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MACROECONOMIC FACTORS AND THE UK STOCK MARKET

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INTRODUCTION

Chen, Roll and Ross (CRR) (1986) claimed recently to have found exogenous economic factors in a multivariate Arbitrage Pricing Model. Using US data for the period 1958 to 1984, CRR asserted that sources of risk from industrial production, changes in a risk premium for bonds, and the term structure are significantly and systematically priced in the stock market. Measures of unanticipated inflation and changes in expected inflation have some influence as well, but only when these variables were highly volatile. More surprisingly, they reported that the value-weighted New York Stock Exchange Index, although explaining a significant portion of the time series variability of stock returns, has an insignificant influence on pricing when macroeconomic factors are also considered.

CRR is the first, in a series of recent studies,[1] to employ specific macroeconomic factors as proxies for the otherwise theoretically undefined state variables in the Arbitrage Pricing Model. The earlier literature on tests of the APM is based on using factor analysis to extract systematic factors influencing stock returns.[2] CRR compared time series of the values of five common factors, obtained from factor analysis, with macroeconomic variables based on economic theory. These macroeconomic variables are assumed to have influenced either future cash flows or the risk-adjusted discount rate, two key variables when stocks are priced by the expectation of the present value of future cash flows. They report in their footnote 7 that the null hypothesis that each of the macroeconomic factors is not related to any one of the five common stock factors is rejected in every case, except for the case of inflation.

If the claims in CRR are true then an implication of their findings is that the Arbitrage Pricing Model (APM) is superior to the Capital Asset Pricing Model (CAPM). Given that there is so much interest, emphasis and effort from both practitioners and academics in computing and assessing security CAPM betas this implication is important.

The two objectives of this study are to reconsider the results in CRR and to see if they are applicable to UK stocks. The CRR methodology and the

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way the authors interpret their test results are, in our opinion, open to criticism. Several critical observations are made in this study. We carry out a similar set of tests using UK data, to discover if the findings reported by CRR for the US can be extended to the UK market. Our results show that variables similar to those of CRR do not affect share prices in the UK in the manner described in CRR. It could be that other macroeconomic factors are at work, or the methodology in CRR is inadequate for detecting such pricing relationships, or possibly both explanations apply.

The structure of this paper is as follows. In the next section we describe in detail the data used in the study. The third section reports the test procedures and results. The test procedures involve three major analyses. We first prewhiten all series so that only the unexpected components are analysed in the subsequent stages. The prewhitening was done by modelling each of the series with a univariate time series model. The second step is to carry out a Fama-MacBeth two-stage regression procedure. The first set of regressions estimates the portfolios' exposures to pricing factors (betas). The second set of regressions estimates the market prices for the beta values obtained from the first set of regressions. The result of this two-stage regression methodology is to generate time series of estimated premia for each risk factor. The third analysis is to test if these time series of risk premia estimates are significantly different from zero. The final section discusses the results and compares them with those of CRR.

DATA

Stock Returns Series

The sample period used in this study begins in January 1965 and ends in December 1984. The standard period is one month. A large sample of 1,570 UK-listed company returns series have been extracted from the London Share Price Database (LSPD). Some of the companies ceased to exist before the sample period ended while some of the others had not come into existence when the sample period started. The number of companies included in the samples ranges from a minimum of 562 in 1971 to a maximum of 1,086 in 1975, and the average number of companies in the samples is 788 for the entire twenty-year sample period.

The returns on the LSPD tape are defined as follows:

$$R_t = \ln (P_t + d_t) - \ln P_{t-1}.$$

Here R_t is the return in month t, P_t is the last traded price in month t, d_t is the dividend declared '*xd*' during month t and P_{t-1} is the last traded price in month $t-1$. The returns are also adjusted for changes in capital structure due to scrip issues or rights issues, etc. The adjustments are based on the principle that the value of a share is unaltered by changes in capital structure.

Following CRR, 20 equally weighted portfolios are formed based on firm size. To use firm size as a criterion to arrange portfolios is a consequence of empirical research: it is not motivated by any theoretical reasoning. Whatever basis is used to form portfolios, the aim is to create a set of portfolios with a good spread of returns. Many researchers have argued that firm size is strongly related to expected returns. Banz (1981), Reinganum (1981) and Levis (1985) have all reported that small firms tend to have larger average/excess returns than large firms. CRR also performed calculations in which portfolios are formed according to (a) betas on a market index, (b) residual variability in a market model regression and (c) level of stock price. Their results show that the first two grouping techniques failed to spread portfolio returns. Grouping by the level of stock price did spread returns, but the state variables were only marginally significant and the market indices were of no significance.

The portfolios in our sample are formed in such a manner that portfolio 1 contains the smallest companies and portfolio 20 contains the largest companies. These portfolios are revised every year according to the capitalized market values of the companies at the beginning of each year. No survival bias is present in the sampling procedure.[3]

Two data screening exercises were implemented during the formation of portfolios. The first is to check for the occurrence of missing price values. All missing values are excluded before computing portfolio returns. The second exercise assessed the magnitude of thin trading by examining the number of non-trading days in a month. Stocks whose prices remain the same as previous month values and which are not traded in the last five days before the month ends are excluded. The average number of missing values[4] is 75, thus the average number of companies included in the sample is 713 (i.e. 788−75).

