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Applying GARCH for examining CAPM and APT across Time

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Biography

N. Soufian is a doctoral candidate at Manchester Metropolitan University. She is researching on pricing of risk in the UK stock market. Her Research interests include asset-pricing, cost of capital, international asset pricing and small firms performance in stock markets.

Abstract

This paper examines the performance of APT and CAPM across time, considering the acquired betas from GARCH-type models. This paper also includes structural breaks for those factors that have undergone significant change in their mean or volatility.

Correction for hetero-scedasticity in the estimation of beta in the first-stage of the two-stage estimation procedure of CAPM gives an improvement over OLS. Relative to OLS, IGARCH gives smaller estimates of betas, higher risk premia, increased in log-likelihood and higher R^2. However, adding the macro-economic factors to the model, the result for market portfolio is different from that of the CAPM. After adding the economics factors coefficient, the power of the market portfolio's beta has either diminished or reduced.

Relative to OLS, applying IGARCH improved the performance of APT for the full time-period, however, over entire three samples, the correction for hetero-scedasticity by GARCH is not sufficient to lead to satisfactory ressult for APT. This paper similar to Soufian, Joseph and Ritche (2000) shows that different macro-economic factors capture the variation in average returns for different time periods.

Keywords: Conditional Capital Asset Pricing Model, Beta Instability, Premium Beta and Conditional Market Risk Premium,

1. Introduction*

In the presence of conditional hetero-scedasticity applying OLS can over-estimate the market risk, Morgan and Morgan (1987). By applying a Generalised ARCH-type model, some improvement in the efficiency of estimators in the regression parameters can be expected. The GARCH-type models perform better in cases where data generating processes produce auto-regressive conditional hetero-scedasticity. Morgan and Morgan (1987) estimate abnormal returns in small and large firms and their results show that the ARCH estimates of market risk are smaller than the corresponding OLS estimates, so the ARCH estimates of average abnormal return are larger. Relative to OLS, correction for hetero-scedasticity substantially improves the residual diagnostic test values and strengthens the evidence for abnormal returns.

This paper examines the performance of CAPM and APT across time when we allow for GARCH and structural breaks. In the first stage of a two stage estimation procedure, the estimation of beta is acquired by using a GARCH-type model in the time series regressions and includes structural breaks for those factors that have undergone significant changes in their mean or volatility.

The contribution of this paper is unique in respect with the followings. This paper attempt firstly to obtain the estimation of beta by using GARCH-type models the first-stage of the two-stage estimation procedure. This paper also includes structural breaks for those factors that have undergone significant change in their mean or volatility. Secondly, considering the acquired betas from GARCH-type models and structural breaks, this paper examines the cross-sectional average return for APT and CAPM across three samples of time periods.

The rest of this paper is organised as follows. The second section describes the estimation procedures to acquire the estimated betas from GARCH-type models and the structural breaks across three samples of time-periods. This section also explains the second stage of the estimation procedure. The estimated betas from stage one are used to examine the cross-sectional expected return across three samples of time-periods (testing

* The author is very thankful for the helpful discussion with Professor Ian Garrett and Dr Nathan Joseph in School of Accounting and Finance in Manchester University.

CAPM and APT). The third section provides the results for time series and cross-sectional regressions across samples. Some concluding remarks are offered in section four.

2. Data and Estimation Procedures

This section proceeds by discussing the data and the estimation procedures.

2.1 Data

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 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. Considering the various attributes of the data, performing various calculations on the data is involved filtering procedures for time period[2], missing values, financial firms[3] and thin trading[4]. Following Fama and MacBeth (1973) on portfolio formation procedure, 49 portfolios are constructed. In this approach, first firms are sorted by their market value into seven size portfolios. Then, each of the seven portfolios are sorted based on their pre-ranked betas into a further seven portfolios. Thus, we end up with 49 portfolios of firms. Each portfolio includes between 25-30 companies. This approach is on the basis of reducing the correlation between size and beta and it provides portfolios with a good spread of returns. Furthermore, this research applies an *ex-ante* sampling rule that is to form portfolios from ranked beta computed from data for one period (36 months), and then using a subsequent period for estimation. This approach makes the errors to a large extend random across securities within a portfolio.

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

2 Due to the interest of this study the data is filtered for different time periods and forms the three sub-sets of data: The full period of 1980-1997, the first sub-period of 1980-1989 and the second sub-period of 1981-1997. These periods are formed on the basis that during each sub-set of data the UK economy underwent different economic conditions.

[3] 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.

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. The followings are the variables that have been used to measure unexpected components of macro-economic factors.

Default Spread

Chen, Roll and Ross (1986) used the difference between the yields on the Government Long term bonds as their proxy for risk premia. However, as in the UK there is no reliable time series data on corporate bond ratings and returns (Poon and Taylor 1991,p623), therefore, this study similar to Poon and Taylor (1991) used the difference between monthly logarithmic returns of the Financial Times Fixed Interest Securities Price Index and the Financial Times Government Securities Price Index. To avoid confussion between terms: risk premia and risk premium, this study uses the term default spread.

Term Structure

The yield on a Government long-term bond, i.e. 20 years, and 3 month Treasury bill was downloaded from datastream and difference between long-term and short term is used for term structure.

Unexpected inflation

The seasonality adjusted UK Retail Price Index (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 RPI. The unexpected inflation variable is defined as

$$UI_t = I_t - E\,[I_t / t\text{-}1]$$

4 One of the obvious adjustments that needs to be made for the UK data is that to control for the problem of thin trading. This study applies the Dimson and Marsh (1983) Trade-to-Trade method for thin trading.

Where I_t is the realised monthly UK inflation rate for period *t*. The series of expected inflation, $E\ [I_t | t\text{-}1]$ was obtained by following the procedures in Fama and Gibbons (1982, 1984).

Change in expected inflation.

This study similar to CRR used ΔE(It) because it is partially unanticipated and might have an influence separable from *UI*. The series of expected inflation, E [It│t-1] was obtained by following the procedures in Fama and Gibbons (1982, 1984). The change in expected inflation is the series of first differences of expected inflation. It is computed as $\Delta E(I_t) = E[I_{t+1} | t] - E[I_t | t-1]$

Monthly and annual growth rates of industrial production

The seasonally adjusted monthly Industrial Production index has been collected from Datastream. 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. *YP* is the annual growth in industrial production. The reason to consider the yearly growth is that the equity market is related to changes in industrial activity in the long run. If P_t denotes the industrial production index in month *t*, then the monthly growth rate (IP_t) is

$IP_t = \ln P_t - \ln P_{t-1}$

And the yearly growth rate is

$YP_t = \ln P_t - \ln P_{t-12}$

2.2. Estimation Procedures

2.2.1. Obtain the estimate of betas from Time Series Model, Considering GARCH and Structural Breaks

In a two-stage model, the estimates of beta come from time series regression, Equation (1) and then prices of risk are obtained from the cross-sectional model, Equation (2).

$$R_{it} = \alpha_i + \beta_{i1} f_{1t} + \ldots + \beta_{ik} f_{kt} + \varepsilon_{it}, \qquad (1)$$

$$R_i = \lambda_0 + \lambda_1 \beta_{i1} + \ldots + \lambda_k \beta_{ik} + \eta_i, \qquad (2)$$

Accordingly, stocks as a whole provide a risk premium over risk-free securities. What is at issue here is the methodology employed in the studies. The time variation in returns and betas is connected to how asset prices are determined in equilibrium. Better knowledge of time series properties of the return generating process is important to advance our understanding of asset pricing. Hence, this paper begins the analysis by examining at the properties of the estimation of betas generated from the time series regressions. Examining the plots for market portfolio and macroeconomic factors has led this study to further the time series analyses by considering two possible sources of variations: Occurrence of structural change in the factors and persistence of hetero-scedasticity.

2.2.1.1. Structural Break

The inspection for an auto-correlation function and unit root served to indicate whether there is a trend present in the factor series[5]. The presence of a structural change, however, can complicate such a test for trends (which might not be captured in the auto-correlation function and unit root tests). A policy change can result in a structural break that makes an otherwise stationary series appear to be non-stationary. Before running the time series model to obtain the betas, this study examines the factor series for structural change.

Inspection of plots for the seven macro-economic factors indicates that term structure is a pertinent candidate for the presence of the structural break. The plots for the term structure in Figure 1 indicate several changes in the mean of the series.

[5] The results for auto-correlation and stationarity tests on market portfolio and macro-economic variables are shown in appendix I.

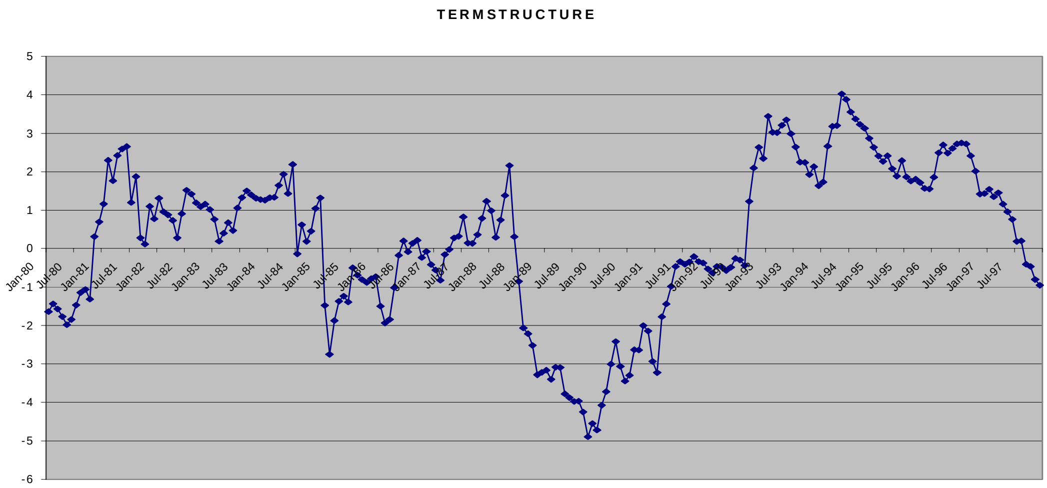

Figure 1: Plots of term structure for the period of 1980-1997

The Perron (1989) test carries out the test for structural break for the series. The stock market crash and other dramatic events are exogenous shocks having permanent effects on the mean of most macro-economic variables. The Perron test is a formal procedure to test for unit root in the presence of a structural change at time $t=\tau+1$. To carry out the test, four possible breaks were identified from the plots of the term structure: 1984, 1988, 1991 and 1992. Using Perron (1989), the term structure series has been examined for a structural break in the case of four break points.

