen and Roll tested the impact of stock splits on the excess return of stocks. For each stock, they ran the regression

$$Ri+ = \alpha i + Bi\ Rmt + eit$$

where

Ri+ = the return on stock i in month t

Rmt = the return on the market index in month t

αi, Bi = constants

eit = the deviation from the regression line in the month t

Tests of Semi-strong-form Efficiency

They examined the difference between the actual return on the stock in month t and the return predicted by the model (i.e., the deviation term eit). This difference is defined as the excess return. Then they calculated the cumulative excess return

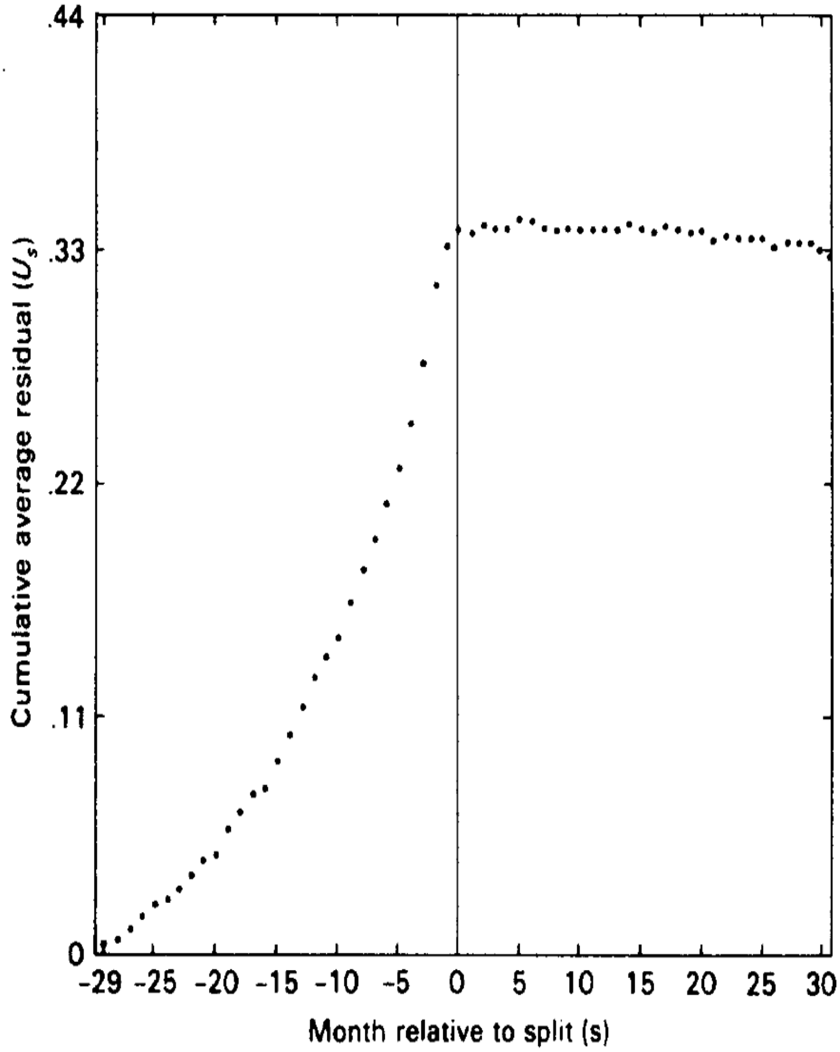
$$\sum_{-30}^{+30} \text{eit}$$

over the period from 30 months before the split to 30 months after the split.

*The diagram summarises the results

FIGURE 5.3b

Cumulative Average Residuals—All Splits



Source: Eugene F. Fama, Lawrence Fisher, Michael Jensen, and Richard Roll, "The Adjustment of Stock Prices to New Information," *International Economic Review* 10 (February 1969): 1–21. Reprinted by permission.

The cumulative average excess return stated increasing as early as 30 months before the split, while after the split it levelled off. The explanation might be that it is the profitable firms who split their stock after it reaches a high price level.

When they divided their samples into two groups, one with firms which increased their cash dividends after the split and the other with firms that did not, they found that the cumulative average excess return of the first group continued increasing while for the latter group it declined. The result seemed consistent with semi-strong-form market efficiency.

