An Empirical Evaluation of CAPM's validity in the British Stock Exchange

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*Abstract-*The CAPM under the means of the two step regression procedure indicated that the cross section of average excess security return is positively related to beta. Under a frame of Computational Econometrics the two step regression procedure is implemented into CAPM, concluding that the strict CAPM test rejects the second H_0 hypothesis on the market risk premium, hence the slope of the Security Market Line (SML) is different from the slope of SML indicated by CAPM. Consequently the CAPM has not a statistical significance in Portfolio Selection.

*Keywords-*Capital Asset Pricing Model, Two Step Regressions Procedure, Financial Management

I. INTRODUCTION

EMPIRICAL tests of the Capital Asset Pricing Model (CAPM) performed by means of the two step regression procedure concluded that the cross section of average excess security return is positively related to beta, although Fama & French (1992) noticed that CAPM suffers from endogenous inabilities. The validity of CAPM on the British Stock Exchange is investigated as well as the relation of the model to the beta -systematic risk. The Capital Asset Pricing Model has been widely employed by researchers and professionals in portfolio selection supporting investment decisions. Although CAPM has been standing for almost 40 years, it is the subject of opposite remarks since many researchers accept partial validity on CAPM hypotheses regarding the beta. On the contrary, many other surveys that find lack in the model and a statistically insignificant beta, concluding that CAPM is not an effective investment method and beta is not important.

This research investigates empirically the model for the UK stock market. Implementing a frame of Computational Econometrics, the two step regression procedure, tests the CAPM hypotheses in the formed portfolio. Results indicated that CAPM is not valid, although beta is compatible to the model. Also beta still remains a respectable coefficient to investment analysis. In Section II an analysis of CAPM is given, in Section III are presented the data and the methodology, in Section IV the results are discussed, finally in Section V are the conclusions and future proposals.

II. THE CAPITAL ASSET PRICING MODEL

The CAPM equation that relates a security's risk and return is:

$$E(R_{i,t})=R_f+\{E(R_m)-R_f\}\{Cov(R_i,R_m)/Var(R_m)\} \text{ (1)}$$

Where: $E(R_{i,t})$ is the expected return on asset i in time t, R_f is the return of the risk free treasury bill, $E(R_m)$ is the expected return on a domestic proxy of a market portfolio, $Var(R_m)$ the variance $\sigma^2(R_m)$ of this market portfolio, $Cov(R_i, R_m)$ the covariance between asset i and the domestic market proxy. The quantity $Cov(R_i, R_m)/Var(R_m)=\beta_{ji}$ is known as the beta coefficient, representing the systematic risk of i asset and it is non-diversifiable, $\{E(R_m)-R_f\}$ is the risk premium in the local market. In equality (1) is given the CAPM of Sharpe (1964), Lintner (1965), and Black (1972) {SLB model}. The central prediction of the model is that the market portfolio of invested wealth is mean variance (μV) efficient in the sense of Markowitz (1952). According to Yonezawa (1990) tests of CAPM on the ex post data is simultaneous to tests of the following 3 hypotheses: 1) the market holds in every period, 2) the CAPM holds in every period, and 3) the beta is stable over time. Alexander and Francis (1986) noticed that empirical data cannot easily be used to verify the CAPM for two reasons. Firstly the CAPM states that expected (ex-ante) returns are determined by risk. However,

expected returns are not observable which implies that the test of the CAPM must be conducted using historical (ex-post) returns. Thus a jump is made from an ex-ante theory to ex-post data. If the multivariate probability distribution of results has remained stationary over time, then historical returns can be used to estimate expected returns. However non stationarity in this distribution can cause complications in forming these estimates.

Secondly the market portfolio, central to the CAPM, has never been precisely defined. Often the stocks are used as a proxy for the market portfolio in empirical work. In this connection Roll (1977) argues that no correct and unambiguous test of the CAPM appeared and that there is practically no possibility that such a test can be accomplished in the future. The central idea behind this assertion is based on the observation that there is only one potentially testable hypothesis associated with the CAPM, which is that the true market portfolio is a mean variance efficient portfolio. Nevertheless this hypothesis cannot be tested since the true market portfolio cannot be observed. The reason is that the market portfolio must include all assets many of which are unobservable (i.e. certificate of membership in a tennis club, artwork, etc.). Actually stock market indices are a small part of the M but not all the assets that exist in the market such as: land, gold, bonds, etc.

