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Empirical Content of Capital Asset Pricing Model (CAPM) and Arbitrage Pricing Theory (APT) Across Time

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Biography

N. Soufian is a part-time lecturer in finance, economics and econometrics. Her Research interests include asset-pricing, cost of capital, international asset pricing, small firms performance in stock markets.

Abstract

This paper examines the validity of Capital Asset Pricing Model (CAPM) and its factor models in explaining pricing of assets across time. Three sub-sets of sample are formed for different time periods on the basis that during each sub-set of samples the UK economy experienced different economic conditions (1980-1997).

Consistent with Chen, Roll and Ross (1986) this paper shows that for the three sub-sets of time-periods, the value weighted market return, which is constructed from the sample, has significant explanatory power on pricing for all three-time periods (testing CAPM). However, its explanatory power on pricing diminishes after adding the unexpected economic factors (i.e. testing APT).

This paper also identifies the underlying methodology problem of testing standard CAPM and its factor models across time: different economic factors capture the variation in average returns for different time periods. The sub-sets of samples tight up with the economic cycles, the results therefore suggest that as the riskiness of the economy changes over time, the factors at work change. In other words, the risk premia of factors change over time according to different economic conditions. These results undermine the appropriateness of the CAPM and its factor models to explain pricing of securities across time and in particular indicate that the standard methodology may be strained when applied across time.

Keywords: Capital Asset Pricing Model, Arbitrage Pricing Model and Two-step estimation

1. Introduction

The Capital Asset Pricing Model (CAPM) is a theory that shows assets are priced in relation to their risk, assuming that market portfolio is efficient; i.e. at a given level of risk it obtains higher expected returns. The empirical evidence indicating that the source of risk introduced in CAPM does not explain the cross-sectional expected returns (see for instance Fama and French, 1995, Fama and French, 1996), suggests that one or more additional factors may be required to characterise the behaviour of expected returns. Arbitrage Pricing Theory (APT) is an alternative to the CAPM. APT is more general than CAPM, allowing for multiple risk factors and does not require the identification of the market portfolio.

A number of studies have explored factors that capture the cross-sectional variation in average stock returns. A number of these studies have examined firm specific variables such as firm size and book-to-market-value (see for instance Fama and French, 1992). Other studies have examined the impact of the macro-economic factors (for instance Chen, Roll and Ross (hereafter CRR), 1986, Antonio, Garret and Priestly, 1998 and Poon and Taylor, 1992). This paper is in line with studies of the latter group and assumes 'pervasive' or 'systematic' influences as the likely source of investment risk in the stock market. One of the important aspects of empirically analysing any asset pricing model, apart from the question of whether it adequately prices the assets, is that it must be robust enough whilst simultaneously offering economic insight into the determinants of security returns. That is formulating the relations between returns and economic factors through specifying macroeconomic variable as candidates for pervasive risk factors (e.g. CRR) does not necessarily generate a valid model. Fama (1991) argues that such a model requires more evidence on how different factors explain pricing assets in different samples. And therefore, to determine the economic factors, influencing pricing is not sufficient to assess the empirical content of APT. The validity of APT also depends on its ability to price assets outside of the sample used for estimation; an argument in studies of Fama (1991) and Connor and Korajczyk (1992). Fama (1991) argues that the relations between returns and economic factors may be spurious requiring for a robustness check outside the sample studied. Connor and Korajczyk (1992) argue that a testable implication of the APT is the equality of the prices of risk across different sub-samples of assets.

In this paper, we investigate the validity of CAPM and APT for securities traded on the London Stock Exchange, in order to explain pricing across time. Three different sub-samples of time periods are formed on the basis that during each sub-set of samples the UK economy experienced different economic conditions (1980-1997). Testing the CAPM and APT in three different sub-samples of time periods is in line with the purpose of validation of the relationships between average returns and macroeconomic variables as suggested by Fama (1991). This paper applies the two-stage procedure analysis of Fama and McBeth (1973). The purpose of the procedure is to test the proposition that at any point in time there is a linear and positive relationship between CAPM's β coefficient and expected returns. Studies that have employed the procedure can be used to test multi-factor models like APT, which tests the proposition that at any point in time there is a linear and positive relationship between economic factors' β coefficient and expected returns. Antoniou, Garrett and Priesley 1998 (hereafter AGP (1998) examined the uniqueness of the returns generating process for two sub-samples of assets. Using the estimation method that allows idiosyncratic returns to be correlated across assets, AGP found that three factors are unique in the sense that they carry the same prices of risk in both samples. While AGP's results suggest that the APT with a unique return generating process is capable of explaining a substantial amount of cross-sectional variation in average returns across different assets, this paper examines whether the CAPM and APT models are capable of explaining pricing in case of the same assets for different subsets of time periods.

The rest of this paper is organised as follows. Section 2 discusses the background and methodology employed for this study. The economic factors and the technique used to measure unexpected changes are presented in section 3. Section 4 presents the statistical properties of the data. Finally, the empirical results of testing CAPM and APT for the three sub-sets of time periods are discussed in section 5.

2. Methodology and data

In line with the objective of the study, the methodology consisted of filtering data. Considering the various attributes of UK data is the discussion of this section. The data were mainly taken from the London Share Price Database (LSPD)[1] and Datatstream. The companies' returns and market values (the market data) are taken from LSPD and the seasonality-adjusted series of economic series are downloaded from Datastream. The market data and their filtering procedure are discussed in the following section. The measure for the economic series and their test procedure is discussed in the subsequent section.

2.1 Market data and portfolios formation

The monthly continuously compounded returns for all the firms listed on the London Stock Exchange, except for financial firms, are extracted from LSPD's returns file. The financial firms are excluded from our analysis in accordance with previous research, because they have unusually high leverage ratios compared to other firms. (Fama and French, 1991, p.429) explain that the high leverage of financial firms probably does not imply financial distress, as would be the case in non-financial firms.