Fama's four models of market equilibrium

(a) Expected Returns are Positive

The first model of market equilibrium simply says that the market sets the price of any securities in such a way that the market's expected return on the security from time to time is positive.

$$\tilde{\mathrm{R}}\mathrm{jt} = \frac{\tilde{\mathrm{P}}_{\mathrm{j}} - \mathrm{P}_{\mathrm{j-1}}}{\mathrm{Pj}_{\mathrm{t-1}}} \quad (1)$$

The market always sets Pj_{t-1} so that, given its assessment of the expected price at t,

$$Em\left(\tilde{R}jt \middle| \theta^{m}_{t-1}\right) = \frac{Em\left(\tilde{P}jt \middle| \theta^{m}_{t-1} - Pj_{t-1}\right)}{Pj_{t-1}} > 0 \quad (2)$$

Market efficiency says that in assessing distributions of future prices, the market has all available information and uses it correctly.

$$fm\left(Pjt \middle| \theta^{m}_{t-1}\right) = f\left(Pjt \middle| \theta_{t-1}\right) \quad (3)$$

which implies

$$Em\left(\tilde{P}jr \middle| \theta^{m}_{t-1}\right) = E\left(\tilde{P}jt \middle| \theta_{t-1}\right) \quad (4)$$

$$Em\left(\tilde{R}jr \middle| \theta^{m}_{t-1}\right) = E\left(\tilde{R}jt \middle| \theta_{t-1}\right) \quad (5)$$

If the above holds the true, expected return on any security, it is always positive.

$$E\left(\tilde{R}jt \middle| \theta_{t-1}\right) > 0 \quad (6)$$

'basis' for filter tests.

(b) Fama's Four Models of Market Equilibrium

Expected Returns Are Constant

The market sets the current price of securities so that, given its assessment of the expected value of the future price - $Em\left(\tilde{P}jt \middle| \theta^{m}_{t-1}\right)$

$$Em\left(\tilde{R}jt \left| \theta_{t-1}^{m}\right.\right) = \frac{Em\left(\tilde{P}jt \left| \theta_{t-1}^{m}\right.\right) - Pj_{t-1}}{Pj_{t-1}} = E\left(Rj\right)$$

The model says that E(Rj) is constant through time but different securities can have different expected returns based on differences in risk.

This implies

$$E\left(\tilde{R}jt \left| \theta_{t-1}\right.\right) = Em\left(\tilde{R}jt \left| \theta_{t-1}^{m}\right.\right) = E\left(\tilde{R}j\right) \qquad (8)$$

The above implies that for all $\theta_{t-1}, E\left(\tilde{R}jt \left| \theta_{t-1}\right.\right)$, the regression function of $\tilde{R}jt$ on θ_{t-1} is the constant $E\left(\tilde{R}j\right)$. The usual way of testing the model is

$$E\left(\tilde{R}jt \left| Rj_{t-1}\right.\right) = \partial\tau + V\tau Rj_{t-\tau} \qquad (9)$$

where $Y\tau$ is the autoregression or autocorrelative Co-efficient for lag τ.

The prediction is that autocorrelation of the returns on any security is zero for all values of the lag τ.

(c) Fama's Four Models of Market Equilibrium

The basic assumption is that the joint distribution of security returns of $f\left(R_{1t}.....R_{nt} \left| \theta_{t-1}\right.\right)$ is multivariate normal. This implies that the market model holds

$$E\left(\tilde{R}jt \left| \theta_{t-1}, Rmt\right.\right) = \alpha_j + B_j Rmt \qquad (10)$$

The market's assessment implies market model equations, which are

$$Em\left(\tilde{R}jt \left| \theta m_{t-1}, Rmt\right.\right) = \alpha_j^m + B_j^m Rmt \qquad (11)$$

$$B_j^m = Cov\frac{m\left(\tilde{R}jt, \tilde{R}mt\right)}{\sigma^2\left(\tilde{R}mt\right)}, \text{ and } \alpha_j^m = Em\left(\tilde{R}jt \left| \theta_{t-1}^{m}\right.\right) - B_j^m Em\left(\tilde{R}mt \left| \theta_{t-1}^{m}\right.\right) \qquad (12)$$

$$\tilde{R}jt = \alpha_j^m + B_j^m Rmt + \tilde{e}_{jt}^m \qquad (13)$$

$$Em\left(\tilde{E}_{jt}^m \left| \theta_{t-1}^{m}, Rmt\right.\right) = 0.0 \qquad (14)$$

The above is the basis for the 'event' studies.