The problem of missing values is most severe in January 1975 and December 1983. In January 1975, the number of missing values is 359. However, the population size for that year is 1,086, which is larger than average. The number of remaining companies included in the sample for that month is 727. The data problem is most serious in December 1983.[5] The number of missing values for this month is 439. With the population size for that month being 750, the number of companies in the sample dwindles to 311. These missing values are not concentrated in any particular portfolio.

The portfolios mean sizes, mean returns, correlation coefficients with a value weighted market index and an equally weighted index are reported in Table 1, as also are the average number of companies in each portfolio. Details about the two indices are provided in the next section. Our results appear to be consistent with those of Levis (1985). The rank correlation coefficient between mean size and mean returns is −0.609 in our sample, which is significant at the one percent level. Levis (1985) reports a 6.5 percent per annum premium for smaller UK firms over the period January 1958 to December 1982. The size premium estimated in our sample is 8.2 percent per annum over the period

Table 1

Portfolios Mean Size, Mean Return and Correlation with Market Indices for the Period 1965–1984

Portfolio No.	*Mean Size £M*	*Mean Return (%)*	*Correlation with VW*	*Correlation with EW*	*N*
1	0.53	1.613	0.615*	0.795*	36
2	0.77	1.497	0.680*	0.842*	36
3	1.10	1.320	0.741*	0.885*	36
4	1.53	1.285	0.776*	0.903*	36
5	1.90	1.482	0.770*	0.913*	36
6	2.45	1.124	0.778*	0.916*	36
7	3.06	0.915	0.822*	0.929*	36
8	3.76	1.043	0.839*	0.944*	36
9	4.61	1.079	0.861*	0.953*	36
10	5.68	1.089	0.888*	0.962*	36
11	6.96	1.153	0.883*	0.963*	36
12	8.51	1.121	0.893*	0.963*	36
13	10.74	1.027	0.908*	0.960*	36
14	13.86	1.151	0.911*	0.970*	35
15	18.55	1.095	0.933*	0.967*	35
16	25.83	1.134	0.934*	0.959*	35
17	39.08	1.246	0.951*	0.958*	35
18	60.96	1.009	0.961*	0.942*	35
19	108.23	0.949	0.969*	0.935*	35
20	509.58	0.951	0.982*	0.894*	35

Notes:

1 'VW' and 'EW' are the series of first differences of logarithms of the value weighted and equally weighted market indices.

2 '*' indicates a significant correlation coefficient exceeding two standard errors.

3 N is the average number of companies in each portfolio.

January 1965 to December 1984 using the figures for portfolios 1 and 20. Levis claims that the size premium is even higher on a risk adjusted basis. We do not compute risk adjusted returns in this study, but the results in the final section show that the smaller firms have smaller betas than the larger firms. Thus, on a risk adjusted basis our sample ought also to produce a greater size premium.

Another point to be noted from Table 1 is that all portfolios have returns which are highly correlated with both the value weighted and the equally weighted market indices. As expected, the large firm portfolios are more correlated with the value weighted index since they carry more weight in that index. The correlation with the equally weighted portfolio is more evenly spread.

Macroeconomic Variables

The economic state variables used in this study include:

(i) Monthly and annual growth rates of industrial production calculated from the monthly Industrial Production Index. The index, compiled by the UK Central Statistics Office, is a measure of value added by each industry at constant 1980 prices and is adjusted for the number of working days in each month. If IP_t denotes the index of industrial production in month t, then the monthly growth rate is

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

and the yearly growth rate is

$$YP_t = \ln IP_t - \ln IP_{t-12}.$$

The monthly series of annual growth rates, YP_t, is examined because it is felt that the equity market is related to changes in industrial activity in the long run. The MP series starts in January 1960 and ends in September 1988. The YP series starts in January 1961 and ends in September 1988.

(ii) The unanticipated component of inflation is defined as

$$UI_t = I_t - E[I_t/t-1]$$

where I_t is the realized monthly first difference of the logarithm of the Consumer Price Index for period t and the series of expected inflation $E[I_t/t-1]$ is obtained following the procedures in Fama and Gibbons (1982 and 1984). Details of these procedures are provided in an Appendix available from the authors. A second variable is the change in expected inflation

$$DEI_t = E[I_{t+1}/t] - E[I_t/t-1].$$

DEI_t is partially unanticipated and might have an influence separable from UI. Both inflation series cover the period from January 1960 to August 1988.

(iii) Risk Premium, a measure for investors' required return for accepting risk was determined in CRR by calculating the difference between high-grade and low-grade bond returns. There is some form of bond grading in the UK but, unfortunately, there is no reliable time series data on corporate bond gradings and returns. We use instead the difference between the monthly logarithmic returns of the Financial Times Fixed Interest Securities Price Index and the Financial Times Government Securities Price Index.[6] The risk premium series starts in January 1965 and ends in March 1989.