The return data are calculated on a monthly basis by the LSPD in the following manner

$$r_t = log_e((P_t + D_t)/P_{t-1}). \quad (1)$$

Where r_t is the log-return in month 't', P_t is the last traded price in month t, D_t is the dividend during month t adjusted to a month-end basis. P_{t-1} is the last traded price in month 't-1' adjusted to the same basis (LSPD handbook).

Price values of all of firms are taken from the source file from LSPD. The market value for the beginning of each year is calculated by multiplying the December end price with the number of shares outstanding in the subsequent year. For example, if we perform the calculation for the year 1984, then the price of the shares at the end of December 1983 are taken and multiplied by the stocks outstanding in 1984 to obtain the market value of the firm at the beginning of 1984.

The next step consisted of filtering data for missing values: filtering the returns, obviously, when a company is temporarily suspended, the share prices are not available to calculate returns for the relevant months. In the LSPD, a value of –10.000 is assigned to indicate the missing value (LSPD handbook, 1998). In this study, all missing values are excluded before portfolio formation. Thus, firms that did not have missing values for three years prior to the year of portfolio formation and also the year of portfolio formation are taken into account in the portfolios. The three years prior returns would be needed in estimating the pre-betas while the subsequent returns would be used in calculating the returns of the portfolios. Thus, the missing values are not concentrated in any particular portfolio.

Fama and McBeth (1973) advocate the Rolling method to form portfolios from ranked β_is computed from data for one period, and then use a subsequent period for estimation i.e. an *ex ante* sampling rule. Our study has adopted a similar approach of portfolio formation. That is; 36 months are used to calculate the betas for securities β_i from one period but the betas β_p, and the returns R_p for portfolios are obtained from using the data from subsequent period. This approach makes the errors largely random across securities within a portfolio. The aim is to disperse firms' expected returns, thus averaging away the errors in variables for any specific firms, and not biasing the tests by bunching positive and negative sampling errors within portfolios. Thus, it is hoped that this approach minimises the effect of the errors in the individual security variables within a portfolio. The total number of securities available in the LSPD is 6600. The number of firms included in the sample range from a minimum of 984 in the year of 1988 to a maximum of 1185 in the year of 1980.

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[1] LSPD was generated by the London Business School Financial Database project, which was set up in 1972.

The returns on value weighted (VW) market portfolio return is constructed based on all asset returns collected in the sample. The VW market return is the market average return, which gives a larger weight to the returns of the larger firms. The weight is based on the firms' market values at the beginning of the year.

2.1.1 Thin Trading

One of the obvious adjustments that need to be made for the UK data is to control for the problem of thin trading. Thin and infrequent trading often appears for the smaller companies. All the previous studies of pricing present a serious problem when estimating beta's for thinly traded securities. As has been shown in other studies, when shares are thinly traded, their beta estimates are biased downwards (e.g. Fisher, 1966; Cohen *et al*., 1966, Dimson, 1979 and Sholes *et al*., 1977). To avoid these downward biases by thin trading, Dimson and Marsh (1983) used an alternative approach to derive the beta- coefficients; the so-called Trade to Trade (TT) regressions:

$$\frac{R_{it}}{\sqrt{d_t}} = \frac{\alpha_{it}}{\sqrt{d_t}} + \frac{R_{mt}}{\sqrt{d_t}} + \varepsilon_{it} \tag{2}$$

R_{it} is the continuously compounded return on security i for the time t. R_{mt} is the (VW) market portfolio, which is based on all the stocks collected in the sample. D_t is the length (in days) of the time period t. The Dimson and Marsh (1983) Trade to Trade estimation method is effectively a form of Weighted Least Squares, in which the weights are proportional to the frequency of trade. That is, trade following a trade on the previous day is given full weight, while trade following a trade four days earlier has a weight of a half.

Applying Dimson and March (1983) trade to trade regression, the pre-betas are calculated using 36 months of return data preceding the year of the testing period. For example, if we take portfolio for the year 1984, then the beta is calculated by using the returns for the period of 1981-1983 (36 months). The parameter β_i can be interpreted as the risk of asset i in the market portfolio, measured relative to var(R_{mt}), and the total risk of market portfolio as $\beta_i = cov(R_{it}, R_{mt})/var(R_{mt})$.

2.1.2 Double sorting

Once the Pre-Ranking betas have been calculated through Trade-to-Trade regressions, the next step is to perform the double sorting of returns of assets. Double sorting is a method to sort the returns of firms by, first their market value, and then by their pre-ranking betas in order to construct portfolios. Firstly firms are sorted by their market value into seven size portfolios. Then, each of the seven portfolios are sorted based on their pre-ranking betas into a further seven portfolios. We thus end up with 49 portfolios. Each portfolio includes between 25-30 companies. The above procedure is repeated on a monthly basis for the entirety of our dataset. It needs to be noted that the constitution of each portfolio changes every month. A firm that is in one portfolio in one month may be in another in a subsequent month. Then, the monthly returns on 49 portfolios, with equal weighting of individual securities are computed for each year of the testing period. In the study, the monthly returns for 49 portfolios were calculated for the period of 1980-1997. These returns along with the value weighted market portfolios returns have been merged in the form of a matrix.

2.2 Macroeconomic Data

This section focuses on introducing the state variables and specifies the method that has been applied to obtain the time series of change/unexpected movements in macro-economic variables. This section also focuses on the time-series techniques that have been applied in relation to these variables to identify the process generating the series.

2.2.1 Systematic Variables

Some studies like CRR use unexpected changes in macro-economic variables, where it is assumed that an efficient market will react only to unexpected changes in the factors. However, given the possibility of a delay in the reaction of markets there may not be a substantial difference in this respect when raw changes or unexpected changes are used. In statistics terms, expected changes are based on the predictions of statistical models and they usually follow a martingle process, i.e. they carry information about the past, where unexpected changes are influenced by economic factors other than past forecasting errors.

