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"*Testing Volatility on the Trinidad and Tobago Stock Exchange*"

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Introduction

In most Caribbean countries, the process of economic growth and development is being retarded by the unavailability of an adequate supply of finance for investment. Indeed, several commentators in both public and academic fora have expressed concern over the limited opportunuities which are offered by financial markets in the Caribbean. Although there has been some growth in the financial sector since the 1970s, commercial banks have remained the dominant source of investment funding. Recent financial innovations and advances in computer technology have highlighted the importance and fragility of securities markets as valid alternatives for the effective mobililization of investment finance. The paper has two basic objectives. The first of these is to examine the risk-return profiles on the Trinidad and Tobago Stock Exchange while the second involves an examination of the volatility of returns of various portfolios on the market. These issues are vital if any conclusions are to be made about the effectiveness of the market as an efficient mobiliser of investment funds.

The paper is divided into four sections. Secton 1 of the paper presents a brief overview of the institutional background to the development of the stock exchange in Trinidad and Tobago and discusses the performance of the stock market since its inception drawing on well-established indicators. Section 2 of the paper discusses the relationship between risk and return using as a reference frame the Sharpe-Lintner-Black (SLB) version of the Capital Asset Pricing Model (CAPM). Section 3 examines the volatility of returns on the exchange using the familiar Arch-Garch methodology. In the final section some conclusions and inferences are drawn about efficiency and risk-return performance of various portfolios on the market.

Section 1: Institutional Background of the Trinidad and Tobago Stock Exchange

Although trading on the Trinidad and Tobago Stock Exchange (TTSE) commenced on October 26, 1981, trading in securities is not a new phenomenon in the context of the Trinidad and Tobago economy. In fact, an informal securities exchange existed for over twenty years prior to the opening of the TTSE. However, during the 1970s, government embarked on a policy of localisation which necessitated the establishment of legal and operational structures. The Stock Exchange was one of the institutions which emerged out of this process. Since its inception, only two types of securities are traded on the exchange - ordinary shares and preferences shares.

At the end of 1994, twenty-seven companies were listed on the exchange while some thirty-one securities were traded on the floor of the exchange. The decline in the number of listed companies on the exchange since 1988 reflected an increased number of takeovers and mergers as well as some corporate receiverships influenced by the state of the economy during the period 1982-1990. Additionally, there have been few new listings on the market. Over the period 1981-1994, a total of only eighteen new listings have occurred on the exchange. In terms of the raising of new capital, less than $80 million worth of new capital was funded by primary issues since the inception of the exchange. This results, in large measure, from the low levels of equity financing by companies. Indeed, public companies have continued to rely more and more on debt financing. *

Trading on the Trinidad and Tobago Exchange is heavily influenced by put-throughs or block trading. In 1993, 35.7% of the shares traded on the exchange were owned by companies, 15.9% by trust companies and pension funds, 14.4% by the government, 8.5% by insurance companies, 3.1% by the Unit Trust Corporation (UTC) and the National Insurance Board (NIB) and 22.2% by individuals. These figures indicate that altogether over 70% of the shares on the exchange are held by institutional investors and may never be possessed by ordinary individuals or even traded actively. Sergeant (1994) notes that *there is still no widespread* ownership of marketable securities and attributes this in part to the tradition of of business control by family clans.

The composite price index (1983=100) can be utilized to provide some broad indication of the performance of stock prices on the TTSE. During the period of the 1980s, stock prices remained generally depressed reflecting the effects of recessionary conditions and the accompanying decline in income levels and the propensity to save. The recession itself had an adverse effect on the growth and profitability of companies and served to deter potential investors. Beginning in 1983, the composite price index declined steadily reaching its lowest base value in 1988. Several additional factors also contributed to the increased volatility of the index during the period 1989-1994. For instance, in 1989, the volume and value of stocks traded on the exchange were affected by a series of take-over bids, put-throughs, mergers and delistings. Indeed, in 1990, four of the five take-over bids were successful and contributed to greater volatility on the market.