The Perron (1989) test for these series suggest the occurrence of the structural break for the year 1992; meaning that the structural change for the year 1992 has a permanent effect on the mean of the series. This result is consistent with the fall of the pound sterling in relation to the ERM in the UK exchange market on Black Wednesday September 1992. Hence, dummies similar to the dummies that are introduced in the Perron test i.e. dummies that allow the intercept to change, have been added for term structure to the time series regressions.

Moreover, examining the plots for the value weighted market portfolio's returns in Figure 2 shows a substantial fall in stock market prices during the crash October 1987. Inspection of the plots for the market portfolio's return has been carried out from a different angle. As can be seen in the plots, there are several spikes associated with stock market crashes. The biggest spike is related to Black Monday in October 1987. As the crash happened in October 1987, one could see that there was a return back to the point before the crash and there is no trend in the sequence before and after the crash. Therefore, in order to avoid cancellation, this study has selected dummy variables for the followings pulses; first; a dummy for the period before the crash and at the points of the crash (i.e. 30.09.1987, 30.10.1987), a second dummy for the first points after the crash (i.e. 30.11.1987), which return to the level attained before the crash. A third dummy for (30.12.1987) that reaches almost the same level as before the crash. Hence, dummies for the pulse immediately before, the exact time of the crash and after the crash are added to the time series regression.

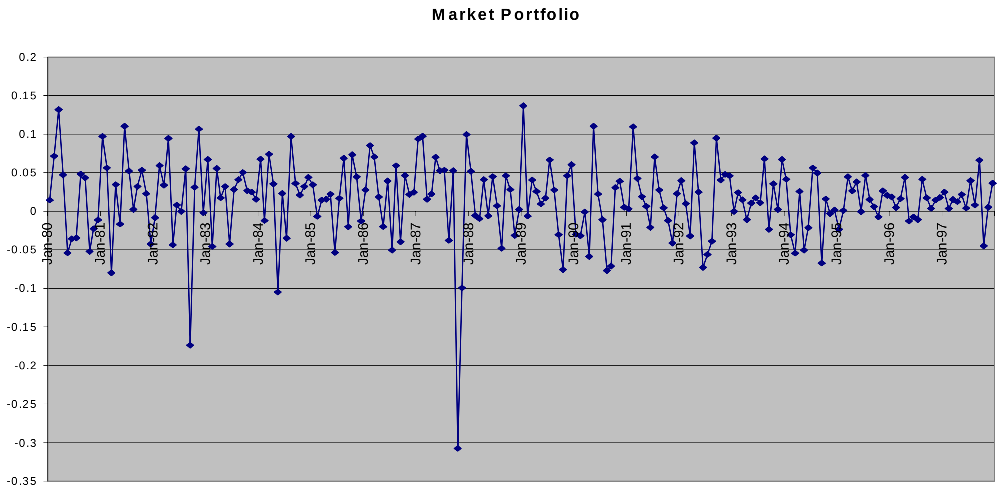

Figure 2: Plots of value weighted market portfolio for the period of 1980-1997

2.2.1.2. Conditional Hetero-scedasticity

For most of the data exhibiting volatility across time, the unconditional variance (the long-term variance) is constant even though the conditional variance during some periods is unusually large. Therefore, the estimation methods that use conditional variances are more appropriate for this type of data, as the hetero-scedasticity in the disturbances biases the test statistics, leading to incorrect inferences. More importantly, in the presence of any non-spherical disturbances, the estimators themselves are no longer best linear unbiased. The BLUE of the parameter vector (β) in spherical disturbances (i.e. homo-scedastic and non-auto-correlated disturbances) is given by $\hat{\beta} = (X'X)^{-1} X'Y$. With non-spherical disturbances, the vector (β) can in fact be shown to be $\beta^* = (X'V^{-1}X)^{-1} X'V^{-1}Y$ where V is the variance-covariance matrix that violates the constant variance and zero covariances of disturbances.

There are several approaches to dealing with hetero-scedasticity. Studies like Morgan and Morgan (1987) examine the small firm effect comparing the OLS and ARCH estimates of abnormal returns. Their results demonstrate how the existence of persistent hetero-scedasticity affects the estimates of abnormal returns. They emphasise that correction for auto-regressive hetero-scedasticity, by applying ARCH estimation methods substantially improves the estimators. The Generalised ARCH model allows the conditional variance to follow an ARMA process for both auto-regressive and moving average components in the hetero-scedastic variance. The GARCH model is an approach to modelling time series with hetero-scedastic errors. This paper used GARCH to estimate the variance-covariance matrix of returns, in order to obtain the estimates of beta.

$$R_{it} = \alpha_i + \beta_{i1} f_{1t} + ... + \beta_{ik} f_{kt} + dummies + \varepsilon_{it}, \quad (3)$$

$$\varepsilon_t = \sqrt{h_t} e_t \quad (4)$$

$$h_t = \omega + \sum_{i=1}^{q} \alpha \varepsilon_{t-i}{}^2 + \sum_{j-1}^{p} \gamma_j h_{t-j} \quad (5)$$

The dummies in Equation (3) are for those factors that have undergone significant change in their mean or volatility. Equation (5) shows that this technique allows the conditional variance (h_t) to be an ARMA process. The ARCH (q) model is the same as the GARCH (0,q) model. The key feature of GARCH models is that the conditional variance constitutes an ARMA process that allows for both auto-regressive and moving average components in the hetero-scedastic variance. The obtained betas from the time series models, Equation (3), are added to the second stage of estimation (cross-sectional regressions) as independent variables.

2.2.2. Cross-sectional Regressions (Applying APT and CAPM)

The second-pass consists of cross-sectional regressions. The resulting estimated 49 portfolio betas, acquired from time series regressions (applying GARCH-type models and including structural breaks), are used as independent variables in the cross-sectional regression, with portfolio returns being the dependent variable. The resulting estimated 49 portfolio betas are the measure of the portfolios' exposure to the VW market portfolio and macro-economic factors. In the second stage, three data sets for three samples of time-periods are constructed. The number of columns include the monthly portfolio returns and resulting estimated portfolios' betas acquired from the time series regressions. Each coefficient resulting from the cross-sectional regression provides an estimate of the risk premia, if any, associated with the exposure to the market portfolio and 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 full time-period, 18 years estimation, the time series means for 216 resulting estimated coefficients, were tested by a *t*-test for a significant difference from zero.

3. *Results and Hypotheses Tested*

The present section provides a detailed analysis of the results of the time series and cross-sectional regressions applied to examine the constant expected return asset pricing models (CAPM and APT) across time in the UK stock market. This section is organised as follows. Section 3.1 outlines the test for the structural breaks in the factors and their plots indicate structural change. Section 3.2 discusses the results for time series regressions, examining an ARCH effect in the time series model. The results from the ARCH test, are used to estimate the betas by fitting an appropriate GARCH model in the time series regressions. Section 3.3 presents the results when the obtained betas from Equation (3) are applied in a cross-sectional regression (testing CAPM and APT). Section 3.4 demonstrates the results for cross-sectional regressions, examining CAPM and APT, considering the betas acquired from GARCH-type models.

3.1. *Results for Structural Break*

Inspection of plots for the seven factors indicates that term structure is a pertinent candidate for the presence of a structural break. To carry out the tests, four possible breaks points were identified from the plots of term structure: 1984, 1988, 1991 and 1992. Using Perron (1989), the term structure series has been examined for a structural breaks in the case of four break points.

$$TS_t^{1984} = \mu_0 + \mu_1 t + \beta_1 D_p + \beta_2 D_L + \beta_3 D\ (T_b)_t + \alpha\ TS_{t-1}^{1984} + \sum_{i=1}^{k} c_i \Delta TS_{t-i}^{1984} + \varepsilon_t \quad (6)$$

$$TS_t^{1988} = \mu_0 + \mu_1 t + \beta_1 D_p + \beta_2 D_L + \beta_3 D\ (T_b)_t + \alpha\ TS_{t-1}^{1988} + \sum_{i=1}^{k} c_i \Delta TS_{t-i}^{1988} + \varepsilon_t \quad (7)$$

$$TS_t^{1991} = \mu_0 + \mu_1 t + \beta_1 D_p + \beta_2 D_L + \beta_3 D\ (T_b)_t + \alpha\ TS_{t-1}^{1991} + \sum_{i=1}^{k} c_i \Delta TS_{t-i}^{1991} + \varepsilon_t \quad (8)$$

$$TS_t^{1992} = \mu_0 + \mu_1 t + \beta_1 D_p + \beta_2 D_L + \beta_3 D\ (T_b)_t + \alpha\ TS_{t-1}^{1992} + \sum_{i=1}^{k} c_i \Delta TS_{t-i}^{1992} + \varepsilon_t \quad (9)$$

These equations allow for a one-time change in both the intercept and the trend. Each change is assumed to take place at the same time. The subscript *L* is to indicate that the *level* of the dummy changes, the subscript *P* refers to the fact that there is a single *pulse* in the dummy variable which might have a permanent effect on the level of the series and the subscript *t* refers to a time trend. D_L is one if $t>T_b$ (otherwise zero), T_b is the time at which the break occurred in the trend function. D_p is one for the pulse (otherwise zero) and D_t is the trend $t>T_b$ (otherwise zero).

