WORKING PAPERS IN ECONOMICS

A NOTE ON THE TESTABILITY OF
FAMA'S EFFICIENT CAPITAL MARKET HYPOTHESIS*

by

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ABSTRACT

Fama's (1970, 1976) theory of efficient capital markets relies on empirical tests of propositions. It is shown that the conclusion of semi-strong-form capital market efficiency, reached from empirical studies, is still unwarranted.

*I have benefited from Michael C. Blad's advice and discussions. However, I am responsible for any errors in this paper.

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A NOTE ON THE TESTABILITY OF FAMA'S EFFICIENT CAPITAL MARKET HYPOTHESIS

In his 1970 article, "Efficient Capital Markets: A Review of Theory and Empirical Work", Fama put forward three related hypotheses. First, capital markets are efficient in the strong-form if prices in these markets fully reflect all available relevant information at any time. Secondly, capital markets are semi-strong-form efficient if prices reflect all publicly available information. Thirdly, if prices reflect all information contained in past price series then the capital markets are efficient in the weak-form.

The importance of efficient capital markets is seen to lie in the role of allocating resources:

> "The primary role of the capital market is allocation of ownership of the economy's capital stock. In general terms, the ideal is a market in which prices provide accurate signals for resource allocation: that is, a market in which firms can make production-investment decisions, and investors can choose among the securities that represent ownership of firms' activities under the assumption that security prices at any time 'fully reflect' all available information. A market in which prices always 'fully reflect' available information is called 'efficient'" (3, p. 383)

Fama's work has given rise to a large number of empirical studies which are concerned with testing one form or another of Fama's capital market efficiency hypothesis. Summaries of these studies are contained in (2) for United States data and in (1) for the Australian data.

Fama (3, 4) viewed the then existing studies as supporting the semi-strong-form hypothesis of capital market efficiency. This conclusion was endorsed by Copeland and Weston (2). Officer (1) reached the same conclusion following his examination of the corresponding Australian studies.

Enthusiasm expressed by these authors about the semi-strong-form efficiency of capital markets is not shared by this writer. On the contrary, it will be shown in the following that, given the formal definition of capital market efficiency presented by Fama in 1976, the hypothesis is in fact not testable. This does not augur well for the type of methodology of economic research which relies on empirical tests of hypotheses at the expense of theoretical analysis based on well defined concepts and clear statements of assumptions.

DEFINITION OF CAPITAL MARKET EFFICIENCY (FAMA, 1976)

In 1976 Fama presented a 'formal discussion' of an efficient capital market. His aim was to provide a "more detailed specification of the process of price formation, one that gives testable content to the term 'fully reflect'" (4, p. 134). Fama's notation and definition, which is applied here, is as follows:

let "θ_{t-1} = the set of information available at time t-1, which is relevant for determining security prices at t-1.

"θ^{m}_{t-1} = the set of information that the market uses to determine security prices at t-1. Thus θ^{m}_{t-1} is a subset of θ_{t-1}; θ^{m}_{t-1} contains at most the information in θ_{t-1} but it could contain less.

"p_{jt-1} = price of security j at time t-1, j = 1, 2, ..., n, where n is the number of securities in the market.

"$f(p_{1t+r}, \cdots, p_{nt+r} | \theta_{t-1})$

= the 'true' joint probability density function for security prices at time t+r ($r \geq 0$) that is 'implied by' the information θ_{t-1}.

"$f_m(p_{1t+r}, \ldots, p_{nt+r} | \theta^m_{t-1})$

= the joint probability density function for security prices at time t+r ($r \geq 0$) assessed by the market at time t-1 on the basis of the information θ^m_{t-1}."