(iv) Term structure is measured by the difference between long-term and short-term Government interest rates. The long-term interest rate is approximated by the yield on a Government long-term bond, the 2.5 percent Consol, and the short-term interest rate is approximated by using the 91-day Treasury bill. Both interest rates are converted to their monthly equivalents to be comparable with stock returns. The term structure series starts in January 1960 and ends in October 1988.

(v) Returns on a value weighted market index and an equally weighted market index are compiled based on all the stock returns collected in the sample. As their names imply, the value weighted index return is the market average return giving a larger weight to the returns of the large firms. The weight is based on the firms' market values at the beginning of the year. Whereas the equally weighted market index is the average return with all the firms having the same weight. Missing values are dealt with as in the previous sub-section, and no survival bias occurs in the computation of these two indices. Both market series cover a period from February 1955 to December 1984.

All the economic series were collected on-line from Datastream. The original source of the first four macroeconomic series is the OECD Publication Service.[7] The value weighted market index and the equally weighted market index are compiled from the returns data collected from LSPD. The macro series were collected at different periods during the empirical test. In anticipation of the data loss from ARIMA modelling and the fifteen regression leads and lags, we tried to collect as much data as possible. Some of the series were not available before January 1965. This explains why the macroeconomic series start and end at different dates.

EMPIRICAL TESTS AND RESULTS

Before testing the relationship between stock returns and macroeconomic series, it is important that only the innovation or unexpected components are analysed. Failure to adequately filter the various series may create a spurious relationship and introduce an errors-in-variables problem (e.g. Coen, Gomme and Kendall, 1969; and the criticism in Box and Newbold, 1971). Thus, in the next sub-section, we report the prewhitening process for the portfolio returns, market indices and the macroeconomic series. This is followed by a sub-section where we first describe the two-stage regression technique, then proceed to analyse the relationship between portfolio returns and each individual macroeconomic factor.

Autocorrelation and Univariate Models

The autocorrelation coefficients for the returns from the twenty portfolios are reported in Table 2. Table 3 reports those of the market indices and macroeconomic series. The autocorrelation coefficients are useful for identifying time series structure. The prewhitening process is carried out by fitting a univariate ARIMA (Autoregressive Integrated Moving Average) model to each series.

One distinctive feature of the results in Table 2 is that all but one of the

Table 2

Autocorrelations of Monthly Portfolio Returns 1965–1984

Portfolio No.	Autocorrelation at lag 1	2	3	4	5	6	11	12	13
1	0.349*	0.206*	0.218*	0.148	0.076	0.143	0.059	0.047	−0.064
2	0.282*	0.196*	0.159*	0.104	0.002	0.088	−0.001	0.002	−0.110
3	0.311*	0.151*	0.172*	0.081	0.046	0.059	0.043	0.045	−0.157
4	0.329*	0.167*	0.181*	0.082	−0.007	0.119	0.038	0.046	−0.103
5	0.256*	0.108	0.151	−0.021	−0.053	0.036	0.013	0.015	−0.136
6	0.212*	0.069	0.113	0.001	−0.043	0.106	−0.025	0.007	−0.192*
7	0.196*	0.019	0.197*	−0.017	−0.064	0.072	0.029	0.016	−0.082
8	0.222*	0.082	0.114	−0.005	−0.053	0.049	0.008	0.019	−0.146*
9	0.309*	0.088	0.180*	−0.006	−0.064	0.046	0.026	−0.002	−0.137
10	0.235*	−0.003	0.104	0.007	−0.078	0.016	0.015	0.021	−0.153*
11	0.275*	0.027	0.122	−0.010	−0.138	0.008	−0.036	−0.002	−0.156*
12	0.303*	0.037	0.097	0.007	−0.076	0.011	0.017	−0.016	−0.158*
13	0.231*	−0.021	0.115	0.013	−0.088	0.015	0.014	0.073	−0.167*
14	0.265*	0.004	0.080	0.018	−0.090	−0.033	0.016	0.007	−0.187*
15	0.212*	−0.005	0.134	0.010	−0.100	0.026	−0.032	−0.014	−0.144*
16	0.197*	−0.061	0.098	−0.009	−0.107	−0.020	0.007	−0.004	−0.198*
17	0.191*	−0.079	0.111	−0.020	−0.127	−0.014	−0.025	0.038	−0.174*
18	0.181*	−0.053	0.131	−0.020	−0.160*	−0.050	−0.018	0.039	−0.127
19	0.149*	−0.065	0.140	−0.026	−0.149*	−0.016	−0.028	0.065	−0.138
20	0.099	−0.073	0.163*	0.032	−0.116	−0.038	−0.027	0.085	−0.157*

Notes:
1 To conserve space, the autocorrelations at lags 7 to 10 are not reported.
2 '*' indicates a significant autocorrelation coefficient exceeding two standard errors.