Testing the four possible break points for $\alpha = 1$, the largest (negative) *t*-ratio is rejected for the null hypothesis in favour of stationarity. Using the critical values in Zivot and Andrews (1992), the choice of September 1992 minimises the *t*-ratio for $\hat{\alpha} = 1$ over all possible break points. Table 6.1 shows the results.

Table 1: Test for structural change

	α	T-Ratio
Break point 1984	-1.53	-9.37
Break point 1988	-1.036	-7.66
Break point 1991	-.1.14	-15.05
Break point 1992	-0.102	-3.43

The critical values in Zivot and Andrews (1992) for α=1 is: -5.57 (1%), -5.08 (5%) and –4.82 (10%).

The break point of September 1992 is coincident with the sudden fall of the pound sterling in relation to ERM in the UK exchange rate market on Black Wednesday. According to these results, the crash in the exchange rate has had a long-term effect on the mean of the term structure. Hence, dummies similar to the dummies that are introduced in the Perron test i.e. dummies that allow the intercept to change, have been added for term structure to the time series regressions, Equation (3).

The plots for market portfolio's return show that the biggest spike is related to Black Monday in October 1987. As the stock market crash happened in October 1987, one could see that there was a return back to the point before the crash and there is no trend in the sequence before and after the crash. Therefore, in order to avoid cancellation, this study has selected dummy variables for the period before the crash, the exact crash and after the crash are added to the time series regression, Equation (3).

The next section presents the results of examining the time series regression for an ARCH effect and fitting appropriate GARCH models in the above time series regressions.

3.2. Results for Modelling the data with Conditional Hetero-scedasticity

3.2.1. Results of Testing for ARCH effect

The entire macro-economic variables and market portfolio have been filtered for non-stationarity and auto-correlation[6]. However the series might have conditional hetero-scedasticity despite having constant unconditional (or long run) mean or variance (i.e. this fact does not imply that conditional hetero-scedastisity is a source of non-stationarity). By filtering the series, we removed the non-stationarity problem[7]. However, this section aims to examine the series for conditional hetero-scedasticity. Some economic series, at some periods of time, fluctuate widely compared with other times. A series might grow slow throughout one period, but become highly volatile in the next period. In other words, the unconditional (or long-run) variance of a series might be constant but there are periods in which the variance is relatively high. Such time series properties can be well modelled by different time varying econometric techniques like GARCH. By applying a GARCH-type model, some improvement in the efficiency of the estimator of regression parameters can be expected.

3.2.2. Applying IGARCH

In a two-stage model where the estimates of betas are obtained from time series, a time series analysis is a crucial stage in identifying the properties of the returns generating process. The time series analysis performed for this study has identified the factors with a structural break and the ARCH effect in the residual of the time series regressions. Such time series' properties can be adequately modelled by applying GARCH. This

[6] The results for auto-correlation and stationarity tests on market portfolio and seven macro-economic variables are discussed in Chapter Five..

[7] Make them to have a constant mean and variance.

technique is used to estimate the variance-covariance matrix of returns in the time series regressions allowing the conditional variance to vary over time. Hence GARCH modelling of the time series of regressions' residuals with the conditional variance provides an efficient estimation of betas. It also improves the estimation value itself, Morgan and Morgan (1987).

The following sections discuss the results of correction for hetero-scedasticity on the residuals of the time series regression of the 49 portfolio returns tested against 1) the market portfolio 2) the market portfolio and macro-economic factors, for three samples of time periods.

Results for Applying IGARCH (1,1,M) Time Series Regressions of CAPM, Full Time-period (1980-1997)

IGARCH (1,1,M) is used to model the hetero-scedasticity in the time series regressions' 49 portfolio returns against the market portfolio. Dummy variables for the stock market crash in October 1987 are also added into the 49 time series regressions. Table 2 summarises the estimates of beta, first-order auto-regressive and moving average parameters, R^2 and the residual properties of the 49 time series regressions for the full time-period. The coefficients for betas and first-order auto-correlation and moving average parameters for conditional variances are significantly different from zero in 49 cases. Table 3 demonstrates results for the time series regression, applying OLS for the CAPM for the full time period. The GARCH estimates of betas are consistently smaller than the corresponding OLS estimates of betas that are shown in Table 3 Comparing the log-likelihood and R^2 of OLS and GARCH in Table 2 and 3 shows that the GARCH estimations consistently provide larger log-likelihood and R^2. GARCH approximates the error variance and provide some improvement in the efficiency of the estimators of the regressions parameters. In short, correction for the hetero-scedasticity by IGARCH (1,1,M) gave an improvement over OLS. Relative to OLS, GARCH gives an increase in log-likelihood, higher R^2, smaller conditional variances and smaller coefficients for betas.

Table 2: Result for Time Series Regressions IGARCH (1,1, M) for CAPM (Full time period) Model

$$h_t = \omega + \sum_{i=1}^{q} \alpha\varepsilon_{t-i}{}^2 + \sum_{j-1}^{p} \gamma_j h_{t-j}$$

No Ptf	Log-L	R^2	β_{VW} IGARCH	ω	A_1	γ_1	μ
1	336.82	0.264	0.489***	.0016**	0.215***	0.785***	0.023
2	344.30	0.320	0.386***	.0016***	0.533***	0.533**	-0.008
3	358.14	0.410	0.507***	.0012***	0.478	0.522***	0.001**
4	353.26	0.349	0.665***	.0015***	0.212***	0.787***	0.011*
5	352.28	0.344	0.533***	.0001	0.132***	0.867***	.0012***
6	356.29	0.421	0.595***	.0000	0.074**	0.726***	0.002*
7	329.13	0.353	0.511***	.0017*	0.252***	0.748***	0.005**
8	401.37	0.379	0.377***	.001*	0.483***	0.517***	0.002**
9	397.88	0.475	0.514***	.001**	0.496***	0.504***	0.001*
10	411.78	0.521	0.604***	.001	0.081*	0.819***	0.012
11	398.67	0.470	0.628***	.001***	0.080**	0.001	0.302*
12	394.66	0.480	.688***	.001*	0.474**	0.526***	0.001**
13	354.30	0.466	0.656***	.001**	0.489**	0.511**	0.000
14	343.55	0.424	0.653***	.000	0.048**	0.951***	0.017*
15	406.25	0.510	0.515***	.001*	0.461**	0.540***	-0.003
16	395.47	0.0.470	.523***	.0001***	.001***	.001***	0.693^{8}
17	420.38	0.520	0.646***	.000	0.042*	0.957***	0.030*
18	431.64	0.572	0.607***	.000	0.116***	0.884***	-0.003
19	395.10	0.513	0.619***	.001*	0.179***	0.821***	-0.001
20	373.96	0.563	0.811***	.001*	0.105**	0.894***	-0.011
21	361.46	0.545	0.901***	.000	0.107**	0.893***	0.009**
22	442.97	0.561	0.550***	.0002***	0.491***	0.508***	0.000
23	432.87	0.575	0.660***	.0001*	0.500***	0.500***	0.0001*
24	435.86	0.586	0.604***	.001	0.076**	0.924***	0.0001*
25	416.67	0.589	0.717***	.0006***	0.800***	0.0001**	0.014**
26	428.22	0.604	0.707***	.0002**	0.492***	0.507***	0.0001*
27	409.17	0.607	0.746***	.000	0.128**	0.872***	0.013*
28	378.09	0.558	0.826***	.000	0.124***	0.876***	0.013
29	462.59	0.552	0.556***	.0001*	0.480**	0.520**	-0.001
30	450.17	0.630	0.735***	.0002*	0.477**	0.522**	0.001
31	434.56	0.646	0.706***	.0001*	0.462**	0.538**	0.002*
32	439.75	0.649	.813***	.0002**	0.497***	0.502***	0.0001*
33	444.20	0.688	0.854***	.000	0.078**	0.921***	0.014*
34	415.51	0.631	0.918***	.000	0.086**	0.913***	0.004
35	392.93	0.622	0.977***	.000	0.095**	0.905***	0.039**
36	460.77	0.681	0.780***	.0001*	0.492***	0.508***	0.001*
37	464.36	0.730	0.855***	.0001*	0.500**	0.500**	0.000
38	484.91	0.771	0.931***	.0001*	0.489***	0.511***	0.000
39	476.84	0.793	1.053***	.000	0.109**	0.891***	0.012***
40	476.86	0.782	1.019***	.000	0.054**	0.845***	0.008***
41	464.27	0.782	1.073***	.000	0.031*	0.569***	-0.002
42	418.98	0.760	1.147***	.0002**	0.481***	0.518***	0.001*
43	551.68	0.871	0.899***	.00007**	0.500***	0.500***	0.0001*
44	587.62	0.901	1.047***	.0000	0.184**	0.815***	0.359***
45	583.23	0.911	1.060***	.0002***	0.023	0.877***	0.830*
46	580.24	0.892	1.076***	.000	0.500***	0.500***	0.000
47	544.04	0.877	1.066***	.0002***	0.000	0.0001***	0.001***
48	553.54	0.891	1.168***	.000	0.072**	0.827***	-0.005
49	520.41	0.887	1.167***	.0003	0.129**	0.871***	0.009*

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

Table 3: Result for Time Series Regressions OLS for CAPM (Full time period)

