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# The Efficient Market Hypothesis - EMH

## 1 – Introduction

Modern financial economics rests on rational models like the EMH (efficient market hypothesis). However, the accumulation of anomalies found in the last three decades, have not yet been taken as counter-examples to contradict traditional rational theories. Instead, special cases are presented to protect the core of assumptions.

This work will start by exploring the main assumptions of the traditional finance theory with its implications. In section three, it will analyze the anomalies found in the markets: That is the price deviation from the fundamental values established by traditional and rational models like the CAPM (Appendix 1). Consequently, in the second section, this paper will discuss both theoretical and empirical attacks to the EMH. Section four will briefly introduce the behavioural finance theory as an alternative to the EMH. The work will conclude outlining some of the criticism recently raised from the rationalist-supporters side, discussing some future challenges for finance theory in general, and finally putting the question to rest of whether the investor irrationalities can really invalidate the EMH.

## 2 – The traditional Finance Theory – The EMH.

The EMH has been the central pillar of finance theory over the last 40 years. According to traditional theory, stock prices must equal the fundamental values due to the facts that all investors are rational and that arbitrage[1] eliminates any price anomaly. Fama (1970) has defined: "*an efficient financial market as one in which security prices always fully reflect the available information*".

The University of Chicago, where these ideas were developed, has become the world centre for academic finance. Jensen (1978), one of its creators, stated: "*There is no other proposition in economics which has more solid empirical evidence supporting it than the EMH*".

[1] **Arbitrage Definition**: Attempting to profit by exploiting price differences of identical or similar financial instruments, on different markets. Consequently the arbitrage pricing theory (APT) was developed by Stephen Ross (1976).

The EMH explicitly assumes rationality. Rationality implies: First, that investors are risk averse; Second, that they are unbiased[2] in their forecasts; Third, they respond instantaneously to new information.

Furthermore, the acceptance of EMH allowed researchers like William Sharpe (1964), through a simple rational process, to introduce the Capital Asset Pricing Model[3]; a generalization which can be empirically tested by its capability to predict past returns.

The CAPM extended Harry Markowitz's portfolio theory to introduce the notions of systematic and specific risk. For his work on CAPM, Sharpe shared the 1990 Nobel Prize in Economics with Harry Markowitz and Merton Miller[4].

## 2.1 - Theoretical foundations for the EMH

To fully appreciate the behaviouralists' theoretical propositions, we need to first understand the nature of a decision making process under the homo-economicus[5]

[2] Cash flows are not influenced by investor emotions.

[3] CAPM is interdependent with the EMH (they are called joint hypothesis).

[4] See Modiglioni and Miller (1958).

[5] The earlier version of homo-economicus can be traced back to Adam Smith and David Ricardo in the 17th and 18th century. The later version was first indirectly suggested by Cowles in the 1930s who stated that investors were unable to outperform the market. Consequently, in 1953, Kendall argued that the movement of shares was random leading ultimately to the creation of the Random Walk Hypothesis, and

assumption whose foundations are based on the principle of conditional probabilities as established in 1763 by the mathematician Thomas Bayes[6].

The EMH is based on three progressive assumptions. First, the investors are rational. Second, if some of them are not, their interactions are random and non-correlated thus eliminating any irrational impact in pricing. Third, if some of them are not correlated, the rational arbitrageurs present in the market offset the non-correlated irrationality of the markets.

The first assumption means that all investors should value each stock according to its fundamental value. "*A rational investor assesses a stock by its fundamental value*" (Blanchard 2000), that is: Valuation is the mechanism by which investors trade cash today for future claims on cash flows and the value refers to those future cash flows discounted at a rate which incorporates their levels of systematic risk.

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the EMH. Finally, based on these ideas, Von Neumann and Morgenstern (1944) introduced a new perspective, followed by the vast majority of the financial economists of the second half of the 20th century. Under this view, homo-economicus refers to a greatly simplified model of human behavior where an individual is characterized by perfect self-interest, perfect rationality and free access to perfect information. On the grounds of simplicity, mathematical applicability and the deductive-empirical reasoning, human behavior was oversimplified.

[6] Bayes' rule argues that the probability of an event can be viewed as the degree of belief of an "ideal" person whose beliefs are considered the most efficient ones, as long as they are consistent and follow the basic axioms of probability theory.