Poon and Taylor (1991) employ the UK's substitution data to estimate CRR's systematic variables. Our study uses variables that are similar to those used by Poon and Taylor's (1991). The following are the variables that have been specified in this study to measure unexpected changes. All the following macro-economic variables are collected from Datastream. For the UK Retail Price Index (RPI) the industrial production seasonality adjusted modifier (SAM) programme was run in order to download the seasonality adjusted macroeconomic series.

Risk Premia

To capture the effect on returns of unanticipated changes in risk premia, CRR (1986) use the difference between high-and low-graded bonds. Poon and Taylor (1991, p623) note that there is no reliable time series data on corporate bond grading and returns in the UK. Our study similar to Poon and Taylor (1991) uses the difference between monthly logarithmic returns of the Financial Times Fixed Interest Securities Price Index and the Financial Times Government Securities Price Index.

Term Structure

Poon and Taylor (1991) use the term structure defined as the differences between long-term and short-term Government interest rates. They used the 2.5% Consol to approximate for the long-term interest rate and the 3 months Treasury bill to approximate for the short-term interest rate. Our study uses the difference between the yield on a Government long-term bond, i.e. 20 years, and 3 month Treasury bill.

Unexpected inflation

The unexpected inflation variable is defined as

$$UI_t = I_t - E\,[I_t \mid t\text{-}1] \tag{3}$$

Where I_t is the realised monthly UK inflation rate for period t. The seasonality adjusted RPI is downloaded from Datastream. The inflation rate is the change from month t-1 to month t in the natural log of the UK Retail Price Index. The series of expected inflation, $E\,[I_t \mid t\text{-}1]$ was obtained by following the procedures in Fama and Gibbons (1982, 1984).

Change in expected inflation.

The change in expected inflation is the series of first differences of expected inflation. It is computed as

$$\Delta E(I_t) = E[I_{t+1} \mid t\,] - E[I_t \mid t-1] \tag{4}$$

$\Delta E(I_t)$ is partially unanticipated and might have an influence separable from UI. While, strictly speaking, $\Delta E(I_t)$ need not have a mean of zero, under the additional assumption that expected inflation follows a martingale, this variable may be treated as an innovation. It can contain information not present in the UI_t variable. This would occur when inflation forecasts are influenced by economic factors other than past forecasting errors. The UI_t series and $\Delta E(I_t)$ series will contain the information in a series of innovations in the nominal interest rate, TB.

Monthly and annual growth rates of industrial production

Monthly and annual growth rates of industrial production are obtained from the monthly Industrial Production index. IP is the monthly growth in industrial production, the change of industrial production of month *t* and month *t-1* in the natural log of monthly industrial production. The seasonally adjusted IP has been collected from Datastream. If IP_t denotes the industrial production index in month *t*, then the monthly growth rate (MP_t) is

$$MP_t = \ln IP_t - \ln IP_{t-1} \tag{5}$$

And the yearly growth rate is

$$YP_t = \ln IP_t - \ln IP_{t-12} \quad (6)$$

The reason to consider the yearly growth is that the equity market is related to changes in industrial activity in the long run.

2.2.2 Time Series Technique for the Pre-whitening Process

Before testing the relationship between stock returns and macro-economic series, it is essential to identify the process that generating the series. If, as is usually the case for the macro-economic series, an input series is auto-correlated, the direct cross-correlation function between the input and response series gives a misleading indication of the relation between the input and response series. One solution to this problem is called prewhitening. The pre-whitening process is done by fitting an univariate ARIMA (auto-regressive integrated moving average) model to each series. Since the estimated risk premia in asset pricing are sensitive to the way that the unexpected components are generated to test the APT and CAPM, it is essential to use an appropriate method to generate the unanticipated factors. In tests of the APT, it is important to identify the process that generates the expectation in order to generate unanticipated factors, which enter into the APT specifications. APT does not specify how investors form their expectations of observed factors. However, a required condition of an unanticipated component and any expectation process is that they should be mean-zero; serially uncorrelated white noise processes. The techniques that have been employed to generate this process are the rate of change and auto-regressive model. The former technique simply uses the first difference of the factor as the unanticipated component and essentially assumes that the factors follow a random walk where the expectation is the current value. The latter technique assumes that investors use the auto-regressive model to form expectations and unanticipated components are the residuals from these models. This technique is more general, and the random walk can be a special case that generates the unexpected factors.

Statistically, it is possible to obtain the time series of unexpected movements by identifying and estimating a vector auto-regressive model in an attempt to use its residuals as the unexpected innovations in the economic factor. This paper performs the pre-whitening process for the input series; market portfolios and the macro-economic series. Firstly, this consists of fitting an univariate ARIMA model to each series sufficient to reduce the residuals to white noise and then, secondly filtering the input series with this model to get the white noise residual series.

Since monthly rates of return of VW market portfolios are nearly uncorrelated, they can be employed as innovations without alteration.

2.2.3 Two-pass regression method

The following two-stage regression technique adapted from Fama and McBeth (1973) has been used in this study to examine the asset pricing in relation to market portfolio and economic series. For each stage univariate and multivariate regression have been performed: univariate regression for testing CAPM and multivariate for testing APT.

First-pass involves the time series regressions. In this stage the portfolios' exposure to VW market portfolio is examined by regressing the time series of portfolio returns against once with VW market portfolio alone (uni-variate regression). In the multivariate regressions, the economic variables are added into the regression to measure the portfolio's exposure to the economic series. In the first stage, the beta of portfolios is measured over three estimation periods. Provided this study aims to test to test the CAPM and APT in different economic conditions, the following sub-sets of data are formed. These periods are taken on the assumption that during each sub-set of data the UK economy was subject to different business conditions: (i) full period 1980-1997; (ii) fist sub-period of 1980-1989; (ii) second sub-period of 1990-1997.