first lag autocorrelations are significant at the five percent level.[8] Only the autocorrelation for the largest portfolio is not significant. Autocorrelations at other lags do not appear to be important. One explanation for this first-lag autocorrelation in portfolio returns is thin trading or the non-synchronous trading effect in the market as proposed by Roll (1981). Similar autocorrelation is observed in the index returns (VW, EW, see Table 3). Roll suggested that portfolio returns, especially those of small firm portfolios, exhibit autocorrelation because their constituent securities are less-frequently traded. The results of Officer (1975), Scholes and Williams (1977) and Gibbons and Hess (1981) also suggest that portfolios of stocks and stock indices can display more first-lag autocorrelation than individual stocks, because of the market factor and thin trading of smaller companies.

Evidence for a thin trading explanation can be obtained from Tables 1 to 3. The rank correlation between the first lag coefficient in Table 2 and size in Table 1 is −0.757 which is significant at the one percent level, confirming the prediction that smaller firm portfolios have larger autocorrelations. In Table 3, the autocorrelation in VW is less than that in EW as the small size firms, which are normally associated with thin trading, have a smaller weight in VW than EW. Following Scholes and Williams (1977), we fit an MA(1) model for

Table 3

Autocorrelations of the Monthly Macroeconomic Series

Series Name	Autocorrelation at lag 1	2	3	4	5	6	12	13	N
VW	0.138*	−0.042	0.096	0.026	−0.090	−0.042	0.058	−0.119*	359
EW	0.263*	0.051	0.117*	0.020	−0.068	0.030	0.025	−0.137*	359
PR	−0.304*	−0.021	−0.097	0.062	−0.076	0.160*	0.084	−0.029	291
(1−B) TS	0.023	0.027	−0.079	0.039	0.066	0.026	−0.003	0.026	346
MP	−0.067	−0.400*	−0.160*	0.218*	−0.026	−0.104	0.842*	−0.005	345
YP	0.697*	0.681*	0.599*	0.497*	0.456*	0.362*	−0.182	−0.096	334
(1−B) YP	−0.474*	0.108	0.034	−0.103	0.092	−0.033	−0.443*	0.193*	333
UI	0.073	0.026	0.033	−0.120	−0.036	−0.062	−0.147*	0.011	344
DEI	0.083	0.061	0.005	−0.120	0.015	−0.031	−0.118	0.019	344

Notes:

1 'VW' and 'EW' are the series of first differences of logarithms of the value weighted and equally weighted market indices.

2 'TS' is the term structure of interest rates, defined as the difference between long-term (2.5 percent Government Consol) and short-term (91-day Treasury Bills) interest rates.

3 'PR' is the first difference of the risk premium series. Risk premium is approximated by the difference between the monthly logarithmic returns of the Financial Times Fixed Interest Securities Price Index and the Financial Times Government Securities Price Index.

4 'MP' and 'YP' are the series of one and twelve period differences of the logarithm of industrial production.

5 'UI' and 'DEI' are respectively, the unexpected inflation and first differences in expected inflation derived from the Fisher Hypothesis.

6 '*' indicates a significant autocorrelation coefficient exceeding two standard errors.

7 N is the number of observations in each series.

those portfolios that have a significant first lag autocorrelation to remove the first-lag dependence. This potential thin trading problem is not addressed in CRR.

Next consider the autocorrelations of the macroeconomic series. The first differences of the term structure series (TS) appear to be close to an uncorrelated innovation series. A first order moving-average term may be required for the Risk Premium series (PR). The monthly (MP) and annual changes in industrial production (YP) both exhibit strong annual seasonality. Apart from the lag 12 autocorrelation for UI, which is just significant, both the UI and DEI series are not autocorrelated at any other lags, suggesting that they are both approximately white noise series.

Given the autocorrelation estimates, several contending models were estimated, but only one ARIMA order combination (p,d,q) was chosen to represent each series based on the variance of the residual series and how well the residual series approximate to white noise.

The referee commented that to use one *ex post* ARIMA model based on full sample data to produce the unanticipated components of the explanatory variables, as in an earlier version of this paper, is inconsistent with the *ex ante* orientation of the Fama-MacBeth two-stage regression procedure. We accept that rolling-period prediction models estimated over the same periods as the β coefficients in the two-stage regressions might be more plausible. This method

Table 4

Univariate ARIMA Models for Pricing Factors

$$VW_t = \underset{(2.79)}{\underset{0.0094}{\alpha}} + (1 - \underset{(3.08)}{\underset{-0.1607}{\vartheta_1}} B)\,\xi_t$$

$N = 359$, $R^2 = 0.022$, $\sigma^2 = 0.3086 \times 10^{-2}$, $DW = 2.02$, $Q(24) = 31.5$

$$EW_t = \underset{(3.48)}{\underset{0.0116}{\alpha}} + (1 - \underset{(5.48)}{\underset{-0.2779}{\vartheta_1}} B)\,\xi_t$$