Additionally, Samuelson (1965) and Mandelbrot (1966), verifying this first assumption, show how in competitive markets, risk-neutral rational investors, returns are unpredictable and stock prices follow a "random walk". According to Fama (1970), rationality implies the impossibility of earning superior risk-adjusted returns. Under this perspective, "*investors cannot beat the market*"

The third assumption regarding arbitrage has been studied in detail by Friedman (1953) and Fama (1965). Friedman (1953), observes that competition amongst arbitrageurs will ensure that irrational traders will tend to accumulate losses and eventually their wealth will diminish, leaving the field open to rational investors. If either response is correct, prices will be settle back into equilibrium and market efficiency will hold.

## 2.2 - Empirical foundations for the EMH

The empirical evidence found in the 1960s and 1970s seemed to support the EMH. In general, the empirical predictions of the EMH can be divided into two important categories. Firstly, the rapid and exact price response to information. Secondly, the non-reaction to irrelevant information.

Fama (1970) distinguishes three types of information by which three types of EMH could be defined. First: The weak-form by which prices are based on past information. This is the case in which it is not possible to have risk-adjusted profits nor to make predictions by

looking at past movements in share prices (Fama 1965). Second: The semi-strong form by which prices are based on all available public information. This is the case in which it is only possible to have risk-adjusted profits by getting "*inside information*". Third: the strong-form by which even inside information is incorporated into pricing.

Fama (1965) demonstrates the weak-form by which stock prices follow a random walk. There is also evidence regarding the semi-strong form also pioneered by Fama et. al. (1969) who used event studies to analyze the effect of dividend announcements. Keown and Pinkerton (1981) studied how takeover target stock prices are affected during all the announcements steps.

The non-reaction to irrelevant information was specially studied by Scholes (1972) through his "*substitution hypothesis*", in which he proves that the accessibility of close substitutes for a security, leads to extremely low or no impact to the stock price, as this is determined not by share supply but by the relative price of the alternate asset. With substitutes, investors' arbitrage takes prices back to equilibrium.

In general, no market is believed to be strong-form efficient. However, various studies tried to challenge this "reality" by confirming the existence of inside information.

Neiderhoffer and Osborne (1966) showed that specialists from the NYSE obtained superior returns using their monopolistic access to the book of limit order[7].

In 1974, Jaffe, by studying data on insider trading on 861 observations in the 1960s, concluded that investors who posse insider information do make positive abnormal returns, discarding the strong form hypothesis. An even more complete study was accomplished by Finnerty in 1976[8], and the conclusion was similar to Jaffe's (Copeland et al., 2005).

## 3 – Critics of the EMH and the Birth of BFT

### 3.1 – Theoretical Attacks on the EMH.

The argument against rationality started with a series of papers from Kahneman and Tversky (1972,1973) and Tversky and Kahneman (1971,1973,1974). These authors stated that individuals, in making predictions under uncertainty, ignore prior information

[7] A record of unexecuted limit orders which is maintained by specialists. A limit order is an order to buy a security at no more (or sell at no less) than a specific price. This gives the customer some control over the price at which the trade is executed, but may prevent the order from being executed.

[8] The time period for his study runs from January 1969 to December 1972. The data are from the S.E.C.'s Official Summary of Stock Transactions for NYSE firms. The data file contains identification of the company and the individual insider, buy or sell code, and closing price on the day of the trade. For the total period, there are recorded over 30,000 individual transactions: 9,602 buy transaction and 21,487 sell transaction.

contrary to the *Bayes rule*. Instead individuals use certain heuristics in making decisions under uncertainty. Black (1986), argued that investors interact with markets on noise instead of on information.

According to these authors, distortions should not be regarded as an exception or an expression of human stupidity, but rather the normality "generated" by the same cognitive constraints that Simon (1979) argues underlie the bounded rationality of human behaviour.

Kahneman and Riepe (1998), state that individuals systematically deviate from standard decision-making theory. In their new theory, investors do not follow the rationality of Von Neumann and Morgenstenn[9], that is: investors do not look at the final level of wealth that can be achieved, instead they look at losses and profits in relation to some particular conditions which could vary from individual to individual. For instance: Loss-aversion. In this way, a more sophisticated utility function is proposed in the "*Prospect Theory*" of Kahneman and Tversky (1979).

Psychological evidence (showed by Kahneman and Tversky 1972-1974) clearly proves that individuals do not deviate from rationality randomly, as proposed by the second

[9] Expected utility hypothesis predicts that, under uncertainty, investors assess utility, trough a mathematical relation which takes into account the size of a payout, the probability of occurrence, risk aversion, and the different utility of the same payout to people with different personal preferences.