Roll also assumes that if the market portfolio is narrowly construed as to include only equity shares, then a stock market index can be used as the market portfolio in empirical tests. But then CAPM must be viewed as a partial equilibrium model because it only explains diversification among common stocks and has an asset pricing implications for only common stocks. Roll claims that the use of proxies for the true market portfolio is unacceptable because they might:

a) be efficient when the true market portfolio is inefficient, thus leading the researcher to falsely accept CAPM or

b) inefficient when the true market portfolio is efficient, thus leading the researcher to falsely reject the CAPM. As a result a slight misspecification in the proxy composition can lead the researcher to draw an incorrect conclusion. This is why one does not know what to conclude regarding the ability of CAPM and

c) have a difficulty in specifying the risk free asset. Roll (1977) assumes that the two-parameter asset pricing theory is testable in principle and there is (a) no correct and unambiguous test of the theory that has appeared in the literature, (b) no possibility practically that such a test can be accomplished in the future. Roll concludes that (I) there is only a single testable hypothesis associated with the generalized two-parameter asset pricing of Black (1972). This hypothesis is that the market portfolio is mean-variance efficient, (II) all the others so called implications of the model the best known being the linearity relation between expected return and beta follow from the market portfolio efficiency and are not independently testable, (III) in any sample of observations on individual returns, regardless of the generating process, there will always be an infinite number of ex post mean variance portfolios. From each one, the sample betas calculated between it and individual assets will be exactly linearly related to the individual sample mean returns (IV) the theory is not testable unless the exact composition of the true market portfolio is known and used in the tests. This implies that the theory is not testable unless all individual assets are included in the sample (V) using a proxy for the market portfolio is subject to two difficulties. First the proxy itself might be mean variance efficient even when the true market portfolio is not. This is a real danger since every sample will display efficient portfolios that satisfy perfectly all of the theory implications. On the other hand the chosen proxy may turn out to be inefficient. Furthermore most reasonable proxies will be very highly correlated with each other and with the true market whether or not they are mean variance efficient. This high correlation will make it seem that the exact composition is unimportant, where as it can cause quite different inferences. (VI) Fama & MacBeth (1973), Black, Jensen & Scholes (1972) and Blume and Friend (1973) discussed their rejection of the Sharpe-Lintner model. It is known that their tests results are fully compatible with the Sharpe Lintner model and a specification error in the measured market portfolio.

A. Previous empirical studies

In the U.S. Stock Market, Fama & French (1996) confirming Banz (1981) assume that, sorts on size and beta like those in Kothari, Shanken and Sloan (KSS 1995) consistently reject the central CAPM hypothesis that beta suffices to explain expected return. In addition to this in recent years the size effect has been displayed as the prime embarrassment of the CAPM. KSS (1995) also emphasize that the use of annual returns is better than the use of monthly returns in the calculation of betas because it provides a stronger positive relation between average return and beta. Fama & French (1996) also claim evidences that beta does not suffice to explain expected return is compelling. The unexpected results of CAPM's average returns are serious enough to infer that the model is not a useful approximation.

Black, Jensen and Scholes (1972) and Miller and Scholes (1972) find that in the period from 1931 through 1965 low beta stocks in the USA had higher returns than those predicted by CAPM, while high beta stocks had lower. Several authors find that this scheme continued in subsequent years, at least through 1989. It has also been found that the estimated slope of the line relating average return and risk is lower than the slope of the CAPM line which relates expected return and risk. Stattman (1980), and Rosenberg, Reid and Lanstein (1985) find that the average returns on the U.S. stocks are positively related to the ratio of a firm's book value of common equity BE, to its market value, ME. Chan, Hamao and Lakonishok (1991) find that book to market equity BE/ME also has a strong role in explaining the cross section of average returns on Japanese stocks. Maru and Royama (1974) performed tests on the annual data of 103 stocks of the first section of Tokyo Stock Exchange; they concluded that although CAPM was not valid according to their data, a linear relationship between risk & return was observed. Konya (1978) performed CAPM tests using means of Fama & MacBeth's methodology and found that the first and second out of the three hypotheses of Fama & MacBeth failed to be rejected. Furthermore, as the beta was insignificantly negative, she concluded that her beta were not consistent with the zero beta version of the CAPM. Sakakibara (1981, 1983) tested the CAPM by means of Black Jensen and Schole's methodology using monthly rates of return of the stocks listed on the first section of Tokyo Stock Exchange

