Market Efficiency Today

By

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1 Historical Backgrounds

Economists have long been fascinated by the sources of variations in the stock market. By the early 1970's a consensus had emerged among financial economists suggesting that stock prices could be well approximated by a random walk model and that changes in stock returns were basically unpredictable. Fama (1970) provides an early, definitive statement of this position. Historically, the 'random walk' theory of stock prices was preceded by theories relating movements in the financial markets to the business cycle. A prominent example is the interest shown by Keynes in the variation in stock returns over the business cycle.

The efficient market hypothesis (EMH) evolved in the 1960's from the random walk theory of asset prices advanced by Paul Samuelson (1965). Samuelson showed that in an informationally efficient market price changes must be unforecastable. Kendall (1953), Cowles (1960), Osborne (1959, 1962), and many others had already provided statistical evidence on the random nature of equity price changes. Samuelson's contribution was, however, instrumental in providing academic respectability for the hypothesis, despite the fact that the random walk model had been around for many years; having been originally discovered by Louis Bachelier, a French statistician, back in 1900!

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Although a number of studies found some statistical evidence against the random walk hypothesis, these were dismissed as economically unimportant (could not generate profitable trading rules in the presence of transaction costs) and statistically suspect (could be due to data mining). For example, Eugene Fama (1965), concluded that "...there is no evidence of important dependence from either an investment or a statistical point of view". Despite its apparent empirical success, the random walk model was still a statistical statement and not a coherent theory of asset prices. For example, it need not hold in markets populated by risk averse traders, even under market efficiency.

The efficient market hypothesis (EMH) was articulated and developed by Fama during 1960's, and popularized through his highly influential review of "Efficient Capital Markets", published in 1970.

2 Return Predictability and Alternative Versions of the Efficient Market Hypothesis

In his 1970 review, Fama distinguishes between three different forms of the EMH.

1. The "Weak" form asserts that all price information is fully reflected in asset prices, in the sense that current price changes can not be predicted from past prices. This weak form was also introduced in an unpublished paper by Roberts (1967).

2. The "Semi-strong" form that requires asset price changes to fully reflect all publicly available information and not only past prices.

3. The "Strong" form that postulates that prices fully reflect information even if some investor or group of investors have monopolistic access to some information.

Fama regarded the strong form version of the EMH as a benchmark against which the other forms of market efficiencies are to be judged. With respect to the weak form version he concludes that the test results strongly support the hypothesis, and considered the various departures documented as economically unimportant. He reached a similar conclusion with respect to the semi-strong version of the hypothesis; although as he noted, the empirical evidence available at the time was rather limited and far less comprehensive as compared to the evidence on the weak version.

2.1 Dynamic Stochastic Equilibrium Formulations and the Joint Hypothesis Problem

Evidence on the semi-strong form of the EMH was revisited by Fama in a second review of the Efficient Capital Markets published in 1991. By then it was clear that the distinction between the weak and the semi-strong forms of the EMH was redundant. The random walk model could not be maintained either - in view of more recent studies, in particular that of Lo and MacKinlay (1988).

A large number of studies in the finance literature had confirmed that stock returns over different horizons (days, weeks, and months) can be predicted to some degree by means of interest rates, dividend yields and a variety of macroeconomic variables exhibiting clear business cycle variations. A number of studies also showed that returns tend to be more predictable the longer the forecast horizon. While the vast majority of these studies had looked at the US stock market, an emerging literature has also considered the UK stock market. US studies include Balvers,Cosimano and MacDonald (1990), Breen, Glosten and Jagannathan (1990), Campbell (1987), Fama and French (1989), and subsequently by Ferson and Harvey (1993), Kandel and Stambaugh (1996), and Pesaran and Timmermann (1994, 1995). See Granger (1992) for a survey of the methods and results in the literature. UK studies after 1991 included Clare, Thomas and Wickens (1994), Clare, Psaradakis and Thomas (1995), Black and Fraser (1995), and Pesaran and Timmermann (2000).

Theoretical advances over Samuelson's seminal paper by LeRoy (1973), Rubinstein (1976) and Lucas (1978) also made it clear that in the case of risk averse investors tests of predictability of excess returns could not on their own confirm or falsify the EMH. The neoclassical theory cast the EMH in the context of dynamic stochastic (general) equilibrium models and showed that excess returns weighted by marginal utility could be predictable. Only under risk neutrality, where marginal utility was constant, the equilibrium condition implied the non-predictability of excess returns.

As Fama (1991) noted in his second review, the test of the EMH involved a joint hypothesis - market efficiency and the underlying equilibrium asset pricing model. He concluded that “Thus, market efficiency per se is not testable.” (p. 1575). This, did not , however, mean that market efficiency was not a useful concept. Almost all areas of empirical economics are subject to the joint hypotheses problem.