EMH assumption. Shiller (1984) argues that "*investor sentiment behaves like epidemics and noise traders may behave socially and follow each other's mistakes by listening to rumours or imitating their neighbours*".

The EMH, therefore, should depend on the efficacy of arbitrators who should redirect the prices to their fundamental values. However the central claim of the BFT in contrast with that of traditional theory is the fact that the efficacy of arbitrage in the real world is limited because it depends on the presence of close substitutes for those securities which are under the influence of noise trading.

### 3.3 – Empirical Attacks on the EMH – The First Anomalies

Empirical criticisms have preceded the theoretical ones can be divided into the following main groups:

- **The Equity Premium Puzzle**[10]: The stock market has historically earned a high excess rate of return. Campbell and Cochrane (1999) report that the average log return on the S&P 500 index is 3.9% higher than the average log return on short-term commercial paper. Fama and French (2002) estimate that the equity premium calculated with fundamentals (dividend-growth model), 4,32% are much lower than the equity premium produced by the average stock return, 7.43 percent.

[10] The reason they are called puzzles is that they are hard to rationalize in a simple rational-based model.

- **Volatility Puzzle**: Stock returns and price–dividend ratios are both highly variable and much higher than expected (Campbell 1999).

One of the first papers that put the EMH under question was that of Shiller (1981). He showed how market stock prices in the US are much more volatile than those proposed by the EMH model in which prices should equal the net present value of future dividends.

According to Fama (1991), the presence of this volatility is due to the fact that investors experience risk aversion and that expected returns are not constant in time. However, Campbell et al. (2001) showed a noticeable increase in firm-level volatility relative to market volatility over the period from 1962 to 1997 and argued that this could be explained through the arrival of new investors with different preferences and levels of risk aversion. Such evidence might confirm an alternative vision which sees market volatility as a signal of investors' irrationality.

An important anomaly was found by Basu (1977) who showed that stocks with low P/E ratios earned a premium for investors during the period 1957-1971. Additionally, Banz (1981) observed a strong relation between company size and stock returns. Over long periods of time, small companies seem to provide a greater return than the average returns without a corresponding increase in risk. This so called "*size-effect*" is shown in figure 1.

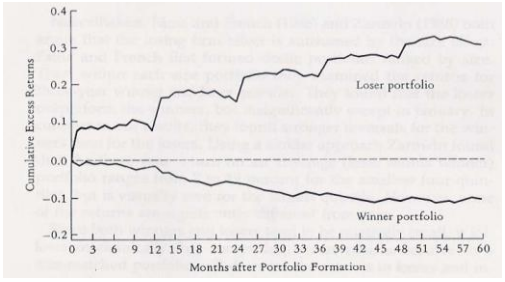
**Figure 1**


Chan and Lakonishok (1992) argued that, due to the level of noise in stock returns, the magnitude of the beta risk premium would have to be quite large in order to appear significant in statistical tests. While this may be true, it does not explain the observed relationship between firm size and stock returns. Unless firm size is somehow related to measurement errors in beta, so that small firms actually have higher betas than those estimated using conventional procedures, there is no CAPM-consistent explanation for the firm size effect.

De Bondt and Thaler (1985,1987) showed that stocks that have registered the lowest returns "*losers*" over the previous three-five years (observation period) did better during the following three-five years (test period) than those that previously had the highest positive return "*winners*". This so called *losers-and-winners* effect yielded an abnormal market adjusted return of 24.6% for the arbitrage portfolio (*losers* minus *winners*).

These observations are consistent with the overreaction hypothesis, that is: The excessive investors' reaction to current information which seems to characterize all the securities. To test such hypothesis, De Bond and Thaler (1985) expect to observe mean-reverting in stock returns. The conclusions of this test are shown in figure 2.

Figure 2




Three relevant aspects emerged: Both winner and loser returns were mean-reverting; Past losers outperformed the market mean and past winners underperformed it; The price reversals for the past losers were much more pronounced (about +30% from the mean) than the past winners (about -10%). Furthermore, the most important part of the losers

excess happened in January (*January effect*) which can be clearly seen in the figure in the five return jumps.

Two explanations for these effects were given by De Bond and Thaler. First, they detected the presence of more small companies in the losers portfolio, claiming that this could be the reincarnation of the "*size-effect*"; Second, they explained that due to the fact that the losers are stocks with bad performance, they had became riskier (higher beta), thus producing higher returns but normal when adjusted by the new risk.