from January 1957 to December 1978. The CAPM was rejected in the test using data for the whole period 1957-1978, although CAPM failed to be rejected in some sub periods. Yonezawa & Maru (1984) tested the CAPM by means of the two-step regression test procedure grouping monthly data from 1953 to 1981 into 6 sub periods and performed the tests by the market model. Their results seem to be in accordance with those of Black et al. (1972), and those of Fama & MacBeth as their data were consistent with the zero-beta version of the CAPM. Yonezawa & Hin (1990) performed tests of the Sharpe-Lintner-Mosin model of CAPM based on a modified version of Gibbons methodology, using rates of return of data of the first section of the Tokyo Stock Exchange from January 1952 to December 1986. Their data were divided into seven periods of five years each. They concluded that the lack of diversification is the main reason for the invalidity of the CAPM in the Japanese stock market.

Finally, Clare and Priestley (1998) using data from three emerging South East Asian stock markets Hong Kong, Malaysia, and Singapore, have shown that in these markets there is a positive and significant relationship between beta and average stock returns. These results are in sharp contrast to recent results in the U.S. stock market like those of Fama & French (1992) and in previous studies in South East Asian stock markets [like those of Cheung & Wong (1992), Wong and Tan (1991) who investigated the most developed markets of Hong Kong and Singapore, and Cheung, Wong & Ho (1993) who performed research in the less well developed markets: Korea and Taiwan]. Clare and Priestley attribute this result to the efficiency of the one step estimation technique employed by them as opposed to the usual two-step procedure. They have also found that a domestic version of the CAPM for these three markets can be augmented by a proxy for world risk.

III. DATA AND METHODOLOGY

In this survey the two step regression procedure was performed in 39 stocks from London Stock Exchange on monthly basis for the period of January 1980 to February 1998. Firstly rates of return were calculated for each stock, during the period of 18 years. Then the stationarity property of the time series return was examined, for each stock using the Dickey-Fuller test. The auto-correlation test was performed using Durbin-Watson test, for regressions of the 1st class, or checking Q's and levels of significance for these Q's. The following step was the calculation of beta for each stock. The second part of the regression procedure was the cross section procedure which pointed out the difference between the theoretical part and the objective figures that appear in the stock market. The main subject in this empirical work is the research of the CAPM adequacy as a useful tool of security pricing. The ex-ante (theoretical) CAPM is:

$$E(R_i) = R_f + b_{i,m}(E(R_M) - R_f) \quad (2)$$

and it expresses the researchers expectation. Unfortunately expectation measuring is inevitable while average price of return of i asset cannot be objectively measured. An approach of the estimation problem could be the use of hypotheses which will transform the problem to historical data. The point now is the transformation of the problem from ex ante to ex post model. The first hypothesis is

known as the fair game hypothesis: the observed return of asset i in time t is equal to the expected return plus the stochastic ε_t coefficient of disturbancy that is:

$$R_{it} = E(R_{it}) + \varepsilon_t \; (3)$$

Where: $E(\varepsilon_t) = 0 \; (4),$

$$Cov(\varepsilon_t, \varepsilon_{t-1}) = 0 \; (5),$$

$$Cov(RM, \varepsilon_t) = 0 \; (6),$$

$$E(R_i) = RM_t + w_t \; (7).$$

Where: w_t another stochastic disturbance coefficient of the market, and RM = E(RM). The observed ex post return is equal to the expected ex ante return in time t plus a possible surprise coefficient. The theoretical CAPM will be effected by the two disturbance coefficients ε_t, and the w_t. By (2), (3), (7), ex ante CAPM becomes $R_{It} - \varepsilon_t = E(R_i)$ or $R_{It} - \varepsilon_t = R_f + b_{Im}(R_{Mt} + w_t - R_f)$ that is $R_{i,t} = R_f + b_{i,m}(RM_t - R_f) + e_t$: ex-post form.