2.2 Information and Processing Costs and the EMH

The EMH, in the sense of asset “prices fully reflect all available information” was also criticised by Grossman and Stiglitz (1980) who pointed out that there must be “sufficient profit opportunities, i.e. inefficiencies, to compensate investors for the cost of trading and information-gathering."

Only in the extreme and unrealistic case where all information and trading costs are zero one would expect prices to fully reflect all available information. But if information is in fact cost-less it would be known even before market prices are established.

As Fama recognized a weaker and economically more sensible version of the efficiency hypothesis would be needed, namely “prices reflect information to the point where the marginal benefits of acting on information (the profits to be made) do not exceed the marginal costs." This in turn makes the task of testing the market efficiency even more complicated and would require equilibrium asset pricing models that allowed for information and trading costs in markets with many different traders and with non-convergent beliefs.

In view of these difficulties some advocates of the EMH have opted for a trade-based notion, and define markets as efficient if it would not be possible for the investors "... to earn above-average returns without accepting above-average risks." Malkiel (2003, p.60). This notion can take account of information and transaction costs and does not involve testing joint hypotheses. But this is far removed from the basic idea of markets as efficient allocators of capital investment across countries, industries and firms.

Beating the market as a test of market efficiency also poses new challenges. Whilst it is certainly possible to construct trading strategies (inclusive of transaction costs) with Sharpe ratios that exceed those of the market portfolios *ex post*, such evidence are unlikely to be convincing to the advocates of the EMH. It could be argued that they are carried out with the benefit of hindsight, and are unlikely to be repeated in real time. In this connections the following considerations would need to born in mind

- Data mining/Data snooping (Pesaran and Timmermann (2005))

- Structural change and model instability (choice of observation window)
- Positive relationship that seem to exit between transaction costs and predictability
- Market volatility and learning

'Beat the market' test is not that helpful either in shedding light on the nature and the extent of market inefficiencies. A more structural approach would be desirable.

3 Theoretical Foundations of the EMH

At the core of the EMH lies the following three basic premises:

1. Investor rationality. It is assumed that investors are rational, in the sense that they correctly update their beliefs when new information is available.
2. Arbitrage: individual investment decisions satisfy the arbitrage condition, and trade decisions are made guided by the calculus of the subjective expected utility theory a la Savage.
3. Collective rationality:The random errors of investors cancel out in the market. This requires individual errors (departures from individual rationality) to be cross sectionally independent or at least only weakly correlated.

To illustrate how these premises interact, suppose that at the start of period (day, week, month) t there are N_t traders (investors) that are involved in act of arbitrage between a stock and a safe (risk-free) asset. Denote the one-period holding returns on these two assets by R_{t+1} and r_t, respectively. The arbitrage condition for trader i is given by

$$\hat{E}_i \left(R_{t+1} - r_t \left| \Omega_{it} \right. \right) = \lambda_{it} + \delta_{it},$$

where $\hat{E}_i \left(R_{t+1} - r_t \left| \Omega_{it} \right. \right)$ is his/her subjective expectations of the excess return, $R_{t+1} - r_t$ taken with respect to the information set

$$\Omega_{it} = \Psi_{it} \cup \Phi_t,$$

where Φ_t is the component of the information which is publicly available, $\lambda_{it} > 0$ represents trader's risk premium, and $\delta_{it} > 0$ is her/his information and trading costs per unit of funds invested. In the absence of information and trading costs, λ_{it} can be characterized in terms of the trader's utility function, $u_i(c_{it})$, where c_t is his/her real consumption expenditures during the period t to $t+1$, and is given by

$$\lambda_{it} = \hat{E}_i\left(R_{t+1} - r_t \left| \Omega_{it} \right.\right) = \frac{-\hat{C}ov_i\left(m_{i,t+1}, R_{t+1} \left| \Omega_{it} \right.\right)}{\hat{E}_i\left(m_{i,t+1} \left| \Omega_{it} \right.\right)},$$

where $\hat{C}ov_i\left(. \left| \Omega_{it} \right.\right)$ is the subjective covariance operator condition on the trader's information set ,Ω_{it}, $m_{i,t+1} = \beta_i u_i'(c_{i,t+1})/u_i'(c_{it})$, $u_i'(.)$ is the first derivative of the utility function, and β_i is his/her discount factor.