The second-pass is cross-sectional regressions. The resulting estimated 49 portfolios betas (post-ranking betas), from the first stage, are used as independent variables in the second stage (cross-sectional regression), with portfolios returns being the dependent variable. The resulting estimated 49 portfolio betas are the measure of the portfolios' exposure to the VW market portfolio and economic variables. In the second stage, 3 data sets are again constructed. The numbers of columns include the monthly portfolio returns and resulting estimated portfolios' betas, which are associated with the exposure to the economic variables, acquired from the first stage. Each coefficient resulting from the cross-sectional regression provides an estimate of the risk premia, if any, associated with the exposure to the unexpected/changes of the macroeconomic state variables.

Steps 1 and 2 were repeated for each month, obtaining for each macroeconomic variable a time series of its associated risk premia. For the case of 18 years estimation, the time series means of 216 resulting estimated coefficients, were then tested by a t-test for a significant difference from zero.

2.3 Statistical Properties of Portfolios and macroeconomic series

This section presents and discusses the statistical properties of the macro-economic series, portfolios and VW market portfolios and portfolio returns. In this study Market data collected from LSPD and the original data to obtain the risk premia, term structure, inflation and industrial production are collected from Datastream. The inflation rate is the change from month t-1 to month t in the natural log of the UK RPI.

(i) The portfolios mean size, mean returns, correlation coefficients with a value weighted market index are shown in table 1, as are the average number of companies in each portfolio. As table 1 shows all portfolios have returns that are highly correlated with a value weighted market index. As expected, the large firm portfolios are more correlated with a weighted index since they carry more weight in that index.

(ii) The macroeconomic data and VW market portfolios used for the univariate and statistical description test. The normality test is usually tested for the third and fourth moments of the mean. The third moment about the mean is a measure of the skewness or symmetry of a distribution, while the fourth moment is regarded as a measure of kurtosis or peakness. Based on the skewness and kurtosis in table 6, it appears that none of the series are normally distributed.

(iii) The correlation matrices of table 7 are computed for several different periods: part A covers the entire 216 months sample period from January 1980 through December 1997 and the remaining parts cover three sub-periods. The strongest correlation is between UI and ΔEI. This is expected since they both contain EI series. There is negative correlation between the market index and risk premium and a positive correlation between YP and TS. The production series, YP and IP, are correlated with each other and with each of the other variables, except with RP. A number of other correlations are negligible, as they are far from perfectly correlated.

3. Results

3.1 Empirical Results for the Time Series Analysis and Univariate Models on the Macroeconomic Variables

This section presents and discusses the results for the time-series analysis. Autocorrelation coefficients are a useful tool to identify time-series structure. Given the identification stage of ARIMA model, the autocorrelation estimates, several contending models were estimated, but only one ARIMA order combination (p, d, q) was chosen to represent each series on the basis of the variance of the residuals series and how well the residual series approximate to white noise. Using SAS, the Extended Sample Autocorrelation Function (ESACF) method is applied to identify the tentative ARIMA model.

Table 4 displays the auto-correlations for the state variable and the market index computed over the entire sample period (January 1980-December 1997) and two sub-periods (1980-1989 and 1990-1997). The white-noise test is an approximate statistical test to examine the hypothesis that none of the auto-correlation of the series up to a given lag is significantly different from zero. If this is found to be true for all lags, then there is no information in the series to model and no ARMA model is needed for the series. In SAS, the auto-correlation checks for white noise is grouped in order of 6.

Augmented Dicky Fuller (ADF) tests have been performed to test the stationarity of the market portfolio and state variables. Table 5 shows the ADF tests of the variables for the following hypotheses: the first is to test for pure random walk, the second test is to add an intercept or drift term, and the third test includes both a drift and linear time trend. As table 4 shows, the level of the term structure (TS) and risk premium (RP) are highly autocorrelated. The white noise hypothesis for both TS and RP are strongly rejected, which is to be expected since table 5 shows that both series are non-stationary. The *p* values for all lags are highly significant. However, the first differences of the TS and RP appear to be close to the uncorrelated innovation series. Consistently, table 4 and table 5 show that both TS and RP series have become became stationary after first differences.

The auto-correlations of IP series show no strong auto-correlations and the chi-square for white noise test is rejected. The autocorrelation for the 36 lags shows a slight peak in January (repeated on intervals of 24 months), warning that this variable, although originally seasonally adjusted still appears to be seasonally affected. Consistently, the YP the yearly growth rate, the change of production in month t and month t-12 in the natural log of monthly industrial productions, are significantly auto-correlated. Therefore the first difference of YP has been put in the cross-sectional test.

The VW market portfolio series is uncorrelated at all lags. The behaviour of the sample auto-correlations for unexpected inflation (UI) series that is obtained from Fama and Gibbons (1982, 1984) suggests that these are approximately white noise series. UI series are not auto-correlated at any other lags. However, the chi-square for sample auto-correlation of change on expected inflation, ΔEI, does not suggest that the series are white noise.

3.2 Empirical Results for the Two-stage Regressions Technique

The results of the t-test for the estimated coefficients of the cross-sectional regressions (price of risk) are illustrated in table 6. For CAPM, the coefficients for the full period, first and second sub-period, are significantly different from zero, at the level of 1%, 10% and 5% respectively.

Applying the multivariate approach and adding the filtered unexpected economic factors to the model, the result for the market portfolio is different from that of the CAPM. For the full period, the coefficient sign has become negative and insignificantly different from zero and for the first and second sub-period, the coefficients for the market portfolio's betas are significant at the level of 5%. However, the coefficients of market portfolio's betas are significant for the two-sub-periods, but the level of significance appears to have been reduced. By adding the macro-economic factors to the model, the rejection of the null hypothesis is less strong in the sub-periods, and it is not rejected for the full period.