However, if betas are an accurate measure of risk, they should not create asymmetries between winners and losers. In fact, De Bondt and Thaler found an important anomaly in the CAPM by demonstrating how betas calculated in up markets (bull betas) are not symmetric to betas calculated in down markets (bear betas) as it should be according to the implicit assumption of the CAPM . Bear betas are higher (down markets are riskier) than bull betas.

Therefore, according to De Bondt and Thaler, the only alternative explanation for these observations is the presence of irrational behaviour in investors decisions by which returns on loser securities are underestimated and returns on winner securities are overestimated, producing an excess of reaction in stock prices "overreaction". This explanation takes us back to the psychological theory which shows how market operators do not use the *rule of Bayes* and give excessive importance to recent information.

Further empirical studies of overreaction over long horizons are numerous. The core of the evidence is that, over horizons of 3 to 5 years, there is a relatively slight negative autocorrelation in stock returns. Furthermore, over similar horizons, some measures of stock valuation, such as the dividend yield, have predictive power for returns in a similar direction: a low dividend yield or high past return tends to predict a low subsequent return (Campbell and Shiller, 1988).

In the same way, empirical analysis of aggregate time series has produced some evidence of underreaction. Cutler et al. (1991) examine autocorrelations in excess returns on various indexes over different horizons. They looked at returns on stocks, bonds, and foreign exchange in different markets over the period 1960-1988 and generally, though not uniformly, found positive autocorrelations in excess index returns over horizons of between one month and one year.

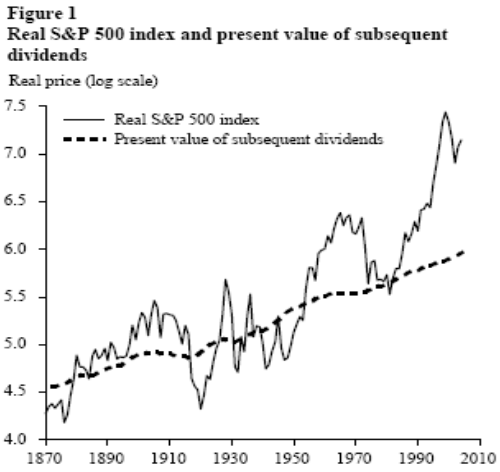
This autocorrelation evidence is consistent with the underreaction hypothesis, which states that stock prices incorporate information slowly, leading to trends in returns over short horizons. More convincing support comes from the cross-section studies of stock returns, like that of Bernard (1993) who examined one class of such studies, which deals with the underreaction of stock prices to announcements of company earnings.

Further evidence of underreaction comes from Jagadeesh and Titman (1993) who demonstrated that stocks with high short-term past returns (based on previous 3 to 12 months portfolio formation periods) continue to perform better in the future than the stocks with low short-term past returns. Contrary to overreaction hypothesis where the long-term tendencies reverse (De Bondt and Thaler), in the underreaction hypothesis, also called *momentum-effect*, these short-term tendencies continue.

Fama and French (1991,1993,1996) interpret some of the anomalies (the small-size-effect and the book-to-market ratio) as a fundamental part of a stock risk measure through the three-factor model (Appendix 2) in which small companies and companies with low book-to-market ratios must get higher returns because of the higher risk involved in such companies. However, there is no clear evidence supporting these arguments. Furthermore, Fama and French have not been able to explain both the small-capital-effect being concentrated in January and the *momentum-effect*.

If one computes for each year since 1871 the present value subsequent to that year of the real dividends paid on the S&P Composite Stock Price Index, discounted by a constant real discount rate equal to the geometric average real return 1871-2002 on the same S&P Index, one finds that the present value, if plotted through time, behaves remarkably like a stable trend. In contrast, the S&P Composite Stock Price Index gyrates wildly up and down around this trend. Figure 3 illustrates these patterns (Shiller 2003).

**Figure 3: Real Stock Prices and Present Values of Subsequent Real Dividends**




LeRoy and Porter (1981), have also demonstrated that stock prices appear to exhibit "*excess of volatility*". Similar conclusions were addressed by Roll (1984, 1988). Bubble models help to account for this excess volatility because they allow stock prices to become detached from fundamentals.

One example is the "*irrational exuberance model*" of Shiller (2003). If asset prices start to rise, the success of some investors attracts less sophisticated investors and bid up prices. This "*irrational exuberance*" heightens expectations of further price increases, as investors extrapolate recent price action far into the future. But the bubble carries the seeds of its own destruction; if prices begin to sag, pessimism can take hold, causing some investors to exit the market. Downward price motion begets expectations of further downward motion, and so on, until a bottom is eventually reached. As a conclusion,

Shiller's feedback model says that investors eschew fundamentals in favour of simple price extrapolation rules.