Where: $e_t = b_{i,m}w_t + \varepsilon_t \; (9),$

$$E(\varepsilon_t) = E(w_t) \; (10),$$

The fair game hypotheses in ex post CAPM are :

$$E(e_t) = 0 \; (11),$$

$$Cov(e_t, e_{t-1}) = 0 \; (12),$$

$$Cov(RM_t, e_t) = 0 \; (13)$$

The stock market prices of this survey were collected from the Datastream. All estimations were performed by the econometric program RATS. As it is known in literature stock prices follow the Lognormal distribution. The monthly average return of each security is:

$$R = (P_1 - P_0)/P_0 \; (14)$$

If price variables are continuous then $P_1 = P0/(1+R)$ or $R = lnP_1 - lnP_0$. The return of all securities and the return RM of FTSE all shares in London Stock Exchange is calculated:

$$r_t = lnP_t - lnP_{t-1} \; (15)$$

In order to check the stationarity of the time series return the Augmented Dickey Fuller is used. In this test for a sample of n, the hypothesis is that this time series belongs to A case: test equation without intercept, according to the table of Augmented Dickey Fuller test and for 5% level of significance in the space of critical values {-1.98, -1.91} for samples between 50 to 250. Generally the space of critical values is related to the number of observations. Dickey- Fuller test gives results on the stationarity of lnPt. The autocorrelation test is examined by h test of Durbin:

$$h = (1-d/2) \sqrt{\frac{n}{1 - ns_b^2}}^a \sim N(0,1) \quad (16),$$

where s^2 is the variance of the time delay of estimator coefficient, which is the interpretative variable, d the Durbin-Watson statistic for the first order auto correlation. Nevertheless the auto correlation test is performed by the Q level of significance where if a Q level of significance < 0.05 then there is autocorrelation of a greater order. The series lnP_t which represents returns is more appropriate for stationarity test because its data are very small numbers, near 0. Thus Augmented Dickey-Fuller test is repeated for the regression of the second order equations of differences of lnP_t:

$$lnP_t = C_0 + C_1 * lnP_{t-1} + e_t = lnP_t - lnP_{t-1} \ (17)$$

Usually in this case there is abs(t-stat. C1) $<$ abs(c.v.), H_0 is rejected assuming stationary series return. The average return and its variance are stable for each point of this time series, and the autocorrelation Q level of significance test is repeated. The calculation of systematic risk (beta) of each security will be carried out by the regression:

$$R_{i,t} = A_0 + A_1 * RM_t + U_t \ (18)$$

Where: A_0 regression's constant or the alpha coefficient, A_1 the beta, RM_t the average return of FTSE-All Shares, which in 70% represents the Market portfolio, U_t the residuals into regression. A_0 shows the percentage rate of overpricing or undervaluing of the expected return of i asset when the investors of M portfolio expect 0 return from i asset. The beta calculated by the regression is the short term beta. Usually a company tends to adjust to the market requirements and follows the rest of its branch competitors, putting aside the majority of its incompatibilities and innovations that had when it first entered in the market. In this way the short time beta is replaced by the long time beta that better describes systematic risk for this company. Long term beta is:

$$beta_{long \ term} = (2/3) * beta_{short \ term} + 1/3 \ (19)$$

The following table 1 demonstrates the short and long term betas received, whilst figures 1, 2 and 3 provide a graphical representation of the values and their comparison. These findings reveal that the short term betas ranking is reproduced in an identical order to the long term betas ranking. The second step of the regression procedure that is elaborated here is the cross section regressions. In this case one portfolio of 39 FTSE stocks is formed based on betas' ranking, the sum of the slopes from regressions of monthly returns on the current and one lag into the stocks and the FTSE-All Shares market return. The formation period that the betas use is 218 months of past returns. After ranking the stocks according to their beta, and thus creating a portfolio the fair game hypotheses are checked performing the regression:

$$RP_t = A_0 + bPm \ RM_t + e_t \ (20)$$

Where bPm the portfolios beta, RP_t the portfolios return, A_0 the return of risk free investments, RM_t the market return. The game fairness was tested and results were given I table 1. The fair game test is being done by the values of Durbin-Watson statistic. In the 39 stocks portfolio the Durbin-Watson price which was produced by the cross sectional

regression was 1.91207 a number quite close to 2 which according to the Durbin-Watson statistic gives a minimum autocorrelation. After that it is concluded that the fair game hypotheses are fulfilled. The next step is the cross sectional regression

$$R = G_0 + G_1 * beta + rest \ (21)$$

where $R = E(R_t)$ the average return of each stock, beta the estimated one, rest the residuals. In reality the previous regression is the CAPM According to theory the risk free treasury bills G_0 are in (23), whilst (24) gives the market premium G_1

$$G_0 = R_f \ (23)$$

$$G_1 = (E(RM) - R_f) = (RM - R_f) \ (24)$$

IV. RESULTS

The cross section regression was done and Durbin Watson statistic 1.912 has an acceptable price. Also fair game hypothesis is fulfilled. To perform the t-statistic test that the calculated $R_f = 0.0065$ is statistically equal to the observed Rf we consider as Rf the value of 0.87%. According to Barklays bank BZW Equity Gilt study (1996) the mean returns of Treasury Bills over the period 1946-1995 was 0.87%. Standard errors corrected for heteroscedasticity using the White approach as follows (robusterrors):

$$R = G_0 + G_1 * (beta) + rest \ (25)$$

1) H_0 : constant $= Rf$
   H_A: constant different from Rf .

Where

t-statistic= (0.0065 - 0.0087)/0.001839   <   Abs (-1.91) then H_0 is accepted

2) H_0 : $G_1 = (RM - Rf)$
   H_A: $G_1 \neq (RM - Rf)$

Where

t-statistic=(0.003567-0.0087)/0.002088   >   Abs (-1.91) then H_0 is rejected

3) centered $R^2 = 0.073$

V. CONCLUSIONS AND FUTURE RESEARCH

Beta is a significant coefficient of measuring the returns and it is supported by CAPM hence it can be said that beta is compatible to CAPM. There is a signal for partial verification of CAPM. The constant value G_0 is also statistically significant and it is also compatible to CAPM. This is the second signal of partial CAPM verification. The correlation coefficient R^2 is relatively low (7%) in accordance to previous surveys which have also found a low price for R^2. The strict CAPM test rejected the second H_0 hypothesis for the market risk premium which means that the slope of the Security Market Line (SML) is different from the slope of SML indicated by CAPM. Hence the CAPM's validity is rejected overall although

beta was proved to be a reliable asset measurement. More advanced models of Portfolio Selection such as the Fama and French, (1993), Three Factor Model or the Five Factor Model provided similar invalid results enforcing the need