No Ptf	Log-L	R^2	β_{VW} OLS	No Ptf	Log-L	R^2	β_{VW} OLS
1	333.391	0.237	0.577***	26	407.901	0.561	0.827***
2	338.385	0.239	0.567***	27	395.047	0.573	0.901***
3	348.900	0.333	0.680***	28	358.002	0.527	0.974***
4	340.505	0.317	0.682***	29	401.139	0.516	0.564***
5	329.963	0.278	0.653***	30	409.684	0.619	0.736***
6	340.301	0.341	0.721***	31	407.877	0.623	0.820***
7	316.070	0.287	0.712***	32	409.135	0.622	0.825***
8	381.574	0.283	0.521***	33	425.840	0.657	0.892***
9	381.254	0.392	0.666***	34	406.147	0.612	0.927***
10	390.321	0.425	0.684***	35	375.124	0.593	1.042***
11	387.529	0.411	0.668***	36	406.837	0.670	0.791***
12	385.577	0.434	0.711***	37	460.657	0.711	0.895***
13	338.504	0.405	0.833***	38	408.927	0.733	0.921***
14	328.835	0.363	0.797***	39	470.306	0.766	1.050***
15	398.636	0.455	0.699***	40	473.148	0.770	1.044***
16	395.792	0.392	0.622***	41	460.447	0.722	1.066***
17	414.003	0.484	0.689***	42	409.387	0.726	1.223***
18	407.255	0.476	0.701***	43	505.130	0.855	0.933***
19	373.840	0.448	0.772***	44	569.431	0.872	0.995***
20	355.860	0.512	0.952***	45	577.538	0.891	1.023***
21	342.756	0.503	1.002***	46	508.775	0.855	1.055***
22	440.379	0.520	0.650***	47	506.539	0.842	1.070***
23	426.612	0.519	0.693***	48	504.840	0.871	1.136***
24	420.061	0.513	0.710***	49	511.236	0852	1.183***
25	414.338	0.559	0.800***				

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

Results for Applying IGARCH (1,1,M) Time Series Regressions for CAPM, two sub-periods (1980-1989 and 1990-1997)

IGARCH (1,1,M) is used to model the hetero-scedasticity in the time series regression of 49 portfolio returns against market portfolio for the first and second sub-periods (1980-1989 and 1990-1997). Dummy variables for the stock market crash in October 1987 are added into the 49 time series regressions for the first sub-period (1989-1989). Table 4 shows the results for the first sub-period. The first two columns of Table 4 compare the coefficient estimates of beta for OLS and IGARCH, and the rest of the columns summarises the log-likelihood, the first-order auto-regressive and moving average parameters and the residual properties of the 49 time series regressions. Consistent with the full time-period, in the first sub-period, the coefficients for betas and first-order auto-correlation and moving average parameters for conditional variances are significantly different from zero in 49 cases. The GARCH estimates of betas are consistently smaller than corresponding OLS estimates of betas. Table 5 gives the results for the second sub-period (1990-1997) in the same format as Table 4. In Table 5, the GARCH estimates of betas are consistently smaller than the corresponding OLS estimates. The outcomes in Tables 4 and 5 are essentially similar to that for the full time-period. In short, correction for the hetero-scedasticity by IGARCH (1,1,M) gave an improvement over OLS for the estimators across three samples of time-periods.

Table 4: Result for IGARCH (1,1,M) for CAPM (First sub-period 1980-1989)

Model $h_t = \omega + \sum_{i=1}^{q} \alpha \varepsilon_{t-i}{}^2 + \sum_{j-1}^{p} \gamma_j h_{t-j}$

No	β_{VW} OLS	β_{VW} IGARCH	Log-L	ω	α_1	γ_1	μ
1	0.6183***	0.51955***	205.82	0.00111	0.785***	0.785***	0.00833***
2	0.5790***	0.30086***	204.97	0.00116	0.467***	0.467***	0.06960***
3	0.6982***	0.51740***	207.72	0.00113	0.522***	0.522***	0.00144***
4	0.7199***	0.58497***	217.02	0.00095	0.788***	0.788***	-0.00024
5	0.7166***	0.61897***	213.22	0.00089	0.868***	0.868***	-.77479
6	0.7250***	0.63186***	201.66	0.00120	0.926***	0.926***	0.00368
7	0.7146***	0.52866***	204.90	0.00109***	0.748***	0.748***	0.77549
8	0.5761***	0.46924***	224.95	0.00081	0.517***	0.517***	0.02965***
9	0.6901***	0.46480***	226.56	0.00081	0.504***	0.504	0.00142
10	0.6750***	0.61292***	238.33	0.00066	0.919***	0.919***	-0.00001
11	0.6766***	0.58210***	233.15	0.00064***	.001***	.001***	0.00352
12	0.7077***	0.65185***	215.15	0.00102	0.526***	0.526***	-0.00483
13	0.8293***	0.61659***	206.81	0.00113	0.511***	0.511***	0.05787***
14	0.8004***	0.65618***	211.43	0.00099	0.952***	0.952***	0.00215
15	0.7475***	0.55878***	224.86	0.00081	0.539***	0.539***	-0.01025
16	0.6596***	0.57234***	234.86	0.00073***	.001***	.001***	-0.01341
17	0.7303***	0.80762***	237.40	0.00054	0.958***	0.958***	0.06252
18	0.7285***	0.57483***	251.88	0.00050	0.884	0.884	-0.00012
19	0.7472***	0.66103***	236.67	0.00066	0.821	0.821	0.00244***
20	0.9125***	0.83817***	217.14	0.00105***	0.895	0.895	0.00153***
21	0.9525***	0.78137***	214.14	0.00100	0.893	0.893	0.02471***
22	0.6663***	0.58982***	252.01	0.00059	0.509***	0.509***	-0.00026
23	0.7062***	0.67968***	242.95	0.00055***	0.500	0.500	0.00000
24	0.7023***	0.59222***	239.19	0.00061***	0.924	0.924	0.00699***
25	0.7602***	0.71492***	228.92	0.00082	0.070	0.070	-0.02012
26	0.8034***	0.69162***	263.35	0.00039	0.508***	0.508***	0.00000
27	0.8423***	0.59158***	234.23	0.00065	0.872	0.872	0.03244***
28	0.9259***	0.81194***	236.89	0.00070***	0.876	0.876	0.04638***
29	0.5822***	0.59160***	262.71	0.00040	0.520***	0.520***	-0.00073
30	0.7358***	0.72236***	264.80	0.00046	0.522***	0.522***	-0.00116
31	0.8155***	0.67117***	245.17	0.00052	0.538***	0.538***	0.00064***
32	0.8140***	0.79528***	244.45	0.00068	0.502***	0.502***	0.00077***
33	0.8993***	0.92805***	250.46	0.00054	0.922***	0.922***	0.00044***
34	0.8809***	0.80960***	242.67	0.00063	0.914***	0.914***	0.00020
35	0.9676***	0.97731***	245.19	0.00052	0.905	0.905	0.00049***
36	0.8343***	0.81837***	271.91	0.00034	0.508***	0.508***	0.00031
37	0.8968***	0.84469***	267.29	0.00037	0.500	0.500	0.09310***
38	0.9047***	0.90918***	283.11	0.00028	0.511	0.511	-0.00045
39	1.0047***	0.99503***	277.31	0.00032	0.891***	0.891***	0.00002
40	1.0243***	0.99403***	270.56	0.00041	0.946	0.946	-0.00009
41	1.0276***	1.05187***	261.60	0.00045	0.969***	0.969***	0.00213***
42	1.1581***	1.11533***	252.44	0.00051	0.519***	0.519***	0.00041
43	0.9490***	0.93999***	300.41	0.00023	0.500	0.500	0.00000
44	0.9902***	0.95625***	308.68	0.00019	0.816	0.816	0.07690
45	0.9787***	1.01175***	306.87	0.00020	0.977***	0.977***	0.00000
46	1.0370***	1.06712***	325.85	0.00015	0.500***	0.500***	0.00015
47	1.0248***	1.00252***	311.04	0.00021	0.050***	0.050***	-0.00004
48	1.0924***	1.10524***	311.73	0.00019	0.928***	0.928***	0.00227***
49	1.1426***	1.13722***	283.61	0.00030	0.871***	0.871***	0.00000

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

Table 5: Result for IGARCH (1,1,M) for CAPM (Second sub-period 1990-1997)

Model $h_t = \omega + \sum_{i=1}^{q} \alpha \varepsilon_{t-i}^{2} + \sum_{j-1}^{p} \gamma_j h_{t-j}$