Among the more striking of the long-term anomalies is the study of IPOs (initial public offerings) and SEOs (seasoned equity offerings) (Loughran and Ritter 1995; Dechow, Hutton and Sloan, 2000; Chahine, 2001). In these cases, analysts exhibit overoptimistic forecasts concerning the potential growth of the offering firms.

The equity premium puzzle is a term coined by economists Mehra and Prescott (1985). It is based on the observation that in order to reconcile the much higher return on equity stock compared to government bonds, individuals must have implausibly high risk aversion according to standard economics models (the expected utility model).

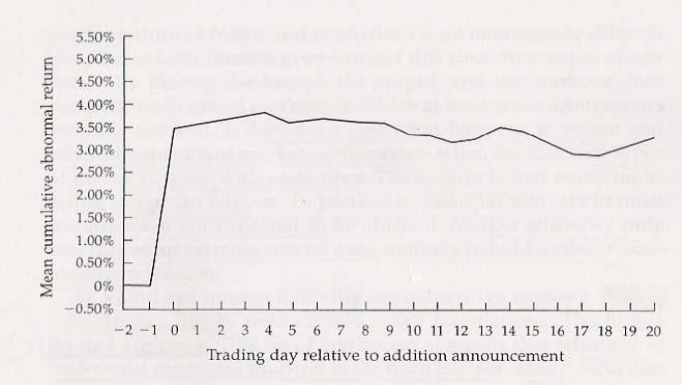
The answer that Benartzi and Thaler (1995) propose is based on two concepts. The first is consistent with the loss aversion which refers to the tendency for individuals to be more sensitive to reduction in their levels of wealth than to increases. The second is the *mental accounting* (Kahneman and Tversky 1984) which means that because of the presence of loss aversion, the aggregation rules are not neutral. For example: Brown et al. (1995) have argued that the equity premium is overstated due to survivorship bias.

Freeman (2004) argues that the equity premium puzzle arises due to entry barriers (both practical and psychological) which have traditionally impeded entry by individuals into the stock market, and that returns between stocks and bonds should stabilize as electronic resources open up to a greater number of traders.

Other researchers have concentrated on the study of the traditional proposition that stock prices do not react to the "non-information". In this arena, the most important finding is represented by the "*crash of 1987*". On October the 19th 1987, the Dow Jones Average felt 22,6%, the biggest daily fall ever, without having had any apparent new information. Cutler et al. (1991) studied several movements like this and found that they did not derive from any relevant news.

Other important studies regarding the non-information effects can be attributed to Denis, McConnel, Ovtchinnikov, and Yu (2003), who provide direct evidence that, although Standard & Poor's claims that their announcements of firms' inclusion in the S&P 500 index contain no information about future performance, companies newly added to the S&P 500 experience significant improvements in both analyst forecasts and actual realizations of the subsequent annual earnings following inclusion in the index. Figure 4 shows the mean cumulated abnormal return after the announcement (Wurgher and Zhuravikaya 1999).

Figure 4




The anomalies outlined can be summarized as follows: The *January effect*, the *size-effect*, the *P/E ratio effect*, the *losers-winners* effect or the *over- and under-reaction* to earnings announcements anomaly, the *IPOs and SEOs anomaly*, the *S&P insertion effect*, and the *crash of 1987 anomaly*. All of them attack the semi-strong form of EMH since they are public information: The excess of returns based on "*stale information*" is clearly in contrast with the semi-strong assumption.

In order to provide evidence against the weak-form, we should demonstrate that stock prices do not reflect past returns. De Bondt and Thaler (1985,1989), through their *losers-and-winners* effect, intend to prove how the stock prices are mean-reverting in the long term and therefore predictable or non-random walk. The predictability of the stock prices had already been an old controversy long before these questions appeared.

The EMH is associated with the idea that prices are unpredictable or as stated by Brealey and Myers (1988:289) capital markets "*have no memory*". The logic of this statement is the following: If prices were predictable, competition and arbitrage would assure the adjustment of prices to fundamentals, thus leaving random movements (casual) to non-anticipated events.