Regarding the economic factors for the full period, the coefficients for betas of the following economic factors; risk premium, term structure, unexpected inflation, growth in annual industrial production and change in the expected inflation, are different from zero at 1% and 10%. The monthly growth of industrial production and market portfolio does not have any explanatory power over the average stock returns for the full period. For the second sub-period, the unexpected inflation, the growth of annual industrial production, the change in expected inflation and market portfolio have explanatory power for the average stock returns. For the third sub-period, the coefficients of the betas for the following economic factors: risk premium, unexpected inflation, growth of monthly and annual industrial production are significantly different from zero at the level of 1%, and market portfolio at the level of 10%. Over the entire full period and the sub-periods, the growth of annual industrial production is highly significant and the measure of unexpected inflation appears to be influential as well.

4. Conclusion

This paper examines the standard CAPM and APT in three different sets of time-periods (periods of 1980-1989 and 1990-1997) associated with different economic conditions. Testing the CAPM and APT in three different sub-samples of time periods is in line with Fama's (1991) suggestion for validating the relationship between average returns and macroeconomic variables.

On the one hand, consistent with US studies (e.g. CRR), this study finds that the influence of value-weighted market portfolio on pricing diminishes when macroeconomic factors are added to the model. Table 6 shows that in the first model, the coefficient for market portfolio's beta is significant at the level of 1% for all the three samples studied. However, in the second model when other macroeconomic factors are added, the coefficient for VWIN becomes negative and smaller (-.001) and statistically insignificant. This finding might suggests that the explanatory power of market portfolio may have less to do with economics and more to do with the statistical observation that large, positively weighted portfolios of random variables are correlated.

Moreover, this study shows that for the full time period, risk premium, term structure, changes in expected inflation, unexpected inflation and changes in yearly industrial production are statistically significant in explaining the variation of average returns. More importantly, despite the fact that different economic factors capture the variation in average returns for different time periods, changes in yearly industrial production and unexpected inflation have remained significant throughout the three samples. These results may suggest more work on the influence of growth of economy and inflation on pricing in the UK stock market. Moreover, as the sub-sets of sample tight up with the economic cycles, these results indicate that as the riskiness of the economy changes over time, the factors at work change consequently. In other words, the risk factors change over time according to economic conditions.

On the other hand, these results indicate that the assumption of a constant beta is the major difficulty in the empirical support of static CAPM and its factor models when applied across time. If the assumed framework of the above models is correct, then the risk premium should be the same for each period. In other words, the same variables should be priced in different samples of time periods and the model should work outside of each sample. However, the results show that different variables are priced for different samples in each period according to different economic conditions. Hence, the pillar of this paper has been to identify the underlying methodology of testing the CAPM and its factor models across time. Accordingly, this paper in line with Jaganathan and Wang’s (1996) study suggests further research on cross-sectional variation on average returns that allows beta to vary over time.

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Table 1 Portfolios mean size, mean returns and correlation with market indices

A (1980-1997)

Portfolio No.	Mean Return%	Mean Size £M	Correlation with VW	No. of companies In each portfolios
1	0.36	0.217	0.408*	25
2	-0.33	0.221	0.441*	25
3	-0.48	0.234	0.466*	26
4	-0.91	0.224	0.481*	26
5	-0.98	0.244	0.443*	25
6	-0.56	0.245	0.481*	27
7	-1.104	0.230	0.441*	27
8	0.91	0.593	0.455*	26
9	0.53	0.640	0.534*	26
10	0.17	0.649	0.617*	26
11	-0.03	0.646	0.560*	26
12	-0.20	0.639	0.566*	25
13	0.20	0.631	0.574*	25
14	-0.16	0.638	0.489*	25
15	1.24	1.319	0.588*	25
16	1.00	1.302	0.546*	25
17	0.49	1.327	0.603*	25
18	0.58	1.325	0.618*	26
19	0.45	1.345	0.574*	26
20	0.07	1.334	0.665*	26
21	0.70	1.282	0.654*	26
22	1.53	2.714	0.661*	26
23	0.87	2.721	0.634*	25
24	1.12	2.731	0.595*	27
25	1.14	2.752	0.673*	27
26	0.61	2.726	0.680*	27
27	0.92	2.788	0.676*	27
28	1.11	2.696	0.654*	27
29	1.89	5.659	0.607*	25
30	1.56	5.847	0.738*	25
31	1.41	5.772	0.720*	25
32	1.14	6.150	0.711*	25
33	1.02	5.995	0.727*	25
34	0.87	62.348	0.707*	27
35	1.05	6.015	0.714*	27
36	1.78	16.021	0.722*	27
37	1.46	16.028	0.797*	27
38	1.40	17.243	0.812*	27
39	1.15	17.862	0.842*	27

40	1.07	17.297	0.843*	26
41	1.30	18.585	0.832*	27
42	1.18	16.642	0.816*	27
43	1.49	251.874	0.888*	25
44	1.42	228.359	0.916*	27
45	1.40	240.433	0.922*	25
46	1.41	189.785	0.931*	25
47	1.31	148.054	0.922*	25
48	1.48	144.361	0.928*	26
49	1.38	115.722	0.889*	26

VW is the value weighted market return, which has been constructed from the sample.

* Significant at 10%, ** significant at 5%, *** significant at 1%.

N is the average number of companies in each portfolio.