The subsectoral indices[1] also displayed movements that were quite similar to those recorded for the market composite. In general, most of the subsectoral indices mirrored the decline experienced in the period 1983-1988 with the exception of the sub-index for manufacturing 1 which exhibited some growth especially over the period 1983-1985. The most significant declines seem to have occured in the performance of the subindices relating to Comglomerates, Trading and Properties. There was a general recovery in the subindices for Commercial Banks and Manufacturing II over the period 1990-1994. However, the indices for Manufacturing I displayed greater volatility in the post 1990 era. The sub-index for property remained quite stable over the period 1990-1994.

Section 2: Risk and Return on the Trinidad and Tobago Stock Exchange

The total risk of a stock can generally be divided into systematic risk - the portion of risk that is peculiar to a particular firm and unsystematic risk- that portion of risk that is market-related and non-diversifiable. There is, of course, no reward associated with

[1] These are stock price indices for Commercial Banks, Conglomerates, Manufacturing I and II, Trading and Property.

unsystematic risk since it can be eliminated through diversification. Investors, however, on the stock market are normally rewarded in terms of higher expected return for bearing more systematic risk.

The relationship between risk and return has been the subject of considerable research and debate dating as far back as the 1960s with the seminal contributions of Markowitz (1952) and Tobin (1958). These studies were succeeded by the formulation of the Capital Asset Pricing Model (CAPM) of Sharpe (1964) and Lintner (1965). The ex-ante form of this model gives the theoretical equilibrium relationship that should exist between the expected return on a stock, $\mathbf{E(R_i)}$ and its expected risk, β_i.

$$\mathbf{E(R_i) = R_{ft} + \beta_i[E(R_{mt}) - R_{ft}]}$$

where $\mathbf{E(R_i)}$ is the expected return on stock **i**; $\mathbf{R_f}$ is the risk free rate of return; $\mathbf{E(R_m)}$ is the expected return on the market portfolio and β_i is a measure of systematic risk. According to this model, the expected return on a risky asset is equal to the return on a risk free asset plus a risk premium which is proportional to the βeta (β) coefficient of the asset. The proportionality factor or market risk premium is the difference between the expected return on the market as a whole and the risk free rate of return. The model asserts that a positive linear relationship should exist between βeta and expected return. βeta therefore gives an estimate of the riskiness of the particular stock. If βeta > 1 the return on the stock is more volatile than the market. In short, the stock is an aggressive stock and hence risky. If βeta < 1 then the rate of return on the stock is less volatile than the market rate and hence the stock is defensive. If βeta=1 the stock is neutral and its rate of return changes at a rate identical to the market rate.

In its present form, the CAPM is not very useful unless some attempt is made to measure expectations. As a result, it becomes necessary to transform the model from an ex-ante representation to a form that uses the observed data (i.e an ex-post representation). Normally, if capital markets are efficient and the rate of return on an asset is a fair game, the transformed model can be defined as follows:-

$$\mathbf{R_{it} = E(R_{it}) + \beta_i\delta_{mt} + u_{it}}$$

where $\mathbf{E(u_{it}) = 0}$; $\mathbf{Cov\ (u_{it}, \delta_{mt}) = 0}$; $\mathbf{Cov\ (u_{it},u_{i,\,t-1}) = 0}$;
$\mathbf{\beta_i = Cov\ (R_{it}, R_{mt})/(Var\ (R_{mt}))}$; $\mathbf{\delta_{mt} = R_{mt} - E(R_{mt})}$;

Under the assumption that asset returns are jointly normal, the β_i in the fair game model is defined in the same way as the β_i in the CAPM. Substituting $E(R_i)$ from the CAPM model into the fair game model yields:-

$$\mathbf{R_{it} = R_{ft} + \beta_i\ [E(R_{mt}) - R_{ft}] + \beta_i\ [R_{mt} - E(R_{mt})] + u_{it}}$$

$$\mathbf{R_{it} = R_{ft} + \beta_i[R_{mt} - R_{ft}] + u_{it}}$$

$\Rightarrow [R_{it} - R_{ft}] = \beta_i[R_{mt} - R_{ft}]^2$

This version of the model is expressed in terms of ex-post observations of returns data rather instead of ex-ante observations. Thus the risk premiums for individual assets are functions of the respective βetas as well as the market risk premium.