No	β_{VW} OLS	β_{VW} IGARCH	Log-L	Ω	α_1	γ_1	μ
1	0.4285***	0.39297***	132.28	0.00209	0.00000	0.00000	0.03318
2	0.4921***	-0.03434***	146.45	0.00141	0.00000	0.00000	0.00000
3	0.5852***	0.48069***	154.36	0.00133	0.09567	0.09567	0.07220
4	0.5254***	0.68269***	133.99	0.00207	0.23559	0.23559	0.19118
5	0.4177***	0.27671***	142.17	0.00124	0.20369	0.20369	0.20297
6	0.6592	0.20272	143.41	0.00152	0.08127	0.08127	0.07826
7	0.6514	0.57604	125.08	0.00255	0.00000	0.00000	0.00000
8	0.3364	0.08229	168.82	0.00093	0.27559	0.27559	0.26988
9	0.5633	0.50673	173.49	0.00084	0.00769	0.00769	0.00000
10	0.6874	0.68756	162.52	0.00126	0.07734	0.07734	0.07910
11	0.6167	0.19781	156.67	0.00138	0.00000	0.00000	0.00000
12	0.7025	0.70940	169.86	0.00090	0.82480	0.82480	0.82664
13	0.8131	0.58105	143.88	0.00178	0.06944	0.06944	0.10151
14	0.7503	0.63675	128.20	0.00225	0.00000	0.00000	0.00000
15	0.5422	0.41875	178.01	0.00102	0.00000	0.00000	0.00000
16	0.4985	0.21591	171.92	0.00095	0.00000	0.00000	0.00000
17	0.5464	0.35944	175.36	0.00092	0.00008	0.00008	0.04960
18	0.6116	0.33245	174.43	0.00085	0.05609	0.05609	0.09129
19	0.8274	0.58028	149.85	0.00151	0.18859	0.18859	0.17453
20	1.0375	0.56873	148.10	0.00128	0.49767	0.49767	0.46670
21	1.1249	1.06708	136.86	0.00196	0.11756	0.11756	0.11359
22	0.5860	0.43719	191.32	0.00062	0.05084	0.05084	0.06732
23	0.6454	0.61625	193.31	0.00064	0.00000	0.00000	0.00000
24	0.7457	0.62280	180.97	0.00074	0.00008	0.00008	0.12139
25	0.9049	0.79442	187.69	0.00060	0.19624	0.19624	0.18956
26	0.8952	0.70639	168.27	0.00091	0.16012	0.16012	0.15655
27	1.0628	0.62407	166.70	0.00094	0.15085	0.15085	0.16321
28	1.1206	0.86039	132.98	0.00224	0.13070	0.13070	0.13072
29	0.5018	0.52296	200.47	0.00057	0.00000	0.00000	0.00000
30	0.7266	0.59250	191.76	0.00064	0.00000	0.00000	0.00000
31	0.8202	0.70842	189.42	0.00075	0.00000	0.00000	0.00000
32	0.8546	0.70498	183.13	0.00079	0.00000	0.00000	0.00000
33	0.8793	0.78486	176.78	0.00092	0.11578	0.11578	0.10133
34	1.0473	0.97751	167.60	0.00094	0.20769	0.20769	0.20554
35	1.2586	1.11870	144.12	0.00165	0.11653	0.11653	0.10758
36	0.6501	0.76990	192.95	0.00063	0.00000	0.00000	0.00000
37	0.8967	0.84849	196.17	0.00057	0.00051	0.00051	0.07944
38	0.9678	0.99535	198.42	0.00056	0.00000	0.00000	0.00000
39	1.1805	1.26612	188.10	0.00071	0.00224	0.00224	0.10702
40	1.1098	1.10008	190.60	0.00071	0.00000	0.00000	0.00000
41	1.1845	1.27338	193.05	0.00060	0.15159	0.15159	0.15230
42	1.4128	1.25111	172.65	0.00077	0.00000	0.00000	0.00000
43	0.8867	0.93741	251.56	0.00017	0.00000	0.00000	0.24671
44	1.0106	0.99145	256.67	0.00015	0.23392	0.23392	0.18384
45	1.1490	1.10251	269.34	0.00012	0.00000	0.00000	0.00000
46	1.1027	1.06497	251.52	0.00017	0.11394	0.11394	0.11869
47	1.2071	1.31022	244.72	0.00019	0.00000	0.00000	0.00000
48	1.2588	1.29557	231.48	0.00029	0.04174	0.04174	0.10214
49	1.3043	1.29150	221.51	0.00032	0.12569	0.12569	0.18231

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

Results for Applying IGARCH (1,1) for APT, Full-period (1980-1997) and two sub-periods (1980-1989 and 1990-1997)

IGARCH (1,1) is used to obtain estimations of betas for the time series regressions of 49 portfolio returns against the market portfolio and macro-economic factors across three samples of time-periods. Table 6 summarises the estimated coefficients of betas[8] for the market portfolio and macro-economic factors obtained from applying IGARCH (1,1) for the full time-period. Panel B of Table 6 summarises these coefficients for the OLS time series regressions. The GARCH estimates of betas are larger and in some case smaller than corresponding OLS estimators. Tables 7 and 8 for the first and second sub-periods (1980-1989 and 1990-1997) give results in the same format as Table 6 for the full time-period. The outcomes in Table 7 and 8 for the two sub-periods are essentially similar to that for the full time-period (Table 6). Consistent with the results of applying IGARCH for CAPM, correction for the hetero-scedasticity by applying IGARCH(1,1) in APT gives an improvement over OLS for the estimations of betas and in the efficiency of the estimators of the regression parameters across three samples of time-periods

[8] As size of the tables are too large, only the results for the coefficient betas are discussed and presented in this section and the results for log-likelihood and the coefficients for the first-order auto-correlation and moving average parameters for the three time-periods samples are presented in appendix III.

Table 6: Results for the APT (Full Period).

Panel A: Results for the Obtained Betas from IGARCH (1,1)

Ptf	β_{DRP} GARCH	β_{DTS} GARCH	β_{IPG}	β_{DYPG}	β_{UI}	β_{DEI}	β_{vw}
1	0.4987	-0.0041	-0.1566	-0.3189	-0.0028	0.0076	0.5293
2	0.9753	-0.0096	0.2668	-0.2590	-0.0029	0.0073	0.4428
3	0.4541	-0.0013	-0.2134	-0.1057	0.0015	0.0025	0.5221
4	0.7881	-0.0010	-0.0109	-0.3559	0.0066	-0.0048	0.6982
5	0.0503	0.0014	-0.3183	-0.2083	0.0068	-0.0006	0.5284
6	0.6562	0.0034	-0.1954	0.0734	0.0006	-0.0036	0.6392
7	0.3809	0.0021	0.2053	-0.2299	0.0040	-0.0102	0.5135
8	0.2022	0.0037	0.4327	-0.1109	-0.0007	-0.0004	0.4041
9	0.7118	-0.0028	-0.0049	0.1994	0.0020	-0.0016	0.5784
10	0.4321	-0.0109	-0.1667	0.0136	0.0053	-0.0007	0.6377
11	0.3459	-0.0101	-0.0655	-0.0286	0.0008	0.0016	0.6599
12	0.5476	-0.0019	-0.0584	-0.0726	-0.0022	0.0028	0.7265
13	0.7157	-0.0034	0.1777	-0.1466	-0.0062	0.0013	0.6998
14	0.1811	-0.0026	-0.2203	-0.1851	-0.0029	0.0010	0.6646
15	0.4855	0.0011	-0.2694	-0.1162	-0.0021	0.0005	0.5528
16	0.4631	-0.0025	-0.1482	0.1138	0.0015	-0.0035	0.5247
17	0.6126	0.0034	-0.2899	-0.0208	0.0005	-0.0029	0.7423
18	0.4422	0.0024	0.1244	-0.0588	0.0048	-0.0037	0.6214
19	0.7173	-0.0022	-0.1808	0.0864	-0.0052	0.0007	0.6739
20	0.3096	-0.0022	-0.1226	-0.0779	-0.0033	0.0005	0.8446
21	0.4166	-0.0065	0.0292	0.0042	0.0078	-0.0070	0.9454
22	0.4483	0.0003	-0.1625	-0.2090	-0.0061	0.0028	0.5510
23	0.6419	-0.0033	-0.1305	-0.1277	-0.0011	-0.0001	0.6613
24	0.3692	-0.0024	-0.0969	-0.0981	-0.0014	0.0022	0.6319
25	0.7655	-0.0032	-0.0308	-0.0622	0.0055	-0.0017	0.7568
26	0.8035	-0.0013	-0.0469	0.0471	0.0006	-0.0042	0.7703
27	0.2439	-0.0001	-0.1927	-0.0211	-0.0028	0.0053	0.7614
28	0.5380	-0.0018	-0.1526	0.0282	-0.0056	0.0024	0.8669
29	0.1878	-0.0007	-0.2001	0.0572	-0.0024	-0.0005	0.5693
30	0.4399	0.0006	0.0396	0.0158	-0.0040	0.0004	0.7427
31	0.3898	-0.0018	0.0394	-0.0765	-0.0007	0.0002	0.7256
32	0.3022	0.0007	-0.2140	0.0118	-0.0003	-0.0005	0.8711
33	0.3743	0.0016	-0.0089	-0.2781	-0.0016	0.0030	0.8541
34	0.2210	0.0017	0.1176	-0.1666	0.0014	-0.0012	0.9282
35	0.1639	0.0042	-0.4549	0.0609	-0.0059	0.0013	1.0086
36	0.2573	-0.0026	0.0646	0.0375	0.0010	0.0008	0.8040
37	0.5162	0.0037	0.1045	0.0107	0.0002	0.0008	0.8602
38	0.3495	-0.0026	0.0146	0.0820	-0.0017	-0.0023	0.9626
39	0.4348	0.0044	0.3340	0.0059	-0.0031	0.0007	1.0482
40	0.6363	0.0007	-0.0398	0.2509	-0.0010	0.0005	1.0518
41	0.5556	0.0014	0.0210	-0.0116	-0.0001	-0.0013	1.1368
42	0.0928	0.0017	0.2844	0.0241	0.0039	0.0008	1.1495
43	0.0772	-0.0004	-0.0100	0.0212	-0.0010	0.0024	0.8962
44	0.1492	0.0011	0.0052	-0.0131	0.0012	-0.0002	1.0519

45	-0.018	-0.0021	0.1060	0.0852	-0.0050	0.0028	1.0662
46	0.2451	0.0020	0.0673	0.1047	0.0022	0.0015	1.0775
47	-0.012	-0.0007	0.0046	0.1468	-0.0030	0.0010	1.0917
48	0.1528	-0.0018	0.1107	0.0663	-0.0048	0.0004	1.1737
49	0.1012	-0.0007	-0.2115	0.2381	-0.0009	-0.0009	1.1831

Panel B: Results for the Obtained Betas from OLS for the APT (Full Period)