Table 2 Univariate Test and Descriptive Statistical of VW market portfolios and Macro-economic Variables

A. Full period 1980-1997

Variable	Mean	Std Dev	Min	Max	Skew	Kurtosis	T:mean=0	P-Value	N
RP	0.103	0.070	-0.002	0.291	0.457	-0.739	21.545	0.0001	216
TS	0.241	1.983	-4.897	4.026	-0.500	-0.384	1.791	0.074	216
IP	-0.001	0.011	-0.037	0.032	-0.363	0.602	1.315	0.189	216
YP	-0.014	0.030	-0.121	0.105	-0.833	2.630	7.133	0.0001	216
VW	0.015	0.050	-0.307	0.136	-1.46	7.932	4.4773	0.0001	216
UI	0.011	0.685	-2.88	2.33	-0.668	3.538	0.248	0.804	212
ΔEI	-0.001	0.936	-3.69	3.51	-0.129	3.250	-0.028	0.977	212

B. First sub-period 1980-1990

Variable	Mean	Std Dev	Min	Max	Skew	Kurtosis	T:mean=0	P-Value	N
RP	0.051	0.033	-0.002	0.124	0.434	-0.716	16.845	0.0001	120
TS	-0.268	1.760	-4.897	2.653	-0.781	-0.064	-1.670	0.095	120
IP	0.001	0.013	-0.039	0.032	-0.327	-0.010	0.929	0.354	120
YP	0.018	0.034	-0.121	0.105	-1.113	2.791	5.861	0.0001	120
VW	0.018	0.0580	-0.307	0.136	-1.800	8.036	3.491	0.007	120
UI	0.056	1.440	-4.71	3.2	-0.760	1.218	0.420	0.674	116
ΔEI	-0.004	1.223	-2.97	2.83	0.238	0.024	-0.041	0.966	117

C. Second sub-period 1990-1997

Variable	Mean	Std Dev	Min	Max	Skew	Kurtosis	T:mean=0	P-Value	N
RP	0.167	0.047	0.086	0.291	0.237	-0.165	34.696	0.0001	96
TS	0.879	2.069	-4.073	4.026	-0.675	-0.567	4.164	0.0001	96
IP	0.0008	0.007	-0.024	0.015	-0.518	0.390	1.045	0.298	96
YP	0.010	0.023	-0.055	0.58	-0.378	0.909	4.206	0.0001	96
VW	0.0112	0.037	-0.076	0.110	-0.019	0.495	2.907	0.0045	96
UI	0.028	0.438	-0.59	1.91	1.730	4.134	0.626	0.532	93
ΔEI	-0.031	0.529	-3.26	1.23	-2.830	15.695	-0.578	0.564	94

VW = Value weighted market index,

RP = Risk premium

TS = Term structure

IP = Monthly industrial production

YP = Yearly industrial production

ΔEI = Change in expected inflation

UI = Unexpected inflation

Table 3 Correlation Matrices for Macroeconomic Series and market Portfolios

A. Full period (1980-1997)

Variables	*TS*	*RP*	*IP*	*YP*	*VW*	*UI*	$\Delta E(I_t)$
TS	1.000						
RP	0.253***	1.000					
IP	0.099	0.040	1.000				
YP	0.391***	-0.000	0.377	1.000			
VW	0.002	-0.461	0.078	-0.014	1.000		
UI	-0.124	-0.055	-0.054	-0.080	-0.024	1.000	
$\Delta E(I_t)$	-0.0186	0.005	-0.040	0.033	-0.001	0.683***	1.000

B. First sub-period (1980-1990)

Variables	*TS*	*RP*	*IP*	*YP*	*VW*	*UI*	$\Delta E(I_t)$
TS	1.000						
RP	-0.582	1.000					
IP	0.080	0.069	1.000				
YP	0.338	0.088	0.388**	1.000			
VW	0.004	0.007	0.109	-0.059	1.000		
UI	-0.144	-0.250	-0.044	-0.141	0.079	1.000	
$\Delta E(I_t)$	-0.040	-0.023	-0.040	-0.000	-0.061	0.427***	1.000

C. Second sub-period (1990-1997)

Variables	*TS*	*RP*	*IP*	*YP*	*VW*	*UI*	$\Delta E(I_t)$
TS	1.000						
RP	0.494	1.000					
IP	0.173	0.137	1.000				
YP	0.687	0.386	0.35	1.000			
VW	0.059	0.049	-0.021	0.075	1.000		
UI	-0.239	-0.395	-0.052	-0.030	0.222	1.000	
$\Delta E(I_t)$	0.110	-0.177	0.075	0.058	0.328	0.461***	1.000

* Significant at 10%, ** significant at 5%, *** significant at 1%.

Table 4 Autocorrelations for the Macro-economic Variables
Full period (1980-1997)

	TS_t	ΔTS_t	RP_t	ΔRP_t	IP_t	YP_t	ΔYP_t	VW_t	UI_i	ΔEI_t
ρ_1	0.95	0.05	0.96	-0.21	-0.227	0.821	-0.247	0.005	0.065	-0.416
ρ_2	0.91	0.01	0.94	-0.06	0.033	0.722	0.038	-0.143	-0.002	-0.052
ρ_3	0.86	-0.05	0.92	-0.00	0.139	0.623	0.138	-0.121	0.027	0.058
ρ_4	0.82	0.01	0.89	0.01	-0.067	0.507	-0.115	0.011	-0.0547	-0.051
ρ_5	0.78	-0.02	0.87	-0.04	0.227	0.424	0.242	0.047	-0.011	0.032
ρ_6	0.73	0.05	0.85	0.13	-0.082	0.266	-0.175	-0.057	-0.057	-0.089
ρ_7	0.69	0.01	0.83	-0.15	-0.010	0.183	-0.020	-0.056	0.076	0.127
ρ_8	0.65	-0.08	0.82	0.07	0.132	0.119	0.123	-0.123	-0.043	-0.124
ρ_9	0.61	-0.04	0.80	-0.08	-0.138	0.035	-0.160	0.047	0.105	0.161
ρ_{10}	0.58	-0.06	0.79	-0.05	0.035	-0.002	0.127	0.058	-0.093	-0.194
ρ_{11}	0.55	0.02	0.78	0.06	-0.048	-0.059	-0.466	-0.016	0.097	0.157
ρ_{12}	0.53	0.06	0.76	0.04	-0.034	0.003	0.064	-0.079	-0.017	-0.048
ρ_{13}	0.50	0.04	0.75	0.00	0.083	0.39	0.191	0.029	-0.034	0.009
ρ_{25}					0.084	-0.003	0.217			
χ^2 Lag 1-6	960	2.16	1103	15.07	29.76	461.96	40.73	9.08	2.51	41.35
P-value	(0.00)	(0.90)	(0.00)	(0.02)	(0.00)	(0.00)	(0.00)	(0.169)	(0.867)	(0.00)
χ^2 Lag 7-12	1466	6.7	1982	25.18	39.16	473.88	104.50	16.11	10.93	68.91
P-value	(0.00)	(0.87)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.186)	(0.535)	(0.00)