The expected returns could differ across traders due to the differences in the their perceived conditional probability distribution function of $R_{t+1} - r_t$, the differences in their information sets, Ω_{it}, the differences in their risk preferences, and/or endowments. Under the rational expectations hypothesis

$$\hat{E}_i\left(R_{t+1} - r_t \left| \Omega_{it} \right.\right) = E\left(R_{t+1} - r_t \left| \Omega_{it} \right.\right),$$

where $E\left(R_{t+1} - r_t \left| \Omega_{it} \right.\right)$ is the 'true' or 'objective' conditional expectations. Furthermore, in this case

$$E\left[\hat{E}_i\left(R_{t+1} - r_t \left| \Omega_{it} \right.\right) \left| \Phi_t \right.\right] = E\left[E\left(R_{t+1} - r_t \left| \Omega_{it} \right.\right) \left| \Phi_t \right.\right],$$

and since $\Phi_t \subset \Omega_{it}$ we have

$$E\left[\hat{E}_i\left(R_{t+1} - r_t \left| \Omega_{it} \right.\right) \left| \Phi_t \right.\right] = E\left(R_{t+1} - r_t \left| \Phi_t \right.\right)$$

Therefore, under the REH, taking expectations of the individual arbitrage conditions with respect to the public information set yields

$$E\left(R_{t+1} - r_t \left| \Phi_t \right.\right) = E\left(\lambda_{it} + \delta_{it} \left| \Phi_t \right.\right),$$

which also implies that $E\left(\lambda_{it} + \delta_{it} \left| \Phi_t \right.\right)$ *must* be the same across all i, or

$$E\left(R_{t+1} - r_t \left| \Phi_t \right.\right) = E\left(\lambda_{it} + \delta_{it} \left| \Phi_t \right.\right) = \rho_t, \text{ for all } i,$$

where ρ_t is an average market measure of the combined risk premia and transaction costs. The REH combined with perfect arbitrage ensure that different *traders* have the same expectations of $\lambda_{it} + \delta_{it}$. Rationality and market discipline override individual differences in tastes, information processing abilities and other transaction related costs and renders the familiar representative agent arbitrage condition:

$$E\left(R_{t+1} - r_t \left|\Phi_t\right.\right) = \rho_t,$$

This is clearly compatible with trader-specific λ_{it} and δ_{it}, so long as

$$\begin{aligned} \lambda_{it} &= \lambda_t + \varepsilon_{it},\ E\left(\varepsilon_{it} \left|\Phi_t\right.\right) = 0, \\ \delta_{it} &= \delta_t + \upsilon_{it}, E\left(\upsilon_{it} \left|\Phi_t\right.\right) = 0, \end{aligned}$$

where ε_{it} and υ_{it} are distributed with mean zero independently of Φ_t, and λ_t and δ_t are known functions of the publicly available information.

Under this setting the extent to which excess returns can be predicted will depend on the existence of a historically stable relationship between the risk premium, λ_t, and the macro and business cycle indicators such as changes in interest rates, dividends and various business cycle indicators.

The rational expectations hypothesis is rather extreme which is unlikely to hold at all times in all markets. Even if one assumes that in financial markets learning takes place reasonably fast, there will still be periods of turmoil where market participants will be searching in the dark, trying and experimenting with different models of $R_{t+1} - r_t$ often with marked departures from the common rational outcomes, given by $E\left(R_{t+1} - r_t \left|\Phi_t\right.\right)$.

Herding and correlated behaviour across some of the traders could also lead to further departures from the equilibrium RE solution. In fact the objective probability distribution of $R_{t+1} - r_t$ might itself be affected by market transactions based on subjective estimates $\hat{E}_i\left(R_{t+1} - r_t \left|\Omega_{it}\right.\right)$.

Market inefficiencies provide further sources of stock market predictability by introducing a wedge between a "correct" ex ante measure $E\left(R_{t+1} - r_t \left|\Phi_t\right.\right)$, and its average estimate by market participants, which we write as

$$\sum_{i=1}^{N_t} w_{it} \hat{E}_i\left(R_{t+1} - r_t \left|\Omega_{it}\right.\right),$$

where w_{it} is the market share of the i^{th} trader.

Let

$$\xi_t = E\left(R_{t+1} - r_t \left|\Phi_t\right.\right) - \sum_{i=1}^{N_t} w_{it} \hat{E}_i\left(R_{t+1} - r_t \left|\Omega_{it}\right.\right),$$

and note that it can also be written as (since $\sum_{i=1}^{N_t} w_{it} = 1$)

$$\xi_t = \sum_{i=1}^{N_t} w_{it}\xi_{it},$$

where

$$\xi_{it} = E\left(R_{t+1} - r_t \left|\Phi_t\right.\right) - \hat{E}_i\left(R_{t+1} - r_t \left|\Omega_{it}\right.\right).$$

ξ_{it} measures the degree of individual trader irrationality, whilst, ξ_t measures the extent of market irrationality or inefficiency. With N_t sufficiently large, it is clear that individual irrationality can cancel out at the level of the market, so long as ξ_{it} are not cross sectionally strongly dependent, no trader dominates the market, in the sense that $w_{it} = O(N_t^{-1})$ at any time, and

$$E\left[\hat{E}_i\left(R_{t+1} - r_t \left|\Omega_{it}\right.\right)\left|\Phi_t\right.\right] = E\left(R_{t+1} - r_t \left|\Phi_t\right.\right).$$

In general, market inefficiencies and profitable opportunities could exist if ξ_t is non-zero and predictable. Markets could also display inefficiencies without exploitable profitable opportunities if ξ_t is non-zero but there are no stable predictable relationships between ξ_t and business cycle or other variables that are observed publicly.