Ptf	β_{DRP}	β_{DTS}	β_{IPG}	β_{DYPG}	β_{UI}	β_{DEI}	β_{vw}
1	0.3123	0.0027	0.0989	-0.2449	-0.0054	0.0075	0.5764
2	0.8519	-0.0082	-0.0347	-0.0089	-0.0013	-0.0009	0.5797
3	0.3120	-0.0057	-0.1218	-0.0028	-0.0030	0.0022	0.6901
4	0.5254	-0.0038	0.0599	-0.1514	0.0003	-0.0024	0.6932
5	0.3447	0.0030	-0.0755	-0.1746	-0.0045	0.0057	0.6557
6	0.6642	-0.0020	-0.1094	0.1347	-0.0027	-0.0034	0.7320
7	0.5017	0.0030	0.0639	-0.1479	0.0052	-0.0116	0.7215
8	0.4408	-0.0014	-0.0152	0.1387	-0.0072	0.0008	0.5280
9	0.6217	-0.0025	-0.0131	0.2525	0.0004	-0.0039	0.6694
10	0.1441	-0.0053	-0.1241	0.0627	0.0025	-0.0009	0.6933
11	0.4528	-0.0040	-0.0338	-0.0274	0.0022	0.0007	0.6830
12	0.4009	-0.0039	-0.0193	-0.0045	-0.0018	0.0005	0.7148
13	0.7369	-0.0030	0.1390	-0.1062	-0.0053	0.0033	0.8310
14	0.2667	-0.0019	-0.1338	-0.1115	-0.0042	0.0010	0.8070
15	0.4464	0.0008	-0.1798	-0.1260	0.0004	-0.0022	0.7048
16	0.3870	-0.0048	-0.0608	0.1331	-0.0045	-0.0022	0.6296
17	0.5390	0.0029	-0.2399	0.0391	-0.0018	-0.0006	0.6990
18	0.3702	-0.0010	-0.0879	0.1663	0.0014	-0.0041	0.7066
19	0.7182	-0.0016	-0.1392	0.2325	-0.0073	0.0010	0.7851
20	0.1007	-0.0014	-0.0925	-0.1139	-0.0081	0.0022	0.9602
21	0.4346	-0.0056	-0.1075	0.1822	0.0015	-0.0032	1.0162
22	0.2960	-0.0006	-0.1733	-0.0253	-0.0026	0.0007	0.6539
23	0.4425	-0.0018	-0.1356	-0.0711	-0.0002	0.0006	0.7019
24	0.3901	-0.0055	-0.0354	0.0745	0.0002	-0.0007	0.7165
25	0.6443	-0.0023	-0.0104	0.0719	-0.0008	0.0015	0.8043
26	0.7638	0.0009	-0.0207	0.1547	-0.0018	-0.0027	0.8404
27	0.2568	-0.0010	-0.2252	0.1263	-0.0005	0.0023	0.9138
28	0.5957	0.0013	-0.1284	0.0800	-0.0102	0.0049	0.9904
29	0.1240	-0.0019	-0.2065	0.0808	-0.0017	-0.0011	0.5760
30	0.3066	0.0003	0.0339	0.0378	-0.0025	-0.0001	0.7392
31	0.3230	-0.0014	0.0776	-0.0268	0.0000	-0.0009	0.8265
32	0.2485	0.0026	-0.1807	0.0194	0.0006	-0.0003	0.8314
33	0.4120	-0.0005	-0.0555	-0.0194	-0.0020	0.0019	0.8971
34	0.0903	0.0020	0.0945	-0.0759	-0.0017	0.0002	0.9341
35	0.2600	0.0064	-0.4418	0.1442	-0.0082	0.0018	1.0574
36	0.1827	-0.0018	0.0561	0.0369	-0.0037	0.0033	0.8006
37	0.3792	0.0029	-0.0427	0.0895	0.0007	-0.0006	0.8980
38	0.2602	-0.0001	-0.0135	0.0999	-0.0039	-0.0013	0.9257
39	0.3633	0.0066	0.3574	0.0140	-0.0038	0.0009	1.0447
40	0.4032	0.0024	0.0802	0.1627	-0.0036	0.0020	1.0487
41	0.3865	0.0021	0.0421	0.0165	-0.0016	-0.0003	1.0725
42	0.2659	0.0036	0.2437	0.0600	0.0012	0.0020	1.2230

43	0.1387	0.0003	-0.0202	0.0339	-0.0001	0.0011	0.9343
44	0.0944	0.0023	0.1104	-0.1187	-0.0023	0.0041	0.9902
45	-0.0066	-0.0012	0.1602	0.0450	-0.0050	0.0033	1.0208
46	0.2395	0.0020	0.0692	0.1127	0.0012	0.0017	1.0539
47	0.0418	-0.0019	0.0549	0.0546	-0.0047	0.0023	1.0726
48	0.0270	-0.0016	0.0158	0.0621	-0.0066	0.0010	1.1328
49	0.2001	0.0033	0.0221	0.1413	-0.0010	0.0000	1.1865

Table 7: Result for the APT (First sub-period 1980-1989).

Panel A: Result for the Obtained Betas of Applying IGARCH(1,1)

Pf	β_{DRP}	β_{DTS}	β_{IPG}	β_{DYPG}	β_{UI}	β_{DEI}	β_{vw}
1	0.7809	-0.0117	-0.1147	-0.1376	0.0010	0.0070	0.5657
2	0.3071	-0.0117	0.2214	-0.4325	0.0069	0.0033	0.3762
3	0.3399	-0.0076	-0.2193	-0.1851	0.0047	0.0037	0.5013
4	0.1283	-0.0010	0.1378	-0.4555	-0.0012	0.0023	0.5483
5	-0.0032	-0.0057	-0.1543	-0.0815	-0.0035	0.0067	0.6348
6	0.3500	-0.0094	-0.3036	0.0478	0.0095	0.0015	0.6210
7	0.3480	-0.0038	-0.1761	-0.1801	0.0096	0.0016	0.5483
8	0.2889	0.0063	0.4220	0.0324	0.0026	-0.0013	0.4382
9	0.4951	-0.0045	-0.0293	0.2038	-0.0004	0.0025	0.5278
10	0.0507	-0.0141	-0.1292	-0.0135	-0.0010	0.0025	0.6333
11	0.0396	-0.0075	0.1853	-0.0889	0.0039	0.0033	0.6263
12	0.2775	-0.0065	0.1102	-0.0597	0.0026	0.0035	0.6390
13	-0.0995	-0.0092	0.2365	-0.0842	0.0015	0.0045	0.6398
14	-0.7137	-0.0141	0.1337	-0.0928	0.0019	0.0007	0.6826
15	0.3417	-0.0031	-0.1146	-0.2150	0.0035	0.0025	0.5543
16	0.2591	-0.0011	-0.0247	-0.1976	-0.0012	-0.0018	0.6236
17	0.3044	-0.0014	-0.2020	-0.1040	-0.0004	0.0019	0.7716
18	-0.0107	0.0004	0.2178	-0.0844	-0.0016	0.0019	0.6225
19	0.4696	-0.0056	-0.0474	-0.1399	0.0016	-0.0009	0.6564
20	-0.1852	-0.0120	0.1059	-0.1277	0.0037	0.0010	0.8040
21	-0.0682	-0.0087	0.3371	-0.0987	0.0036	0.0023	0.8606
22	0.0348	-0.0056	-0.1563	-0.1554	0.0007	-0.0027	0.5818
23	0.2920	-0.0069	-0.1740	-0.1169	-0.0003	0.0037	0.6404
24	0.2060	-0.0053	-0.0518	-0.0997	-0.0011	0.0025	0.6702
25	0.8176	-0.0068	-0.0399	-0.1123	0.0018	0.0050	0.7344
26	0.4585	-0.0013	0.0461	-0.0368	-0.0012	0.0002	0.7829
27	0.0784	-0.0085	-0.0650	0.0544	0.0017	0.0052	0.7558
28	-0.0296	-0.0054	-0.1349	0.0083	0.0010	-0.0016	0.8719
29	-0.0756	-0.0034	-0.1322	-0.0371	0.0001	0.0016	0.5357
30	0.2430	-0.0028	0.1270	0.0042	0.0014	0.0018	0.6924
31	0.3643	-0.0079	-0.0714	-0.3141	-0.0011	0.0019	0.7927
32	0.1653	-0.0025	-0.0684	-0.0739	0.0012	0.0031	0.7893
33	0.1608	-0.0025	-0.0249	-0.2653	0.0024	0.0010	0.9247
34	-0.2211	-0.0020	0.1781	-0.2773	0.0008	0.0011	0.8414
35	0.1248	0.0021	-0.2820	0.0661	-0.0029	-0.0006	0.9672
36	0.1451	-0.0058	0.0718	0.0476	0.0013	0.0026	0.8444
37	0.4395	0.0006	0.3538	-0.0420	0.0019	0.0012	0.8771
38	0.1753	-0.0028	0.0657	-0.0838	0.0007	0.0003	0.9499
39	0.3387	0.0034	0.5811	-0.0648	0.0022	0.0016	0.9493
40	0.2014	-0.0038	0.0969	0.2893	0.0006	-0.0002	1.0528
41	0.0465	-0.0007	0.1121	-0.0415	0.0025	0.0016	0.9845
42	0.2383	-0.0020	0.1237	0.1528	0.0031	0.0048	1.1495
43	0.4146	-0.0025	-0.0381	0.1485	-0.0002	0.0023	0.9205
44	-0.0500	0.0011	0.0944	-0.0759	0.0021	0.0010	0.9756
45	0.0723	-0.0017	0.3239	0.1472	0.0007	0.0006	0.9502
46	0.2740	0.0015	0.1946	0.1211	-0.0008	0.0030	1.0703

47	0.1158	-0.0021	-0.0551	0.1156	-0.0011	-0.0005	1.0451
48	-0.0181	0.0012	0.1003	0.0646	0.0017	-0.0008	1.0720
49	0.2825	-0.0016	-0.0851	0.1501	-0.0003	-0.0005	1.1707