Table 4a Autocorrelations for the Macro-economic Variables

First sub-period (1980-1989)

	TS_t	ΔTS_t	RP_t	ΔRP_t	IP_t	YP_t	ΔYP_t	VW_t	UI_i	ΔUI_t	ΔEI_t
ρ_1	0.905	-0.008	0.935	-0.285	-.220	0.780	-0.247	-0.012	0.635	-0.076	-0.072
ρ_2	0.814	-0.002	0.895	-0.072	0.058	0.655	0.079	-0.137	0.327	0.147	0.147
ρ_3	0.719	-0.098	0.863	-0.040	0.168	0.523	0.177	-0.113	-0.089	-0.492	-0.494
ρ_4	0.644	-0.009	0.825	0.042	-0.112	0.366	-0.183	0.010	-0.144	-0.084	-0.087
ρ_5	0.572	0.009	0.786	-0.117	0.276	0.265	0.318	0.036	-0.137	-0.058	-0.054
ρ_6	0.499	0.046	0.766	0.189	-0.131	0.068	-0.244	-0.070	-0.092	-0.078	-0.078
ρ_7	0.423	-0.012	0.722	-0.259	-0.023	-0.020	-0.022	-0.051	0.013	0.152	0.152
ρ_8	0.350	-0.089	0.707	0.094	0.143	-0.083	0.147	-0.179	0.007	-0.083	-0.086
ρ_9	0.298	0.027	0.680	0.045	-0.188	-0.178	-0.222	0.026	0.064	0.144	0.143
ρ_{10}	0.241	-0.063	0.645	-0.073	0.042	-0.200	0.115	0.067	0.017	-0.131	-0.132
ρ_{11}	0.194	0.071	0.621	0.014	-0.053	-0.235	-0.414	-0.035	0.064	0.176	0.179
ρ_{12}	0.142	0.061	0.603	0.010	-0.050	-0.150	0.026	-0.045	-0.018	-0.013	-0.013
ρ_{13}	0.082	-0.005	0.571	-0.036	0.121	-0.086	0.202	0.098	-0.094	-0.024	-0.023
Lag 1-6	374	1.52	540	17.31	23.57	188.78	36.69	4.76	67.76	34.41	35.12
P-value	(0.00)	(0.958)	(0.00)	(0.008)	(0.001)	(0.00)	(0.00)	(0.575)	(0.00)	(0.00)	(0.00)
Lag 7-12	440	4.39	891	29.59	31.98	209.69	70.69	10.40	68.91	47.00	48.14
P-value	(0.00)	(0.975)	(0.00)	(0.003)	(0.001)	(0.00)	(0.00)	(0.58)	(0.00)	(0.00)	(0.00)

Table 4b Autocorrelations for the Macro-economic Variables

Second sub-period (1990-1997)

	TS_t	ΔTS_t	RP_t	ΔRP_t	IP_t	YP_t	ΔYP_t	VW_t	UI_I	ΔUI_t	ΔEI_t
ρ_1	0.945	0.203	0.936	-0.074	-0.262	0.889	-0.248	0.052	0.560	-0.161	-0.119
ρ_2	0.885	0.037	0.885	-0.047	-0.038	0.832	-0.114	-0.157	0.260	-0.454	-0.271
ρ_3	0.835	0.060	0.828	0.062	0.060	0.791	-0.013	-0.175	0.354	0.092	0.072
ρ_4	0.788	0.129	0.782	0.011	0.055	0.744	0.133	-0.016	0.367	0.171	0.121
ρ_5	0.732	-0.111	0.728	0.042	0.073	0.665	0.057	0.028	0.235	0.001	-0.031
ρ_6	0.674	0.097	0.674	0.067	0.108	0.594	0.094	-0.096	0.105	-0.110	-0.085
ρ_7	0.617	0.073	0.622	-0.016	-0.044	0.519	-0.067	-0.029	0.068	-0.053	-0.001
ρ_8	0.518	-0.094	0.584	-0.019	0.105	0.453	0.002	0.106	0.077	0.058	0.026
ρ_9	0.491	-0.262	0.553	-0.251	0.001	0.382	0.040	0.155	0.045	0.037	0.008
ρ_{10}	0.462	-0.030	0.519	-0.038	0.017	0.305	0.187	-0.061	-0.019	-0.059	-0.056
ρ_{11}	0.427	-0.064	0.487	0.059	-0.013	0.198	-0.514	-0.080	-0.044	-0.030	0.015
ρ_{12}	0.385	0.072	0.457	-0.022	-0.005	0.201	0.179	-0.157	-0.041	-0.045	-0.007
ρ_{13}	0.355	0.102	0.424	0.009	0.696	0.166	-0.067	-0.070	0.010	-0.030	-0.014
Lag 1-6	403.70	8.42	399.27	1.79	9.41	350.08	10.40	6.92	68.97	27.13	11.40
P-value	(0.00)	(2.209)	(0.00)	(0.938)	(0.152)	(0.00)	(0.109)	(0.328)	(0.00)	(0.00)	(0.077)
Lag 7-12 and P-value	577.67	18.41	588.89	9.19	10.85	435.26	47.36	14.67	70.70	28.59	11.84
	(0.00)	(0.104)	(0.00)	(0.687)	(0.542)	(0.00)	(0.00)	(0.260)	(0.00)	(0.005)	(0.459)