$N = 359$, $R^2 = 0.071$, $\sigma^2 = 0.2442 \times 10^{-2}$, $DW = 2.00$, $Q(24) = 34.9$

$$(1 - B)TS_t = \underset{(0.36)}{\underset{-0.0119}{\alpha}} + \xi_t$$

$N = 346$, $DW = 1.86$, $Q(24) = 30.4$

$$PR_t = \underset{(0.18)}{\underset{0.0001}{\alpha}} + (1 - \underset{(6.86)}{\underset{-0.4041}{\vartheta_1}} B)\,\xi_t$$

$N = 242$, $R^2 = 0.120$, $\sigma^2 = 0.1419 \times 10^{-3}$, $DW = 1.94$, $Q(24) = 26.1$

$$(1 - \underset{(8.93)}{\underset{-0.4425}{\phi_1}} B)(1 - B^{12})MP_t = \underset{(0.16)}{\underset{0.0001}{\alpha}} + (1 - \underset{(21.23)}{\underset{0.7656}{\vartheta_{12}}} B^{12})\,\xi_t$$

$N = 332$, $R^2 = 0.869$, $\sigma^2 = 0.7051 \times 10^{-3}$, $DW = 2.16$, $Q(24) = 58.3$

$$(1 - \underset{(9.55)}{\underset{-0.5201}{\phi_1}} B - \underset{(3.31)}{\underset{-0.1791}{\phi_2}} B^2)(1 - B)YP_t = \underset{(0.27)}{\underset{0.0001}{\alpha}} + (1 - \underset{(21.32)}{\underset{0.7680}{\vartheta_{12}}} B^{12})\,\xi_t$$

$N = 331$, $R^2 = 0.708$, $\sigma^2 = 0.6847 \times 10^{-3}$, $DW = 2.02$, $Q(24) = 43.8$

Notes: See Table 3 for an explanation of notation. DW is the Durbin-Watson statistic, Q(24) is the Box-Pierce statistic for lags 1 to 24. σ^2 is the estimated variance of the residuals ξ_t.

is adopted in this revised manuscript. A program was written to carry out the ARIMA parameter estimations over a rolling period of five years. The one-period ahead residuals are used in the two-stage regressions in the next section.

Not only has this repeated estimation procedure consumed much computer CPU time, it has also generated voluminous statistics. In order to save space we report only the full sample period ARIMA models in Table 4, but readers are reminded that it is residuals calculated from rolling-period ARIMA estimates that are used to form the unanticipated series of the state variables in the two-stage regressions. The seasonal effect is substantial for the two industrial production series. After seasonal differencing over an interval of 12 months, a moving average term at lag 12 is still significant in both cases. The AR(1) term is also significant in both cases indicating that both series have a tendency to be influenced by their values in the previous period.

Economic State Variables and Asset Pricing

The two-stage regression technique used in CRR was adapted from Fama and MacBeth (1973). For the reader's convenience, it is explained in more detail below

(i) The portfolios' exposure to economic variables or market factors was determined by regressing time series of portfolio returns against macroeconomic state variables over an estimation period of five years. Consider a two-variable case,

$$Y_{it} = \alpha_i + \beta_{i1}X_{1t} + \beta_{i2}X_{2t} + e_{it} \tag{1}$$

where Y_{it} is the return for portfolio i during period t, $i = 1,\ldots,20$, $t = -60,\ldots,-1$ (i.e. for a monthly series, it represents returns over the previous five years), α_i is the constant term, X_{1t} and X_{2t} are the unexpected components of the economic state variables or market indices, β_{i1} and β_{i2} are the exposures to X_1 and X_2, and e_{it} is the zero mean idiosyncratic term caused by random effects.

(ii) The resulting estimates of exposure (betas) were used as the independent variables in cross-sectional regressions, as stated below, one regression for each month, with portfolio returns being the dependent variable. In CRR the same betas were used for an entire year. In our case, the betas were revised every month. For a two-variable example,

$$Y_i = \alpha' + b_1\beta_{i1} + b_2\beta_{i2} + e_i'. \tag{2}$$

Here Y_i is the next period return for portfolio i (i.e. for time $t = 0$), β_{i1} is the exposure to factor X_1 for portfolio i estimated from equation (1) above and e_i' is a mean zero random error. Each coefficient from a cross-sectional regression provides an estimate of the risk premia b_i, if any, associated with the exposure to the unanticipated movements in the state variable for that month (see CRR).

(iii) Steps 1 and 2 were then repeated for each month in the sample, yielding for each macroeconomic variable a time series of estimates of its associated risk premium. The time-series means of these estimates were then tested by a t-test for significant differences from zero.

Using this two-stage regression technique we carried out analyses on each individual macroeconomic factor. The correlations between macroeconomic factors are not large enough to produce a collinearity problem. None of the correlation coefficients is greater than 0.5. The multivariate regression results are very unstable. Pricing of a factor can become significant in one case but not in another when different combinations of macroeconomic factors are included in the multivariate regression. The following text concentrates on discussing the univariate tests.