Panel B: Result for the Obtained Betas of Applying OLS for the APT

Pf	β_{DRP}	β_{DTS}	β_{IPG}	β_{DYPG}	β_{UI}	β_{DEI}	β_{vw}
1	0.5985	-0.0068	-0.0760	-0.0630	0.0028	0.0031	0.6152
2	0.5172	-0.0106	-0.0044	-0.1555	0.0026	-0.0001	0.5654
3	0.2525	-0.0070	-0.1708	-0.0504	0.0031	0.0032	0.6623
4	0.1766	-0.0041	0.0708	-0.3592	-0.0004	0.0018	0.6907
5	0.3293	-0.0038	-0.1448	-0.1243	-0.0003	0.0072	0.6978
6	0.3526	-0.0028	-0.1447	0.0508	0.0075	-0.0008	0.6919
7	0.4506	-0.0003	0.0135	-0.2131	0.0056	0.0022	0.6948
8	0.5791	0.0018	0.0751	0.1916	0.0024	-0.0018	0.5721
9	0.5440	-0.0076	-0.1045	0.3420	0.0004	0.0013	0.6955
10	-0.2793	-0.0114	-0.0661	-0.0646	0.0004	0.0013	0.6769
11	-0.1111	-0.0076	-0.0736	-0.0551	0.0045	0.0033	0.6556
12	0.2172	-0.0075	0.0669	-0.0962	0.0028	0.0020	0.6853
13	0.4772	-0.0039	0.2334	-0.1023	0.0026	0.0023	0.7960
14	-0.0593	-0.0101	-0.1224	-0.0504	0.0025	0.0023	0.7907
15	0.5150	-0.0035	-0.1955	-0.0533	0.0012	0.0028	0.7457
16	0.3467	0.0003	-0.0055	-0.0282	-0.0007	0.0003	0.6540
17	0.3543	-0.0013	-0.2394	-0.0655	0.0010	0.0006	0.7149
18	-0.0646	-0.0030	0.0326	0.0597	0.0001	0.0026	0.7156
19	0.5543	-0.0018	-0.0430	0.1287	-0.0002	0.0010	0.7506
20	-0.1436	-0.0077	-0.0132	-0.2025	0.0023	0.0020	0.8888
21	0.0734	-0.0089	-0.0168	-0.0240	0.0030	0.0023	0.9347
22	0.1095	-0.0042	-0.2012	-0.1303	-0.0003	-0.0023	0.6709
23	0.3465	-0.0085	-0.2168	-0.0978	0.0009	0.0033	0.6954
24	0.2937	-0.0065	0.0426	-0.0459	0.0002	0.0028	0.6862
25	0.7350	-0.0071	0.0690	-0.0129	0.0018	0.0048	0.7394
26	0.5056	-0.0011	0.0041	-0.0043	-0.0011	-0.0005	0.8053
27	0.1405	-0.0047	-0.0771	0.0865	-0.0004	0.0045	0.8384
28	0.1630	-0.0043	-0.1938	0.0449	0.0005	-0.0010	0.9202
29	0.0170	-0.0042	-0.1918	-0.0173	-0.0003	0.0001	0.5783
30	0.3105	-0.0048	0.0823	0.0269	0.0006	0.0015	0.7208
31	0.3323	-0.0050	0.1651	-0.1771	0.0008	0.0015	0.8026
32	0.0362	-0.0026	-0.1043	-0.0013	0.0013	0.0032	0.7960
33	0.2226	-0.0057	0.0770	-0.0771	0.0009	0.0020	0.8803
34	-0.2463	-0.0020	0.0920	-0.2347	0.0005	0.0015	0.8653
35	0.1993	-0.0002	-0.3302	0.1059	-0.0017	-0.0009	0.9789
36	0.1837	-0.0057	0.0351	0.0326	0.0024	0.0026	0.8244
37	0.3783	-0.0019	0.0901	-0.0194	0.0013	0.0013	0.8881
38	0.1914	-0.0035	0.0533	-0.0753	0.0006	-0.0005	0.9028
39	0.3561	0.0036	0.5863	-0.0566	0.0017	0.0018	0.9705
40	0.1711	-0.0023	0.1833	0.0934	0.0004	0.0011	1.0180
41	0.0648	-0.0010	0.1077	-0.0314	0.0014	0.0020	0.9995
42	0.2602	-0.0018	0.1314	0.1542	0.0031	0.0060	1.1474
43	0.4243	-0.0018	-0.0359	0.1582	0.0001	0.0019	0.9533
44	0.0048	0.0022	0.1375	-0.1258	0.0028	0.0019	0.9630
45	0.0888	-0.0007	0.2907	0.0429	0.0009	0.0007	0.9685
46	0.2617	0.0008	0.2105	0.1332	-0.0001	0.0026	1.0286
47	0.1551	-0.0017	0.1325	0.0645	-0.0009	0.0004	1.0323
48	-0.0196	-0.0003	0.1050	0.0648	0.0009	-0.0009	1.0900

49	0.2154	-0.0009	-0.0457	0.1468	-0.0005	0.0015	1.1394

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

Table 8: Result for the APT (Second sub-period 1990-1997).

Panel A: Result for the Obtained Betas, Applying IGARCH(1,1)

Pf	β_{DRP}	β_{DTS}	β_{IPG}	β_{DYPG}	β_{UI}	β_{DEI}	β_{vw}
1	0.2024	0.0623	-0.5638	-0.8288	0.0053	0.0217	0.6379
2	1.5120	-0.0092	-0.5183	0.6403	-0.0380	0.0018	0.4134
3	0.3732	0.0123	-0.3352	0.4397	-0.0237	0.0282	0.3880
4	0.9975	0.0110	-0.4814	0.6794	-0.0256	0.0304	0.5667
5	0.1870	0.0238	-1.1300	-0.1111	-0.0184	0.0202	0.4031
6	0.5152	0.0113	-0.6356	0.4478	-0.0099	0.0159	0.6388
7	0.3576	0.0240	-0.2788	0.2410	-0.0276	0.0174	0.6441
8	0.1191	-0.0108	0.1468	-0.2928	-0.0389	0.0328	0.2677
9	1.1675	-0.0008	-0.3793	-0.1268	-0.0311	0.0315	0.4454
10	0.8269	0.0123	-0.9507	0.6461	-0.0025	-0.0045	0.8531
11	1.6445	0.0010	-0.5484	0.0441	-0.0142	0.0126	0.7169
12	0.3802	0.0127	-0.5371	0.4904	-0.0026	0.0059	0.7460
13	0.9453	0.0054	-0.4630	0.2474	-0.0030	0.0340	0.6315
14	0.7384	0.0333	-0.5961	-0.0305	-0.0074	0.0118	0.8628
15	0.5682	0.0095	-0.4824	-0.1523	-0.0334	0.0323	0.5430
16	0.1619	-0.0301	-0.4460	0.7874	-0.0216	0.0078	0.3767
17	0.8067	0.0168	-0.4160	0.5574	-0.0227	-0.0004	0.6313
18	1.1694	0.0119	-0.9332	0.5770	-0.0120	0.0220	0.6511
19	1.1256	0.0061	-0.5374	0.4899	-0.0116	0.0395	0.7312
20	0.6132	0.0104	-0.6803	0.3502	-0.0367	0.0275	0.8617
21	0.7913	0.0138	-0.5355	0.8905	-0.0247	0.0049	1.1037
22	0.8322	0.0128	-0.2638	0.1085	-0.0112	0.0132	0.5055
23	0.6771	0.0064	-0.2197	0.3280	-0.0071	0.0156	0.6076
24	0.3153	-0.0165	-0.3967	0.6280	-0.0287	0.0287	0.5831
25	0.3347	0.0043	-0.1611	0.6595	-0.0106	0.0119	0.8701
26	0.8579	-0.0020	-0.2460	0.3669	-0.0221	0.0233	0.7577
27	0.6109	0.0070	-0.8872	0.2947	-0.0229	0.0142	0.9631
28	1.4315	0.0388	-0.9303	0.4041	0.0048	0.0335	1.0240
29	0.4033	0.0031	-0.4577	0.5222	-0.0068	0.0146	0.4999
30	0.3648	0.0051	-0.2460	0.2533	-0.0092	0.0143	0.8232
31	0.3214	-0.0020	-0.1180	0.7659	-0.0251	0.0288	0.7899
32	0.7354	0.0063	-0.4418	-0.0786	-0.0084	0.0172	0.8838
33	0.5337	0.0078	-0.3404	0.2033	-0.0064	0.0169	0.8447
34	0.4498	0.0120	0.2471	0.2688	-0.0156	0.0116	1.1602
35	0.8396	0.0470	-1.1624	0.2043	-0.0074	0.0171	1.4275
36	0.3505	0.0045	-0.1662	0.3329	-0.0259	0.0113	0.5978
37	0.1993	0.0090	-0.3167	0.6460	-0.0118	0.0228	0.7778
38	0.2551	0.0024	-0.1821	0.7554	-0.0114	0.0295	0.9336
39	0.3955	0.0176	-0.1730	0.0586	0.0040	0.0152	1.1709
40	1.0105	0.0157	-0.4390	0.3429	0.0033	0.0186	1.1046
41	0.8581	0.0154	-0.3314	-0.0920	0.0095	0.0025	1.3112
42	0.2661	0.0228	0.4979	-0.3424	-0.0019	0.0101	1.4494
43	0.2658	-0.0078	-0.0985	-0.0577	-0.0052	0.0160	0.8081
44	0.0909	0.0009	-0.0324	0.0653	-0.0017	0.0071	1.0095
45	0.0430	0.0013	-0.1413	0.0452	-0.0043	0.0076	1.1392

46	0.4066	0.0071	-0.3000	0.2455	0.0080	0.0049	1.0763
47	0.0343	-0.0030	-0.1350	-0.0249	-0.0012	0.0110	1.2360
48	0.2751	0.0030	-0.1823	-0.1067	-0.0049	0.0046	1.2882
49	0.1542	0.0102	0.3126	0.0249	0.0011	0.0078	1.2359

Panel B: Result for the Obtained Betas of Applying OLS (1990-1997).