The fourth approach is to assume that returns conform to a risk-return relationship

These tests use variants of the CAPM as their basis.

Efficient Capital Markets: II

E F Fama - *Journal of Finance*, Dec. 1991

Takes the market efficiency hypothesis to be the simple statement that prices fully reflect all available information

- issue of trading costs
- prices reflect information to the point where the marginal benefits of acting on information (profits to be made) do not exceed the marginal costs.

The joint hypothesis problem

Market efficiency *per se* is not testable - it must be tested jointly with some model of equilibrium.

He suggests that because it has improved our understanding of the behaviour of security returns, the past research on market efficiency is among the most successful in empirical economics.

The main areas of research

Instead of weak form tests suggest a more general category: <u>tests for return predictability</u>.

- includes work on forecasting returns with variables like dividend yields and interest rates.

Some market efficiency and equilibrium pricing issues are inseparable - we should include under this heading the cross-sectional predictability of returns, that is, tests of asset-pricing models and the work on anomalies.

Time varying predicted returns

- short horizon returns

- autocorrelation of weekly returns (Lo and Mackinky 1988) stronger for portfolios of small stocks

- non-synchronous trading effects?
- French and Roll (1988) stock prices are more variable when the market is open
- differences in information flows?

- long horizon returns

Shiller (1988) and Summers (1986) present simple models in which stock prices take large, slowly-decaying swings away from fundamental values (fads, or irrational bubbles), but short horizon returns have little autocorrelation.

However, Fama and French (1988) emphasize that temporary swings in stock prices do not necessarily imply irrational bubbles - they suggest that the movement implied by the existence of irrational bubbles in stock prices is indistinguishable from that implied by rational time varying expected returns.

The Contrarians

De Bondt and Thaler (1985, 1987) find that NYSE stocks identified as the most extreme losses over a 3-5 year period tend to have strong returns relative to the market during the following years. Conversely, the extreme winners tend to have weak returns relative to the market in subsequent years.

- is it the result of failure to risk-adjust returns?

Other forecasting variables

Dividend yields $\left(D/P\right)$ - fractions of returns explained grow with the horizon period. Similarly, E/P have forecasting power.

The predictability of returns from D/P or E/P is not evidence against market efficiency. In an efficient market, D/P says prices are high relative to dividends when discount rates and expected returns are low and vice versa.

Fama and French (1989) suggest the variation in expected returns tracked by D/P and the default spread increase from high-grade bonds to low-grade bonds, and from large stocks to small stocks correspond to intuition about the riskiness of stocks.

Volatility tests

Volatility tests of market efficiency, pioneered by Le Roy and Porter (1981) and Shiller (1979) have mushroomed into a large literature.

- Fama takes the view that the tests are not informative about market efficiency.
- A central assumption in the early volatility tests is that expected returns are constant and the variation in stock prices is driven entirely by stocks to expected dividends. Fama suggests that by the end of the 1970s, evidence that expected stock and bond returns vary with expected inflation rates, interest rates, and other term structure variables was becoming commonplace.

Return Seasonality

Day of the week effect, (French (1980), holiday (Ariel) (1990) - last day of the month Ariel (1987) - beginning and end of day - intra day returns Harris (1986), Keim (1988) argues that seasonals are anomalies in the sense that asset pricing models do not predict them but they are not necessarily embarrassments for market efficiency.

Cross-Sectional Return Predictability

SLB Black Model - early 'success' - anomalies Basu (1987), E/Pratios, Banz (1981) size, Bhandhari (1988) leverage, Fama and French (1991), book/market equity.

- anomalies appear to be related

Multifactor models - consumption based asset-pricing models

Event studies

Event studies are now an important part of finance.

- market efficiency - the typical result in event studies on daily data is that on average, stock prices seem to adjust within a day to event movements.

- some anomalies but the bulk of evidence is supportive.

Tests for private information

1. the profitability of insider trading is established in detail.
2. there is evidence that security analysts (e.g., value line) have information not reflected in stock prices.
3. there is mixed evidence about whether professional investment managers have access to private information.

Fama concludes that we can hope for a coherent story that

(1) relates the cross-section properties of expected returns to the variation of expected returns through time

(2) relates the behaviour of expected returns to the real economy in a rather detailed way