It has been suggested to us that the relationship between macroeconomic and stock market returns may not be contemporaneous. Any macroeconomic impact could be slow and occur 'in the long-run'. Also, if one accepts the efficient market theory, then the reaction of the stock market may lead the performance of the economy. To incorporate potential lead/lag relationships, we ran the program thirty more times, fifteen of which involved a lead factor in equation (1) of up to 15 months and fifteen with lagged terms. This procedure was carried out for each of the market indices and macroeconomic factors. The results, as reported in Table 5(a), show no important pricing relationship unlike that reported in CRR.

Table 5 is a summary of the two-stage regression tests. '+' and '−' respectively indicate a positive and a negative significant relationship when the t-ratio of the regression coefficient exceeds 1.96 or is less than −1.96. '*' indicates that no significant relationship is detected. The mean and median DW statistics indicate a brief description of the distribution of DW statistics of the individual time series of risk premia. 'Lead' indicates that the macro variable leads stock returns and similarly for 'lag'. The numbers reported are the number of leads/lags where the significant relationships are detected. For example, in Table 5(a) a significant positive relationship was found with VW lagging stock returns by nine months.

Some significant t-ratios appear sparingly among the 31 lead/contemporaneous/lag relationships in Table 5(a). The results from CRR are reported in Table 5(b) for comparison. None of the significant t-ratios reported in our tests represents a contemporaneous relationship. The relationships of stock returns to PR, MP and AP appear to be of the wrong sign.

One striking fact is that most of the DW statistics of the time series of risk premium reported in Table 5(a) are above 2, indicating a negative lag 1 autocorrelation in the underlying series. This suggests the time series of risk premia estimates is unstable; a higher than average premium estimate is followed immediately by a lower than average estimate. This fluctuating property of premia estimates is unconvincing as a model of returns expectations. Theoretically, the risk premium ought to be fairly stable, possibly exhibiting a trend movement. CRR do not mention any time series properties of their series of risk premia estimates other than the mean and t-ratio. The negative autocorrelation in our premia series will bias the t-ratios towards zero, as the variance of the sample mean is overstated.

The one common finding in our tests and in CRR is that, although the market index explains a significant portion of the time series variability of stock returns, it has an insignificant influence on pricing. Some of the tests in CRR even

Table 5

Summary Results for Two-stage Regression Univariate Tests
Significant Lead/Lag Relationships and Durbin-Watson Statistics

	Lead	*Contemporaneous*	*Lag*	*DW Mean [Median]*
(a) Prewhitened Series of Macroeconomic/Market Factors with Time Varying Estimates				
VW	*	*	+9	2.37 [2.38]
EW	*	*	−13	2.40 [2.38]
PR	*	*	*	2.52 [2.54]
TS	*	*	−2 −15	2.36 [2.34]
MP	*	*	−13	2.44 [2.44]
YP	*	*	*	2.41 [2.39]
UI	*	*	+9	2.41 [2.39]
DEI	*	*	*	2.42 [2.40]

(b) Significant contemporaneous relationships in CRR:

VW	*/−	multivatiate approach with variations
	+	univariate approach
EW	*	
PR	+	
TS	−	
MP	+	
YP	*	
UI	−	
DEI	−	

	Lead	*Contemporaneous*	*Lag*	*DW Mean [Median]*
(c) Original Series of Macroeconomic/Market Factors:				
VW	+11 −3 +1		*	1.82 [1.80]
EW	−3 +1	*	−13	1.83 [1.84]
PR	−2	*	−2 −7 −14	1.86 [1.84]
TS	+15 −7	*	−6 +14	1.88 [1.79]
MP	−15 −11 +9 −5	*	−1 +3 −7 +15	1.79 [1.79]
YP	−1	*	+13	1.89 [1.87]
UI	−15 +9	*	−3	1.89 [1.90]
DEI	+15 +12 +9	−0	−3 −15	1.88 [1.89]

Notes:
1 '+' and '−' represent a significant positive and negative relationship respectively.
2 'Lead' indicates macro variable leads stock returns.
3 'Lag' indicates macro variable lags stock returns.
4 The numbers reported under 'Lead' and 'Lag' indicate the number of leads/lags at which the risk premium has a t-ratio whose absolute value is greater than 1.96.
5 '*' indicates no significant relationship is detected.
6 See Table 3 for explanations of 'VW', 'EW', 'PR', 'TS', 'MP', 'YP', 'UI' and 'DEI'.
7 DW is the Durbin-Watson statistic.

produce a negative relationship between market index and expected returns; a result which is inconsistent with the CAPM model. CRR call this finding 'striking' (p.402). With the evidence and clues gathered from our tests, we can cast some light on this negative relationship. We computed rank correlations between average market betas, mean returns and firm size. The market betas are generated from the first stage regression. The rank correlations are as follows:

	β_{vw}	β_{ew}	*Returns*
Returns	−0.570	−0.433	—
Firm Size	0.977	0.854	−0.609

The negative relationship between size and mean returns has already been reported in the sub-section headed Autocorrelation and Univariate Models. The returns and market betas relationship appears to be negative and statistically significant, a 'puzzling' fact noted previously. What is new in this rank correlation exercise is the high, significant positive relationship between size and market betas. (This restates the claim we made earlier in the sub-section headed Stock Returns Series that our size premium will increase on a risk adjusted basis, consistent with Levis, 1985.) The negative returns-betas relationships could therefore be induced by the positive size-betas and negative size-returns relationships.