Table 1. Short-term and Long-term betas

| Enterprise	CODE	Beta$_{short-term}$	Beta$_{long-term}$
Rank Group	RNK	1.137	1.091
United Biscuits Spn. Adr.	UTBT2	0.562	0.708
Reed Intl.	REED	1.255	1.17
Reckitt & Colman	RCOL	1.029	1.0193
Rolls Royce	RLRC	1.116	1.0773
TSB Intl.	CTSB	0.951	0.9673
GKN	GKN	0.116	0.4106
Imperial Chemical Industries	ICI	0.943	0.962
Lucas Industries	LUCS	0.245	0.496
National Westminster Bank	NWB	1.097	1.064
Unilever	ULVR	0.787	0.858
Boc Group	BOC	1.028	1.018
Blue Circle Industries	BCI	0.1045	0.403
Cadbury Schweppes	CBRY	0.1797	0.453
Courtaulds	CTLD	1.224	1.1493
Glaxo Welcome	GLXO	1.0054	1.003
Allied DomecQ	ALLD	-0.034	0.31066
Bass	BASS	0.912	0.941
Bat Industries	BATS	1.002	1.0013
Barclays	BARC	1.061	1.0406
Boots	BOOT	0.821	0.8806
British Airways	BAIR	1.227	1.151
British Petroils	BP	0.877	0.918
British Telecommunications	BT	0.803	0.868
Cable & Wireless	CABL	1.249	1.166
General Accident	GACC	1.093	1.062
Guardian R. Ex.	GUEY	1.126	1.084
General Electric	UGE	0.617	0.744
Guiness Peat Gp.	GPG	0.563	0.708
Hanson	HNS	0.892	0.928
Land Securities	LAND	0.907	0.938
Marks & Spencer	MKS	0.884	0.922
ASDA Group	ASDA	0.929	0.952
SBRY	SBRY	0.629	0.752
RBOS	RBOS	1.173	1.1153
LADB	LADB	1.063	1.042
BICC	BICC	-0.102	0.265
BAA	BAA	0.0375	0.358
AGYLW	AGYLW	0.075	0.383
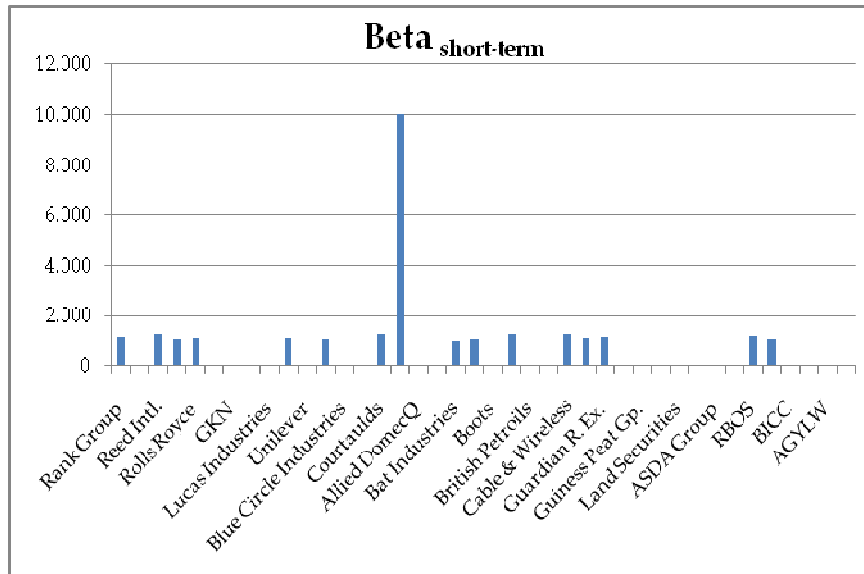
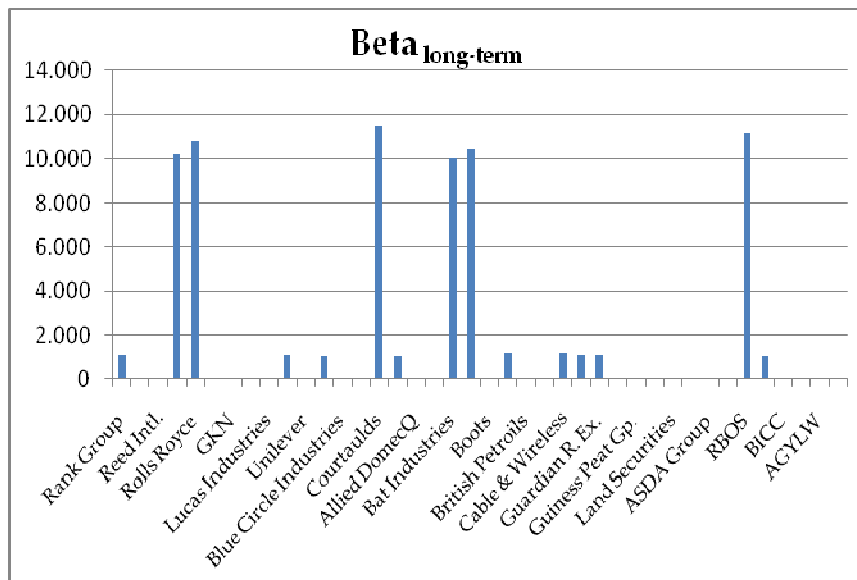Figure 1. The calculated values of beta $_{short-term}$