However, the first finance markets analysts revealed that stock prices could differ from their fundamental values. Keynes (1936:153-154), in his "*General Theory*", argued that "*day-to-day fluctuations in the profits of existing investments tend to have an altogether excessive, and even absurd, influence on the market.*" Graham (1949) recommended to buy stock whose prices seemed to be low in relation to their fundamental values. This "*contrarian strategy*" was based on the fact that prices stayed low only temporarily.

More recently, Poterba and Summers (1988) conducted an international study and concluded that the mean-reversion is more evident in less efficient equity markets. Additionally, Lakonishok, Shliefer, and Vishny (1994) and La Porta (1996) provided some evidence and argued that if investors generally do not understand regression to the mean, they are likely to overestimate a company's "*true greatness*" and pay too much for the company's stock, a decision they will regret when measures of the company's greatness regress to the mean.

Those arguments are in line with the *losers-and-winners* effect of De Bondt and Thaler (1985,1987) in which the high book-to-market ratios could reflect the excessive market optimism regarding future returns. In fact, their results of negative serial correlation for 36 months might be inconsistent with the weak-form.

In addition, although Fama (1965) presents important evidence in favour of the random walk hypothesis, Fama and French (1988) showed that the dividend–price ratio is able to explain only 27% of the variation of cumulative stock returns over the subsequent four years. Therefore, Fama and French (1991) extended the concept of the weak-form to include predicting future returns with the use of accounting or macroeconomic variables.

To reinforce the weak-form, many other studies conclude that stock returns can be predicted by means of publicly available information, such as time series data on financial and macroeconomic variables[11]. On the contrary, other studies have argued that the equity premium is overstated and fundamentals alone cannot explain its value[12].

This on-going discussion proves that there is no clear evidence to reject the weak-form hypothesis. Nevertheless, the empirical evidence suggests that capital markets are not

[11] For example, see the following papers: Balvers, Cosimano, and McDonald (1990), Breen, Glosten, and Jagannathan (1990), Campbell (1987), Cochrane (1991), Fama and French (1986, 1989), Ferson and Harvey (1993), French, Schwert, and Stambaugh (1987), Glosten, Jagannathan, and Runkle (1993), and Pesaran and Timmermann (1995).

[12] See also Blanchard (1993),Claus and Thomas (2001), Fama and French (2002), and Brown et al. (1995).

efficient, at least in the semi-strong-form. Through their trading behaviour, biased investors can cause prices to deviate significantly from fundamental value. These deviations create opportunities, risks for sophisticated investors and therefore the so-called limits-to-arbitrage, giving birth to a new theory: The BFT.

## 4 – Behavioural finance Theory - BFT.

BFT helps traditional finance to explain some of the anomalies observed in the last section by incorporating some psychological concepts. "*The limits of arbitrage create anomalies that the psychology of decision making helps explain*" (Mullainathan and Thaler 2000). According to Barber and Odean (1999), BFT incorporates the observable, systematic, and very human departures from rationality into standard models of financial markets (Barber and Odean 1999).

The BFT is still young and heterogenic. The studies, concepts and models have been elaborated by many different researchers and therefore it still lacks a global and organized vision. For this reason, it was necessary to make a selection and analyze the most important and agreed principles and theories in the academic field.

## 5 – Conclusion

This work was aimed at re-examining the bases of traditional finance in light of the anomalies found with the purpose of grasping the answer to the following questions: Can market anomalies and investor irrationalities invalidate the EMH? Can the BFT be considered as a new direction in finance theory or just an attempt to help traditional finance to understand the anomalies?

Fama (1997) asserts that behavioural finance is more a collection of anomalies than a true theory of finance and that these anomalies will eventually be priced out of the market or explained by appealing to minor adjustments in methodologies like the three-factor model (methodology problem).

Consequently, Fama (1997) argues that long-term anomalies (like over- and under-reaction) are chance results. Additionally, EMH supporters argue that after the publication of the anomalies, investors should understand that their decisions were bad ones or irrational and they should make much better decisions for the future thus eliminating any non-random anomalies. In favour of these ideas there is the fact that there is no clear evidence against the weak-form.

The discussion regarding the semi-strong-form hypothesis is exacerbated by the *joint hypothesis* problem (methodology problem for testing)[13]: In other words, is this a problem of biased cash flows or wrong discount rates calculated with CAPM? In this direction, Fama and French (2002) suggest that discount rates are underestimated thus, causing the equity premium to be overestimated, implying that the problem is the CAPM and not the EMH[14].