We are not entirely convinced that the small size firms have smaller market betas or smaller systematic risk. We suspect the small estimated betas could possibly be due to a thin trading effect. Of course, a question remains: why do small size firms have larger average returns? The tests in this study are not designed to address this issue. The results do show however, that macroeconomic factors may not be priced in the way described in CRR, at least not in the UK.

DISCUSSION

The results in CRR are of considerable interest although they are not particularly convincing. For their Table 4 and Panel B, of the three sub-periods analysed only the second sub-period, 1968–1977, produced significant t-ratios at the five percent level. It is clear that the significant t-ratios for their entire period are dominated by price behaviour in the second sub-period.

If size based portfolio returns exhibit a systematic pricing pattern with respect to macroeconomic factors as suggested by CRR, an intriguing question remains. Is the stock returns-macroeconomic factor relationship induced by their individual relationships with firm size? It is arguable that smaller firms might be exposed to macroeconomic factors to a greater extent than their larger counterparts, the better diversified multi-national corporations. If size is an important property influenced by macroeconomic factors in the US, it may not be possible to apply the model or replicate the tests in the context of another country as many uncontrollable variables are involved. Company legislation, tax law, influential economic variables, etc., vary from country to country. Another related question is that if the relationship between stock returns and macroeconomic factors holds in the manner described in CRR, why did it fail to give positive results for portfolios based on stock price levels? As mentioned in the sub-section headed Stock Returns Series, CRR find that stock price level is an alternative way to group stocks into portfolios that have a wide spread of returns.

Several points are noted about the two-stage regressions and the methodology in CRR. The appropriateness of this test relies very much on the assumption that the market prices assets in a precise, systematic and linear manner. It does not matter if the exposure of the stock returns to particular macroeconomic factors is statistically insignificant or erratic. What matters is that cross sectional returns are linearly related to measures of exposure to that macroeconomic factor (i.e. betas generated by the first regression). In fact, in CRR, the stock market index, although it explained a significant proportion of the time series variability of stock returns, has no significant role in pricing. On the other hand, the industrial production series, which was found to have a strong impact on pricing, is not significantly correlated with the stock market index for the entire period or for any subperiod.

Secondly, we have noted during tests not reported here that the two-step regression analysis is very sensitive to the number of independent variables included in the regressions. A particular factor may appear to be significant in one multivariate analysis but not when other independent variables have been changed or when analysed alone in a univariate model, and vice versa. A similar phenomenon has been observed in Hamao (1988). We suspect that this may be due to the narrow ranges of betas and cross-sectional returns in the second stage regression. In one particular instance, we discovered while performing univariate two-stage regressions on VW that the betas are often very close to 1. On the other hand, size based portfolios can fail to produce a good spread of returns in a short span of time, such as one month. With these narrowly spread betas and returns fed into the second stage regression, it is not surprising that the results do not show a systematic risk premium. It is suggested that a more flexible approach like a Granger-causality test should be adopted. One may also use pricing factor beta to form portfolios. The latter approach becomes complicated when lead/lag relationships are involved.

Thirdly, CRR did not consider any lead/lag relationships between stock market pricing and macroeconomic performance. The relationships may not be captured by a contemporaneous term, especially when the announcements of some macroeconomic variables are subject to publication lags and subsequent revision. When the market is efficient, it has been argued that the market is capable of forecasting future movements and therefore should lead the macroeconomic variables. We have included lead/lag factors in our study, but no important relationships were detected.

Fourthly, the industrial production series in CRR is reported to be highly seasonal. However, they did not make any attempt to remove this seasonality. Also they did not report any serial dependence or thin trading problem for the portfolio returns. The Box-Pierce statistic for EWNY in CRR suggests that the first 24 autocorrelation are not insignificant and the first lag autocorrelation is statistically significant in their Table 3. It is possible that their small size portfolios also suffer from a thin trading problem.

In this study we have shown that the macroeconomic factors CRR claimed to detect in the US market do not influence stock market pricing indiscriminately. At the very least, we have shown that these pricing factors do not affect share prices in the UK market in a manner similar to that described in CRR. It could be that some other macroeconomic factors are at work or the methodology in CRR is inadequate for detecting such pricing relationships or possibly both explanations apply.