Several concerns arise in testing the Capital Asset Pricing Model. The first issue revolves around the question of the stability of the measure of systematic risk (βeta). Can past βetas be used as valid predictors of future βetas? The second issue concerns the realtionship between βeta and the rate of return. Is this relationship a linear one as hypothesized by the CAPM? The third issue relates to the fact that the statistical properties of βeta depend on the adequacy of the assumptions that are utilized in the model.

Stability of βeta: A puzzle?

Several studies have addressed the issue of the stability of βeta. Levy (1971) concluded, using weekly rates of return for the 500 NYSE stocks that βeta was not stable for individual stocks over short periods of time. Both Tole (1981) and Blume (1971) noted that βeta was significantly more stable in portfolios consisting of a large number of stocks,

[2] The ex-post model can have a negative slope whereas the ex-ante version of the CAPM can only have a positive slope [see Wong and Tan (1991)].

while Baesel (1974) and Theobald (1981) noted that the stability of the βetas increased generally as the length of the estimation period was extended. Reilly and Wright (1988) made the important observation that the βeta was sensitive not only to the length of the estimation period but as well to the relative size of the firm. Interestingly, the only study on this issue in the Caribbean (Koot et al (1992) took the stability of βeta for granted.

In order to test the relationship between risk and return on the Trinidad and Tobago Stock Exchange, the study examines the risk-return relationships for portfolios grouped by economic activity on the Trinidad and Tobago Stock Exchange. The rates of return were calculated using closing prices for the available stocks.[3]

$$\mathbf{R_{it} = (P_{it} - P_{i,t-1})/(P_{i,t-1})}$$

In the context of the study, the market portfolio was assumed to be the composite market index for Trinidad and Tobago. One major concern which arises in this case is the fact that the post-1990 period has been characterized by greater trade and financial liberalization. In such circumstances, investors in Trinidad and Tobago may be more inclined to consider returns associated with a more globally based portfolio. Thus the Standard and Poors or the FTA all share prices index may be more useful proxies in the latter period for market returns rather than the composite index derived from trading on the domestic exchange.

[3] It is assumed here that dividend payments for most of the stocks were extremely small or non-existent.

The majority of tests on the CAPM adopt the the three step approach of Fama and Macbeth (1973). In this framework, the sample period is separated into a portfolio period, a portfolio estimation period and a test period. In the portfolio formation period, the betas for each security are estimated by regressing the security's return against the market return. Based on the relative rankings of the estimated betas, the individual securities are grouped into N portfolios. Portfolio betas are then estimated by regressing portfolio returns against the market returns. In the final sample period, the systematic relationship between beta and returns is examined via the following regression.

$$R_{it} = \gamma_0 + \gamma_1 \delta \beta_i + \gamma_2 (1-\delta)\beta_i + \varepsilon_t$$

where $\delta=1$ if $(R_{mt} - R_{ft}) > 0$ or $\delta=0$ if $(R_{mt} - R_{ft}) < 0$;

If the realized market return (i.e $R_{mt} > R_{ft}$) exceeds the the risk-free rate, portfolio betas and realized market returns should be positively related. If the realized return is below the risk-free rate (($R_{mt} < R_{ft}$), then portfolios betas and returns should be inversely related.

One interesting characteristic of the CAPM is the possibility it allows for gauging the riskiness of stocks or portfolios. The absence of detailed weekly data on all the firms trading on the TTSE makes it difficult to execute effectively the Fama-Macbeth methodology. As a result, rather than rank firms according to βetas, we classify the portfolios according to natural economic categories, namely Banking, Conglomerates, Manufacturing I, Manufacturing II, Trading and Property.[4]

[4] This classification may not coincide with the actual beta rankings.

As a first step, the returns for each of the above portfolios were regressed against the market return for weekly as well as monthly data. If the Beta parameter is to be correctly estimated then the error process needs to satisfy certain stansard distributional properties. Financial market data tend generally to display high degrees of skewness and kurtosis. The form of these regression models typically follows the specification for DLR outlined below.