4 Exploiting Profitable Opportunities in Practice

In financial markets the EMH is respected but not worshiped. It is recognized that markets are likely to be efficient most of the time but not all the time. Inefficiencies could arise particularly during periods of important institutional and technological changes. It is not possible to know when and where market inefficiencies arise in advance - but it is believed that they will arise from time to time. Market traders love volatility as it signals news and change with profit possibilities to exploit. Identification of exploitable predictability tend to be fully diversified across markets for bonds, equities and foreign exchange. Misalignments across markets for different assets and in different countries often present the most important opportunities. Examples include statistical arbitrage and global macro arbitrage trading rules.

Predictability and market liquidity are often closely correlated; less liquid markets are likely to be more predictable. Market predictability and liquidity need to be jointly considered in developing profitable trading strategies. Return forecasting models used in practice tend to be recursive and adaptive along the lines developed in Pesaran and Timmermann (1995) and recently reviewed in Pesaran and Timmermann (2005). Recursive modelling (RM) approach is also in line with the more recent developments in behavioural finance. The RM approach aims at minimizing the effect of hindsights and data snooping (a problem that afflicts all ex post return regressions), and explicitly designed to take account of the potential instability of the return regressions over time. For example, Pesaran and Timmermann (1995) find that the switching trading rule manages to beat the market only during periods of high volatility where learning might be incomplete and markets inefficient.

Pesaran and Timmermann (2005) provide a review of the recursive modelling approach, its use in derivation of trading rules and discuss a number of practical issues in their implementation such as the choice of the universe of factors over which to search, choice of the estimation window, how to take account of measurement and model uncertainty, how to cross validate the RM, and how and when to introduce model innovations.

The RM approach still faces many challenges ahead. As PT(2005) conclude:

"Automated systems reduce, but do not eliminate the need for discretion in real time decision making. There are many ways that automated systems can be designed and implemented. The space of models over which to search is huge and is likely to expand over time. Different approximation techniques such as genetic algorithms, simulated annealing and MCMC algorithms can be used. There are also many theoretically valid model selection or model averaging procedures. The challenge facing real time econometrics is to provide insight into many of these choices that researchers face in the development of automated systems."

Return forecasts need to be incorporated in sound risk management systems. For this purpose point forecasts are not sufficient and joint probability forecast densities of a large number of inter-related asset returns will be required. Transaction and slippage costs need to be allowed for in the derivation of trade rules. Slippage arises when long (short) orders, optimally derived based on currently observed prices, are placed in rising (falling) markets. Slippage can be substantial, and are in addition to the usual transactions costs.

Familiar risk measures such as the Sharpe ratio and the VaR are routinely used to monitor and valuate the potential of trading systems. But due to cash constraint (for margin calls etc.) it is large drawdowns that are most feared. A prominent recent example is the downfall of the Long Term Capital who experienced substantial drawdowns, despite a sound long term arbitrage strategy.

Successful traders might not be (and usually are not) better in forecasting returns than many others in the market. What they have is a sense of 'big' opportunities when they are confident of making a 'kill'.

5 New Research Directions

In practice it would be difficult to separate ξ_t from ρ_t and the above discussion might not be much help in developing new tests of market (in)efficiencies. But it is hoped that the discussion would help in identifying new directions of research. There are clearly

- - Limits to rational expectations (for an early treatment see Pesaran (1987)), also see the recent paper on Survey Expectations by Pesaran and Weale (2005).
  - Limits to arbitrage due to liquidity requirements and institutional constraints.
  - Herding and correlated behaviour with noise traders entering markets during bull periods and deserting during bear periods.

Behavioral finance, complexity theory and the Adaptive Markets Hypothesis recently advocated by Lo (2004) all try, in one way or another, to address the above sources of the departures from the EMH. Some of the recent developments in behavioural finance are reviewed in Baberis and Thaler (2003).

Farmer and Lo (1999) focus on the recent research that views the financial markets from a biological perspective and, specifically, within an evolutionary framework in which markets, instruments, institutions, and investors interact and evolve dynamically according to the "law" of economic selection. Under this view, financial agents compete and adapt, but they do not necessarily do so in an optimal fashion.

Special care should also be exercised in evaluation of return predictability and trading rules. To minimize the effects of hindsights in such analysis recursive modelling techniques discussed in Pesaran and Timmermann (1995, 2000, 2005) seem much more appropriate than the return regressions on a fixed set of regressors/factors that are estimated ex post on historical data

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