Fama defined the capital market as being efficient if $\theta^m_{t-1} = \theta_{t-1}$ and $f_m(p_{1t+r}, \ldots, p_{nt+r} | \theta^m_{t-1}) = f(p_{1t+r}, \ldots, p_{nt+r} | \theta_{t-1})$

METHODOLOGY OF DERIVING A TESTABLE HYPOTHESIS (FAMA, 1976)

Let R be the set of two period temporary equilibrium stock exchange economies with n securities, j = 1, ..., n, for which there exists a price system $p^*_{t-1} = (p^*_{1t-1}, \ldots, p^*_{nt-1})$ and a system of expected prices, $p^{e*}_t = (p^{e*}_{1t}, \ldots, p^{e*}_{nt})$ such that the market for n securities clears at t-1 and the expected value of the deviation of realized prices in period t from the expected prices is zero, i.e.

$$\forall_j \quad E(\tilde{\varepsilon}^*_{jt}) = 0, \text{ where} \tag{1}$$

$$\varepsilon^*_{jt} = p^*_{jt} - p^{e*}_{jt}$$

~ denotes a random variable

The following assumptions will be needed.

A1: R is non-empty

A2: the price expectations are formed taking "all available relevant information" into account, i.e. using θ_{t-1}

A3: $\theta_{t-2} \subseteq \theta_{t-1}$

Assumptions A1 to A3 imply that $E(\tilde{\varepsilon}^*_{jt}|\theta_{t-r}) = 0, \underset{j}{\forall}, r = 1, 2.$
Let B be the subset of R which fulfills the condition that the expected prices in period t of the n securities can be expressed as a function of potentially observable variables in period t-1. Two further assumptions are needed.

A4: B is non-empty

A5: $\exists\ B \in B$: $f_m^B = f^B$, where f_m^B, f^B are defined as above for the economy B

Example: in empirical studies of tests of the Fama notion of capital market efficiency one of the most frequently employed models of security market equilibrium is the Markowitz Market Model. Let $B \in B$ be the Markowitz Market Model. This model is well known and need not be derived here. The market clearing price relationship for the jth security is given by

$$\underset{j}{\forall}\ E(\tilde{R}_{jt}|R_{mt}) = \alpha_j + \beta_j R_{mt} \tag{2}$$

where

$$R_{jt} = (p^*_{jt} - p^*_{jt-1})/p^*_{jt-1}$$

$$R_{mt} = \sum_{j=1}^{n} \omega_j R_{jt}, \quad 0 < \omega_j < 1 \ \underset{j}{\forall}, \quad \sum_{j=1}^{n} \omega_j = 1$$

α_j, β_j are real parameters

Introducing the Fama notion of efficient price expectations and assuming also that A5 holds, the efficient expected equilibrium return is given by

$$\underset{j}{\forall} \; E(\tilde{R}_{jt} \mid \theta_{t-1}, R_{mt}) = \alpha_j + \beta_j R_{mt} \tag{3}$$

with

$$E(\tilde{\varepsilon}^*_{jt} \mid \theta_{t-r}, R_{mt}) = 0, \; r = 1, 2 \tag{4}$$

where

$$\tilde{\varepsilon}^*_{jt} = R_{jt} - E(\tilde{R}_{jt} \mid \theta_{t-1}, R_{mt}) \tag{5}$$

Let θ^k_{t-1} be an information structure (e.g. corporate announcements made at a particular stock exchange at t-1 judged to be 'relevant' by researcher k. The null hypothesis that the capital market is efficient with respect to θ^k_{t-1} is

$$Ho^1: \; \underset{j}{\forall} \; E(\tilde{\varepsilon}^*_{jt+r} \mid \theta^k_{t-1}, B) = 0, \; r = 0, 1, 2 \tag{6}$$

The null hypothesis is tested by estimating the expected return vector $E(\tilde{R}_{jt})$ according to some model B, say the Markowitz Market Model. Assuming stationary return distributions $(\tilde{R}_j, \tilde{R}_m) \underset{j}{\forall}$, the estimation equations become for 'event time' t-1, relative to θ^k_{t-1}:

$$\underset{j}{\forall} \; \tilde{R}_{js} = a_j + b_j \tilde{R}_{ms} + \tilde{e}_{js}, \quad s = -z, \ldots, t-1, \; z \in Z, \; z \geq 2. \tag{7}$$

The test hypothesis is then

$$Ho^2: \quad \forall_j \; E(\tilde{e}_{jt+r} | \theta^k_{t-1}, R_{ms}) = 0 \quad \text{for } r = 0, 1, 2 \tag{8}$$

where

$$\tilde{e}_{jt+r} = R_{jt+r} - (a_j + b_j \tilde{R}_{mt+r}) \tag{9}$$

This method will be referred to as the FFJR method.