BFT seems to be far from offering predicting models. In particular, a behavioural asset pricing model seems to be far from being empirically proved and widely recognised. These limitations are increased by the heterogeneity of this new "*theory*" in which too many models and phenomena are presented without a global picture of them and without any consistency regarding the specific psychological phenomenon behind them. Furthermore, through investor re-education, old anomalies will eventually disappear and new irrational anomalies may appear creating a circle that will never end, therefore making impossible it to create predictive-behavioural models which could stand in the long-run.

Past empirical evidence proved that rational-model predictions, far from being perfect, are the best approximations we have overall. On this basis, this essay concludes that the

[13] "*Market efficiency per se is not testable*" Fama (1991). Hawawini and Keim (1998) concluded that finance has no tests strong enough to distinguish market inefficiency from bad asset-pricing models.

[14] See also Fama and French (1992) and the failure of beta to reflect risk.

EMH, as well as the rational models, cannot be invalidated, at least not yet. On the other hand, the presence of anomalies proves that traditional theories alone are not enough to explain certain investor behaviours.

## APPENDIX 1 – THE SLM CAPM

### The Expression and Implication of the CAPM

- The acceptance of EMH allowed researchers like William Sharpe (1964), through a simple rational process, to introduce the Capital Asset Pricing Model ; a generalization which can be empirically tested by its capability to predict past returns. CAPM is interdependent with the EMH (they are called joint hypothesis).
- The CAPM quantifies trade-off between risk and expected return and yields the following expression:

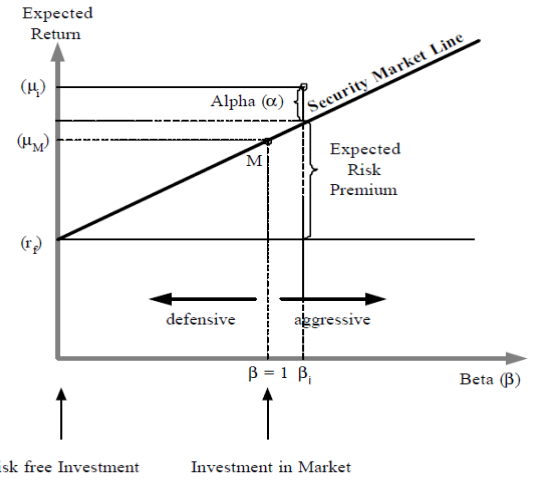
$$E(R_i) = R_f + [E(R_m) - R_f]\beta_i$$

the beta coefficient $\beta_i$ is the sensitivity of the asset returns to market returns, or also ⇒ $\beta_i = \frac{\mathrm{Cov}(R_i, R_m)}{\mathrm{Var}(R_m)}$

### The Expression and Implication of CAPM

The essence of CAPM is that the expected return on any asset is a positive linear function of its beta and that beta is the only measure of risk needed to explain the cross-section of expected returns.

The Security Market Line, seen here in a graph, describes a relation between the beta and the asset's expected rate of return



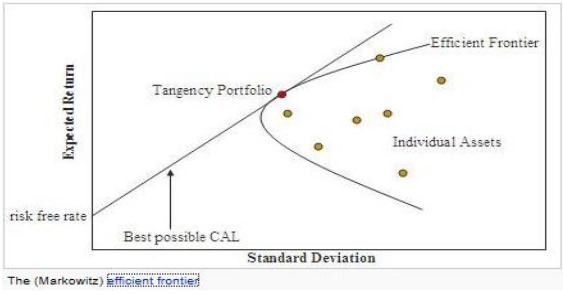
## The Efficient Frontier – Diversification

The CAPM extended Harry Markowitz's portfolio theory to introduce the notions of systematic and specific risk.

In market equilibrium, investors are only rewarded for bearing systematic risk –the type of risk that cannot be diversified away. They should not be rewarded for bearing idiosyncratic risk, since this uncertainty can be mitigated through appropriate diversification.

The CAPM assumes that the risk-return profile of a portfolio can be optimized – an optimal portfolio displays the lowest possible level of risk for its level of return. Additionally, since each additional asset introduced into a portfolio further diversifies the portfolio, the optimal portfolio must comprise every asset, (assuming no trading costs) with each asset value-weighted to achieve the above. All such optimal portfolios, i.e., one for each level of return, comprise the efficient frontier.

## The Efficient Frontier – Portfolio Management



The (Markowitz) efficient frontier

Because the unsystematic risk is diversifiable, the total risk of a portfolio can be viewed as beta.