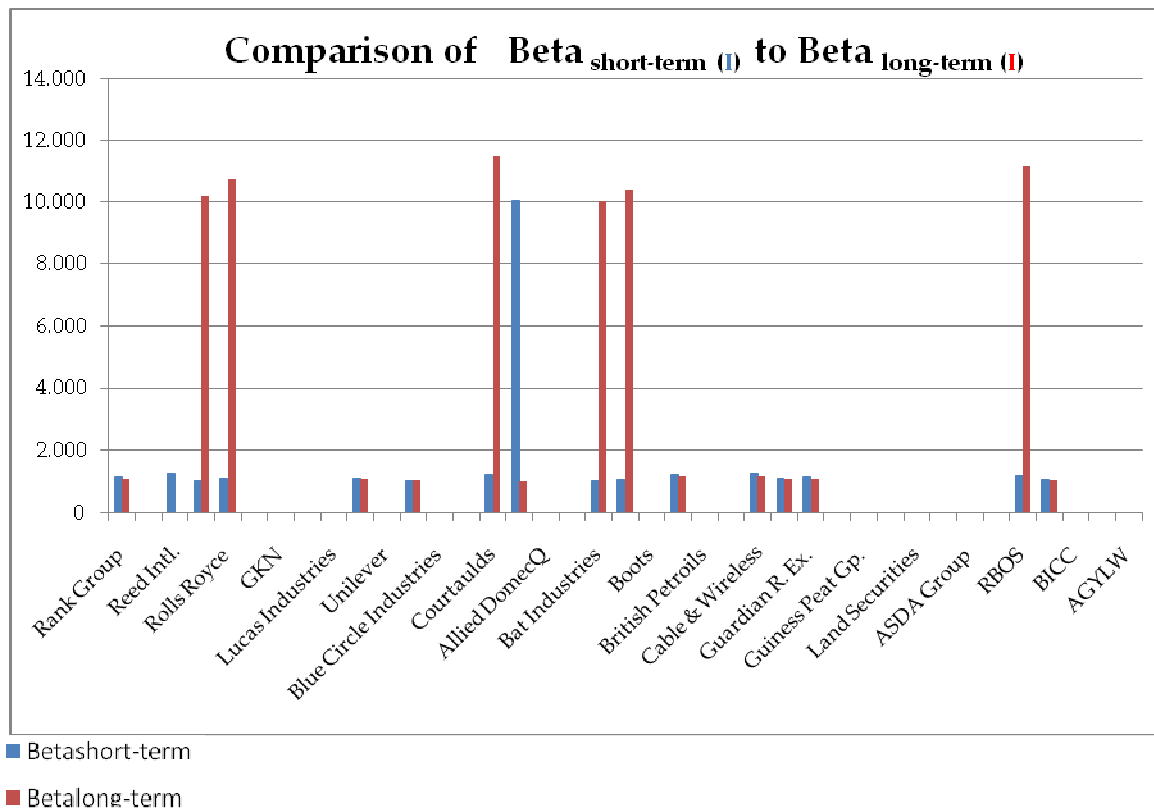Figure2. The calculated values of beta $_{long-term}$

Figure 3. A comparison of the different values produced by beta $_{short-term}$, and beta $_{long-term}$ into each company

of an index in the form of beta, but rejecting an overall model, that under these parameters, it could be an efficient tool in Asset Management. In the future research new fundamental parameters should be considered in asset pricing that could offer more robust information, Loukeris et al. (2008), regarding the objective value of an asset. Whilst effective tools of artificial intelligence can be incorporated within the asset pricing models, to provide optimal portfolio selection, Loukeris and Matsatsinis (2006a), Loukeris and Matsatsinis (2006b), Loukeris (2008).

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