Table 5 Augmented Dicky-Fuller Unit Root Tests

A. Full period (1980-1997)

Variables	$\Delta y_t = \gamma y_{t-1} + \varepsilon_t$	$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \varepsilon_t$	$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \alpha_2 t + \varepsilon_t$
TS	τ=-2.198	τ_μ=-2.21	τ_t=-2.01
ΔTS	τ=-9.82	τ_μ=-9.79	τ_t=-9.80
RP	τ=2.22	τ_μ=0.66	τ_t=-2.47
ΔRP	τ=-12.21	τ_μ=-12.60	τ_t=-12.73
IP	τ=-16.80	τ_μ=-16.76	τ_t=-16.73
YP	τ=-12.35	τ_μ=-13.10	τ_t=-13.06
ΔYP	τ=-18.51	τ_μ=-18.47	τ_t=*-18.44*
VW	τ=-10.45	τ_μ=-11.87	τ_t=-11.90
UI	τ=-10.82	τ_μ=-10.80	τ_t=-10.89
ΔEI	τ=-13.67	τ_μ=-13.88	τ_t=-14.06

B. First sub-period (1980-1989)

Variables	$\Delta y_t = \gamma y_{t-1} + \varepsilon_t$	$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \varepsilon_t$	$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \alpha_2 t + \varepsilon_t$
TS	τ=--1.187	τ_μ= -1.237	τ_t=-2.290
ΔTS	τ= -10.891	τ_μ= -7.597	τ_t= -7.783
RP	τ= 0.088	τ_μ= -1.283	τ_t= -3.845
ΔRP	τ= -10.072	τ_μ= -10.14	τ_t= -10.0967
IP	τ= -8.341	τ_μ= -8.502	τ_t= -8.720
YP	τ= -3.058	τ_μ= -4.037	τ_t= -3.681
ΔYP	τ=--8.423	τ_μ= -8.400	τ_t= *-8.628*
VW	τ= -7.638	τ_μ= -8.761	τ_t=-8.722
UI	τ= -5.136	τ_μ= -5.113	τ_t= -5.346
ΔUI	τ= -6.705	τ_μ= -6.676	τ_t= -6.643
ΔEI	τ= -6.759	τ_μ= -6.729	τ_t= -6.700

C. Second sub-period (1990-1997)

Variables	$\Delta y_t = \gamma y_{t-1} + \varepsilon_t$	$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \varepsilon_t$	$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \alpha_2 t + \varepsilon_t$
TS	τ= -1.693	τ_μ= -2.133	τ_t= -0.853
ΔTS	τ= -6.165	τ_μ= -6.140	τ_t= -6.653
RP	τ= 2.166	τ_μ= 0.650	τ_t=-1.577
ΔRP	τ= -6.834	τ_μ= -7.276	τ_t= -7.456
IP	τ= -8.340	τ_μ= -8.504	τ_t= -8.612
YP	τ= -1.650	τ_μ= -1.923	τ_t= -1.811
ΔYP	τ= -9.140	τ_μ= -9.110	τ_t=*-9.160*
VW	τ= -6.870	τ_μ= -7.871	τ_t= -7.849
UI	τ= -4.737	τ_μ= -4.730	τ_t= -5.642
ΔUI	τ= -12.264	τ_μ= -12.194	τ_t= -12.152
ΔEI	τ= -9.244	τ_μ= -9.209	τ_t= -9.150

Table 6 Cross-sectional Regressions Estimates

1. Model 1: $R_t = \alpha + \gamma\beta_{VW}$

A. Full-period (1980-1997) *R^2=0.19*

Variable	Coefficient	Std Error
VWIN	0.018***	0.0049

B. First sub-period (1980-1989) *R^2=0.18*

Variable	Coefficient	Std Error
VWIN	0.016*	0.007

C. Second sub-period (1990-1997) *R^2=0.19*

Variable	Coefficient	Std Error
VWIN	0.016**	0.004

2. Model 2: $R_t = \alpha + \gamma_1\beta_{RP} + \gamma_2\beta_{TS} + \gamma_3\beta_{UI} + \gamma_5\beta_{IP} + \gamma_5\beta_{YP} + \gamma_6\beta_{DEI} + \gamma_7\beta_{VW}$

A. Full-period (1980-1997) *R^2=0.49*

Variables	Coefficients	Std Error
RP	-0.016***	0.002
TS	0.408***	0.116
UI	-0.359*	0.172
IP	0.002	0.002
YP	0.029***	0.003
DEI	0.945***	0.223
VWIN	-0.001	0.004

B. First sub-period (1980-1989) *R^2=0.38*

Variables	Coefficients	Std Error
RP	-0.001	0.002
TS	0.000	0.157
UI	-0.707*	0.272
IP	0.003	0.002
YP	0.011***	0.003
DEI	-0.503*	0.212
VWIN	0.016*	0.007

C. Second sub-period (1990-1997) *R^2=0.59*

Variables	Coefficients	Std Error
RP	-0.011***	0.002
TS	0.136	0.086
UI	0.424***	0.084
IP	-0.005**	0.001
YP	0.009***	0.002
DEI	-0.043	0.116
VWIN	0.013*	0.005

* Significant at 10%, ** significant at 5%, *** significant at 1%.