Superior portfolio performance
beating the market in terms of earning above-market investment returns with marketlike risk
earning marketlike returns from a portfolio with below-market risk

**APPENDIX 2**

Fama and French (1993) found factors describing "value" and "size" to be the most significant factors, outside of market risk, for explaining the realized returns. They constructed two factors: SMB to address size risk and HML to address value risk. The formula known as the three-factor model of Fama and French is shown as follows:

$$E(R) = Rf + \beta * Rm + bs * SMB + bv * HML + \alpha$$

Where:

**E(R):** is the expected rate of return of a specific asset,

**Rf**: is the risk-free return rate,

**Rm:** is the return of the whole stock market,

**The SMB Factor**: which stands for Small minus Big, is designed to estimate the additional return investors have historically received by investing in companies with small market capitalizations (referred t the size premium). In practice, the SMB monthly factor is computed as the average return for the smallest 30% of stocks minus the average return of the largest 30% of stocks in that month. As a reference point, the historical average from July 1926 to July 2002 of the annual SMB factor has been approximately 3.3% (Womack and Zhang, 2003),

**The HML Factor**, which is short for High minus Low, has been constructed to estimate the so-called "value premium" provided to investors for investing in companies with high book-to-market (B/M) values. Similarly to the SMB, HML is computed as the average

return for the 50% of stocks with the highest B/M ratio minus the average return of the 50% of stocks with the lowest B/M ratio each month. Over the time period from 1926 to 2003, this premium for value stocks has averaged approximately 5.1% annually (Womack and Zhang, 2003),

**The β**: intends to measure the exposure that an asset has to market risk (although this beta will have a different value from the beta in a SLM-CAPM as a result of the added factors),

**The bs**: measures the level of exposure of the specific asset to size risk,

**the bv:** intends to measure the level of exposure of the specific asset to value risk.

These coefficients (**β, bs and bv)** in this model have similar interpretations to beta in the SLM-CAPM. The bs and bv factors, like the market beta, are regression coefficients: the higher the value of bs, the smaller the capitalization. Similarly, the higher the value of bv, the larger the book/price ratio.

In addition, all these factors combined have the greatest predictive power that researchers have tested – often yielding an R-Squared value of approximately 0.95 (Bahl, 2006). However, the HML as a "risk factor" has spurred much discussion. In the case of SMB, which calculates "size risk", small CAPS logically might be expected to be more susceptible to many risk factors due to their undiversified nature and their reduced capability to absorb negative financial events.

Conversely, the HML factor intuitively might suggest higher risk exposure for typical "value" stocks (high B/M) versus "growth" stocks (low B/M). This makes sense intuitively

because companies need to reach a minimum size in order to execute an Initial Public Offering (IPO).

One of the central aspects about the three-factor CAPM devised by Fama and French (1992) is the fact that this model is based on rational behaviour. If assets are priced rationally, variables that are related to average returns, such as size and book-to-market equity, must proxy for sensitivity to common (shared and thus undiversifiable) risk factors in returns (Fama and French 1992).

The Fama and French three factor model (1993) partially captured the cross-sectional variation in past average returns (single type of firms' anomalies). However, the scope of this paper is to have a forward-looking perspective. In fact, the Fama and French (1993) three-factor model was not only developed to explain past anomalies and past performance (backward-looking) but also to predict future returns (forward-looking). Actually, the title of the Fama and French paper (1993) is "The Cross-section of Expected Returns."

This issue of abnormal returns found in the cross-sectional studies was also studied by Jensen (1968) who developed a model, a pillar for this research project that will have to deal with single firms and small portfolios held by PEFs. Therefore, it is important to introduce an important concept known as the Jensen's alpha or Jensen's Performance Index, ex-post alpha and also known as abnormal returns. This is used to assess the performance of individual stocks or portfolios. If such an asset's return is even higher than the risk-adjusted return, that asset is said to have "positive alpha" or "abnormal

returns", which according to the EMH, should be eliminated quite rapidly as the market moves to equilibrium.

Jensen's alpha = Portfolio Return − [Risk Free Rate + Portfolio Beta * (Market Premium)]

$$\alpha_J = R_i - [R_f + \beta_{iM} \cdot (R_M - R_f)]$$

This concept is particularly relevant for this paper[15]. In fact, PEFs need to know what is the future risk-reward trade-off for both their portfolios and their single deals.

[15] Recent academic papers in the PEFs arena found high levels of abnormal returns. Since the target of this thesis is to explain the determinants of the risk-premium, it will have to deal with these unexplained alphas.