Other Research Findings

At the time of revising this manuscript, independent evidence has appeared testing macroeconomic pricing factors in the spirit of CRR. This evidence covers the US, Japanese and Spanish markets. Shanken and Weinstein (1987) used the same set of data as CRR. After correcting for the error-in-variables problem in the *t*-statistics of risk premia estimates, Shanken and Weinstein (SW) found that industrial production and the risk premia on bonds are not priced. Hamao (1988) tested the Japanese market and found strong pricing evidence as suggested by CRR except for the case of Japanese monthly production. Martinez and Rubio (1989) used Spanish data and like us found no significant pricing relationship between stock returns and macroeconomic variables. Moreover, they demonstrated that the multi-factor APT with macroeconomic state variables fails to explain the size effect in Spanish stock returns.

Following SW, Martinez and Rubio (MR) adjust the *t*-statistics for the error-in-variables problem using a type of generalized least square regression. MR also grouped their portfolios based on security betas and industrial sectors. However, they found that these two types of grouping methods failed to spread portfolio returns and did not produce significant pricing relationships.

Apart from a short sample period problem of only ten years, the macroeconomic and market factors in Hamao (1988) are also subjected to serial correlation. Seasonal factors are inherent in some of the series. These problems were also observed in the pricing factors in CRR. The Japanese stock market does not seem to suffer from as many thin trading problems as the UK stock market. Nevertheless, the EW Tokyo Stock Exchange Industry Index is still significantly autocorrelated at lag 1. Evidence will be provided later to show that when serial dependence is not removed spurious relationships may exhibit themselves.

It has been suggested that the prewhitening process in Martinez and Rubio, as in this paper, may have filtered away the pricing information. Using unfiltered series, CRR, SW and Hamao produced some significant pricing relationships. MR tested the original unfiltered series on portfolios grouped by betas. The sign of the risk premium for industrial production changed from negative to positive whereas the coefficients of PR and TS became statistically significant. To make our tests more comparable with other authors, we re-estimated the two-state regressions using the original series which are not subjected to the prewhitening process. The results are reported in Table 5(c). Many significant t-ratios emerged. Again, none of the significant relationships detected is in the contemporaneous term except for the case of *DEI*. It is difficult to convince oneself that the results in Table 5(c) are not spurious. The significant lead 1 influences from VW and EW for example, are probably due to the high lag 1 autocorrelation in stock returns and high correlation between stock returns and market index returns.

In Table 5(c), most of the macroeconomic parameters have some positive and some negative association with stock returns except PR which consistently exhibits a negative influence. With these mixed ' + ' and ' − ' signs, how could one attempt to establish the individual relationships between stock returns and macroeconomic variables? We suspect that significant autocorrelations, seasonal effects and 'reverting' behaviour in the series have a considerable potential to account for these significant ' + ' and ' − ' findings.

One important point to note is that SW, MR and Hamao, unlike CRR, all used cross-sectional regressions running over the same period to estimate betas. Using returns generated betas to predict returns in the same period will create a bias towards producing significant results and is contradictory to the spirit of the *ex ante* orientation of Fama-MacBeth two-stage regressions. Hamao carried out a second type of regression, which is similar to the one used in our study and conforms to the Fama-MacBeth method. The level of significance and the number of significant cases was then reduced. A short sample period is a potential problem in the studies of Hamao and Martinez and Rubio. Hamao's sample period is ten years whereas Martinez and Rubio have only seven years data. The *ex ante* two-stage regression in Hamao (1988) reduced the time series of risk premia estimates to six years.

NOTES

1 Shanken and Weinstein (1985 and 1987), McElroy and Burmeister (1986), Cho and Pak (1986) and Hamao (1988).

2 Brown and Weinstein (1983), Chen (1983) and Roll and Ross (1980).

3 One could argue that survival bias is not crucial in the framework of the APT. What is really needed in tests are assets with a 'good' spread of returns. Nevertheless, the referee helpfully noted in his comments on an earlier version of this paper that survival bias may exclude failed firms, takeover and merger victims, and newly listed companies, for which macroeconomic factors could have been particularly important.

4 It is interesting to note that the number of missing values seems to be higher in December and lower at the beginning of the year. Of the 20 years sampled in this study, 16 of the highest missing value months of the year are December. Also 19 out of the 20 minimum missing value months are spread out in the first quarter and eight of them are January. Although the Christmas–New Year holiday is longer than five days, it is not the main cause for this data

problem for we exclude shares that have not been traded in the last five days before a month ends only if the final share price is the same as the previous month's value. This trading pattern may provide a clue to the phenomenon of the well known turn-of-the-year effect.

5 The referee of the first version of this paper noted that there is a database bug for December 1983 in LSPD.

6 The work of Yaansah and Peasnell (1987) shows that, in the UK, the capital gain contributes a larger proportion than the interest income to the total return of fixed interest securities. The exclusion of interest income therefore may not be crucial to the results of our tests.

7 'Main Economic Indicators', OECD Department of Economics and Statistics, Paris, Cedex 16, France.

8 This first-lag phenomenon is already well documented for daily stock return data. e.g. Fama (1965) and Perry (1982) for US returns and Cunningham (1973) for UK returns.

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