Proposition: to test if $\theta^m_{t-1} = \theta_{t-1}$ cannot be done by the FFJR method.

Proof: equations (3) to (5) can be rewritten as

$$\forall_j \; E(\tilde{R}^m_{jt} | \theta^m_{t-1}, R^m_{mt}) = \alpha^m_j + \beta^m_j R^m_{mt} \tag{10}$$

$$E(\tilde{\varepsilon}^m_t | \theta^m_{t-r}, R^m_{mt}) = 0, \; r = 1, 2 \tag{11}$$

$$\tilde{\varepsilon}^m_t = R^m_{jt} - E(\tilde{R}^m_{jt} | \theta^m_{t-1}, R^m_{mt}) \tag{12}$$

Equations (7) to (9) are estimating equations of (10) to (12) and not of (3) to (5) since market data is used in the estimation. Hence we can have $\forall_j \; E(\tilde{e}_{jt+r} | B) = 0$ without having $\theta^m_{t-1} = \theta_{t-1}$. Hence no test of $\theta^m_{t-1} = \theta_{t-1}$.

CONCLUDING COMMENTS

The research methodology proposed by Fama has several odd features. Firstly, the information set θ_{t-1} which is 'relevant' for optimal resource allocation, in terms of Pareto optimality or some other criteria, may be such that it belongs to an economy which does not belong to the set B. Fama excludes this possibility. It appears that Fama suggests that only economies which belong to the set B and which fulfil the condition expressed in Ho^1 are economies which, in some unspecified manner, imply optimal resource allocation. Secondly, the distinction between semi-strong-form and weak-form capital market efficiency appears to be contrived since information on historical price series, the subject of weak-form tests, seems to be publicly available in the same manner as announcements on share splits, corporate mergers and takeovers which are taken to be the subject of semi-strong-form capital market efficiency tests. Thirdly, and most importantly, the conclusion reached about the semi-strong-form capital market efficiency is still unwarranted. Supposing one observes that Ho^2 is violated. This may be for two reasons. Either the assumed economy B is not the true one, or B is correct and the 'market' is inefficient in the sense that $\theta^m_{t-1} \neq \theta_{t-1}$. It is the problem known as joint hypothesis testing. From the above proposition it follows that by observing that Ho^2 is not violated, one cannot draw the conclusion that $\theta^m_{t-1} = \theta_{t-1}$.

In empirical studies aimed at testing the Fama semi-strong form capital market efficiency hypothesis the deviation of the error term e_{jt+r} from zero in the period $r = 0$ is usually interpreted as price revaluation due to new information. The capital market is then judged to be efficient

if $e_{jt+r} \neq 0$ for $r = 0$ and $e_{jt+r} = 0$ for $r > 0$. While this application of the FFJR method is useful for questions such as: how did the Chicago or London Stock Exchange react, in terms of magnitude and speed of price changes, to corporate announcements of a particular kind at a particular time period, it is not a test of the Fama semi-strong-form capital market efficiency hypothesis. The reason for this is straightforward. Applying the same argument as in the above proposition, the error term e_{jt+r} is obtained from an estimation equation such as (7) which is an empirical estimation equation of the hypothetical equation (10) and not of equation (3) since all one can observe are the recorded price series which are the results of the decisions made by traders in the capital market, i.e. those which 'reflect' θ^{m}_{t-k}, $k \geq 0$. θ^{m}_{t-k} may be equal to θ_{t-k}, namely when the capital market is efficient. A test of the Fama efficient capital market hypothesis has to provide information on whether or not $\theta^{m}_{t-k} = \theta_{t-k}$. Supposing one observes $e_{jt+r} = a$, $a \in \mathbb{R}$ for $r = 0$ and $e_{j+r} = 0$ for $r > 0$. One cannot conclude whether the market is efficient because the price revaluation response conditional on θ_{t-k} may have resulted in $a' \in \mathbb{R}$, whereby $a \neq a'$!

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