Pf	β_{DRP}	β_{DTS}	β_{IPG}	β_{DYPG}	β_{UI}	β_{DEI}	β_{VW}
1	0.4619	0.0192	0.2949	-0.4077	-0.0215	0.0119	0.3627
2	1.4231	-0.0058	-0.0559	0.4888	-0.0439	0.0097	0.3595
3	0.2903	-0.0175	0.1495	0.2757	-0.0271	0.0321	0.4308
4	1.0726	-0.0135	0.0430	0.5730	-0.0336	0.0333	0.3528
5	0.9059	0.0049	-0.1356	-0.0125	-0.0285	0.0385	0.2400
6	0.7815	-0.0069	0.1324	0.2676	-0.0284	0.0221	0.5545
7	0.2789	0.0073	0.4559	-0.0414	-0.0416	0.0253	0.5502
8	0.3823	-0.0219	-0.4380	-0.1142	-0.0309	0.0276	0.1563
9	0.9709	-0.0054	0.2177	0.0020	-0.0365	0.0364	0.3684
10	0.7824	0.0130	-0.4408	0.4859	-0.0080	0.0013	0.6937
11	1.4488	0.0080	-0.1874	-0.0242	-0.0120	0.0096	0.5677
12	0.4594	-0.0013	-0.2382	0.3237	-0.0109	0.0158	0.6567
13	1.1317	-0.0057	-0.2506	-0.2237	-0.0011	0.0252	0.7119
14	1.0959	0.0168	-0.2937	-0.3371	-0.0159	0.0204	0.7063
15	0.4944	0.0012	-0.2785	-0.2462	-0.0146	0.0288	0.4285
16	0.1088	-0.0246	0.0023	0.6018	-0.0217	0.0111	0.4015
17	0.6553	0.0093	-0.0556	0.4377	-0.0205	0.0018	0.5355
18	1.0767	-0.0060	-0.5130	0.4647	-0.0181	0.0400	0.4273
19	1.2922	-0.0066	-0.4166	0.4467	-0.0219	0.0427	0.6511
20	0.5916	0.0004	-0.0948	0.2323	-0.0537	0.0359	0.8800
21	0.8339	0.0006	-0.1263	0.8734	-0.0389	0.0086	1.0574
22	0.7054	0.0068	-0.2183	0.3159	-0.0069	0.0157	0.5211
23	0.6363	0.0066	0.1370	0.1959	-0.0173	0.0238	0.5580
24	0.2274	-0.0126	-0.1773	0.5511	-0.0153	0.0214	0.6284
25	0.3461	0.0013	0.0311	0.5776	-0.0177	0.0221	0.8215
26	0.9727	0.0052	0.0842	0.5221	-0.0166	0.0156	0.8550
27	0.6278	0.0023	-0.6110	0.3454	-0.0300	0.0178	0.9695
28	1.5925	0.0159	0.1692	-0.0193	-0.0075	0.0337	1.0482
29	0.3490	-0.0004	-0.2552	0.4260	-0.0135	0.0230	0.4029
30	0.3386	0.0066	-0.0373	0.1808	-0.0172	0.0184	0.6524
31	0.1015	-0.0004	0.0086	0.6139	-0.0238	0.0180	0.7557
32	0.5491	0.0093	-0.3124	0.1494	-0.0115	0.0188	0.8060
33	0.6085	0.0032	-0.4273	0.2762	-0.0107	0.0182	0.8274
34	0.4423	0.0116	0.3448	0.3685	-0.0179	0.0135	1.0377
35	0.8032	0.0229	-0.7111	0.1785	-0.0203	0.0336	1.1605
36	0.3165	0.0004	0.0287	0.2570	-0.0201	0.0145	0.5907
37	0.2938	0.0102	-0.4241	0.6412	-0.0137	0.0137	0.8321
38	0.2895	0.0071	-0.0830	0.7037	-0.0083	0.0256	0.8887
39	0.4280	0.0152	-0.1227	0.2472	-0.0037	0.0188	1.1396
40	0.9696	0.0143	-0.3123	0.3849	-0.0004	0.0229	1.0561
41	0.7884	0.0088	-0.0031	0.0729	-0.0030	0.0209	1.1417
42	0.3448	0.0174	0.7194	-0.1684	-0.0048	0.0104	1.4209
43	-0.2328	-0.0040	-0.0796	-0.2149	-0.0035	0.0150	0.8334
44	0.2103	-0.0019	0.0340	-0.0156	-0.0024	0.0056	0.9900
45	-0.0320	-0.0014	-0.0944	0.0212	-0.0025	0.0078	1.1243
46	0.3609	0.0064	-0.4070	0.0981	0.0052	0.0027	1.0950
47	0.0078	-0.0015	-0.0896	-0.0396	-0.0009	0.0107	1.1880
48	0.2380	-0.0043	-0.0737	-0.1314	-0.0143	0.0119	1.1770

49	0.2142	0.0142	0.3425	0.1662	-0.0013	0.0104	1.2979

3.3. Results for Cross-sectional Regressions (Applying APT and CAPM)

The results of cross-sections of monthly portfolio returns and estimated portfolios' betas acquired from the time series regressions applying IGARCH and OLS are presented in Table 9 and 10 respectively. From these results it is evident that there is some improvement in the estimated risk premia both in CAPM and APT using IGARCH estimated betas (Table 9).

Comparing Tables 9 and 10 shows that applying IGARCH (1,1,M) for time series regression for CAPM produce higher risk premia over the entire three samples of time-periods and increased R^2 over the full time-period and first sub-period. Consistently, for APT, applying betas obtained from IGARCH (1,1) shows an improvement in the resulting estimated risk premia for the full time-period. Table 9 shows that all the macro-economic factors' coefficient are significantly different from zero at the level of 1% and the coefficient for market portfolio beta has improved. However, over the entire three samples, the correction for hetero-scedasticity by GARCH is not sufficient to lead to satisfactory result for APT. Over the entire three samples of time-periods, different factors are priced and carry different prices in different samples. Consistent with Soufian, Joseph and Ritchie (2000), these results undermine the assumption of constant expected return and the uniqueness of the return generating process in APT.

Table 9 Cross-sectional Regressions

Resulting estimated of risk premia for CAPM and APT. The estimated portfolios' betas acquired from the time series regressions applying IGARCH (1,1,M) for CAPM and IGARCH (1,1) for APT.

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

A. Full-period (1980-1997) $R^2=0.21$

Variable	Coefficient	Std Error
VW	0.021***	0.004

B. First sub-period (1980-1989) $R^2=0.21$

Variable	Coefficient	Std Error
VW	0.025**	0.006

C. Second sub-period (1990-1997) $R^2=0.23$

Variable	Coefficient	Std Error
VW	0.023***	0.004

Cross-sectional Regressions Estimates IGARCH (1,1)

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

A. Full-period (1980-1997) $R^2=0.47$

Variables	Coefficients	Std Error
DR	-0.0045***	0.001
TS	0.252***	0.089
UI	-0.380***	0.100
IP	0.006***	0.001
YP	0.020***	0.003
DEI	0.427***	0.140
VW	0.006*	0.003

B. First sub-period (1980-1989) $R^2=0.44$

Variables	Coefficients	Std Error
DR	0.004***	0.001
TS	0.115	0.117
UI	-0.205	0.153
IP	0.004**	0.002
YP	0.009***	0.003
DEI	-0.641***	0.190
VW	0.008	0.006

C. Second sub-period (1990-1997) $R^2=0.45$

Variables	Coefficients	Std Error
DR	-0003**	0.001
TS	-0.298***	0.070
UI	0.270***	0.065
IP	0.002	0.001
YP	0.001	0.002
DEI	0.153**	0.057
VW	0.0121**	0.004

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

Table 10 Cross-sectional Regressions

Resulting estimated of risk premia for CAPM and APT from Soufian, Joseph and Ritchie (2000). The estimated portfolios' betas acquired from the time series regressions applying OLS.

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

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

Variable	Coefficient	Std Error
VW	0.018***	0.005

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

Variable	Coefficient	Std Error
VW	0.016*	0.007

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

Variable	Coefficient	Std Error
VW	0.016**	0.004

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

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

Variables	Coefficients	Std Error
DR	-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
VW	-0.001	0.004

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

Variables	Coefficients	Std Error
DR	-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
VW	0.016*	0.007

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

Variables	Coefficients	Std Error
DR	-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
VW	0.013*	0.005

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

4. Conclusions

This paper examined performance of CAPM and APT across three samples of time-periods, applying GARCH-type models and structural breaks in the first stage of a two-stage estimation procedure. This paper attempted to correct for hetero-scedasticity in the time series regressions and includes structural breaks for those factors that have undergone significant change in their mean or volatility. Correction for hetero-scedasticity in the estimation of beta in the first-stage of the two-stage estimation procedure of CAPM gave an improvement over OLS. Relative to OLS, IGARCH gave smaller estimates of betas, higher risk premia, an increase in log-likelihood and higher R^2. However, adding the macro-economic factors to the model, the result for the market portfolio is different from that of the CAPM. After adding the economics factors coefficient, the power of the market portfolio's beta has either diminished or reduced.

Consistently, relative to OLS, applying IGARCH improved the performance of APT for the full time-period. Applying betas obtained from GARCH-type models (time-series regressions) shows an improvement in the resulting estimated risk premia (cross-sectional regressions) for the full time-period. Correction for hetero-scedasticity in the time series regressions improves the efficiency in the estimation of the betas, and increaeses the risk premia in the full time period. In the full time-period all coefficients for the macro-economic factors' betas are significantly different from zero at the level of 1%, and the coefficient for the market beta is significantly different from zero at the level of 10%. However, over the entire three samples, the correction for hetero-scedasticity by GARCH is not sufficient to lead to satisfactory result for APT. Consistent with Soufian, Joseph and Ritchie (2000), different factors are priced and carry different prices in different samples. These results undermine the assumption of constant expected return and the uniqueness of the return generating process in APT.

Appendix I

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)

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

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