General Model Specification with Garch Effects Model Specification

Let *DLR* be the rate of return on the market portfolio from time *t-1* to *t* for an information set of past realizations up to *t-1*. In a general model, the rate of return is modelled as a function of a vector of explanatory variables, *X*, and a disturbance term m. The disturbance term is assumed to follow a moving average process, and the innovation, conditional on the information set, follows a specified distribution with variance specified as an augmented GARCH process [see Baillie and DeGennaro (1990)].

$$\begin{aligned} DLR_t|\Phi_{t-1} &= g(X;\theta)+\mu_t \\ \mu_t &= \varepsilon_t - \textstyle\sum_{j=1}^{q}\gamma_j\varepsilon_{t-j} \\ \varepsilon_t|\Phi_{t-1} &\sim \Omega(0,h_t) \\ h_t &= f\left(\varepsilon_{t-j},h_{t-j}\right)+\xi' Z \end{aligned} \qquad (1)$$

Typically, it is assumed that the mean process is linear and the disturbances are innovations which follow a normal distribution. *Z* is a vector of additional variables explaining the variance of the innovation process. Alternative formulations of f, the variance function, exist. Subset restrictions on the parameters of the general structure define special cases and ensure finite variance and stationarity. The above specification shows that critical components in the modelling process include the conditioning sets and the functional forms (f and g) of the variance and mean functions, and the distribution of the innovation process [see Pagan and Schwert(1990)].

The GARCH model hypothesises that the conditional variance can be modelled as a function of the unexpected returns prior to time t. Bollerslev (1986) defines the GARCH(p,q) process as:-

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i h_{t-i} \qquad (2)$$

where $\alpha_1, \cdots \alpha_q$, $\beta_1, \cdots \beta_p$, and α_0 are constant parameters. The model is well defined if the coefficients of the infinite autoregressive representation are all non-negative, and the roots of the moving average polynomial of squared innovations lie outside the unit circle. In the GARCH(1,1) model, the effect of a shock on volatility declines geometrically over time.

Nelson (1991) argues that returns may exhibit asymmetrical conditional variance behaviour in that positive shocks generate an unequal impact on volatility than negative shocks (see also, Black (1976)). He proposed an exponential GARCH or EGARCH(p,q) model to capture that asymmetry:

$$\log(h_t) = \alpha_0 + \sum_{j=1}^{p} \beta_j \log(h_{t-j}) + \sum_{i=1}^{q} \omega_j \left(\gamma \frac{\varepsilon_{t-j}}{\sqrt{h_{t-j}}} + \alpha \left[\frac{|\varepsilon_{t-j}|}{\sqrt{h_{t-j}}} - E\left\{ \frac{|\varepsilon_{t-j}|}{\sqrt{h_{t-j}}} \right\} \right] \right) \qquad (3)$$

where $\omega_j, \beta_j, \gamma$, and α are constant parameters. The terms $\varepsilon_{t-1} / \sqrt{h_{t-1}}$ in the equation ensure asymmetry through their coefficients. If a coefficient is negative, the variance increases (decreases) when the error innovation is negative (positive). Stationarity requires the roots of the autoregressive polynomial to lie outside the unit circle. Since information flow affects portfolio selection, different models of predictability of market volatility will have different implications for asset pricing or strategic decisions.

For the mean process, two models are considered: the base model is the market model of stock returns and an error correction model hyphothesizes that stock returns follow an error correction process with a GARCH error strucutre (ECM-GARCH), reflecting interaction between the equity and treasury bill markets. A more general model could incorporate international influences from world financial and commodity markets by focussing on the expected risk of financial distress, and on the effects of the structural adjustment in the latter part of the estimation period.

This study compares volatility predictions for four standard and four extended models, assuming a linear mean process and uncorrelated normally distributed disturbances. The variance models span nonlinear, symmetric and asymmetric variance functions. Differences among the various models can be obtained by comparing their news impact curves. Engle and Ng (1993) define the relation between the lagged unexpected return and the conditional variance as the news impact curve since it measures how past news affect current volatility. The GARCH model is a quadratic function centred at $\varepsilon_{t-1} = 0$. The EGARCH has its minimum at $\varepsilon_{t-1} = 0$, and increases exponentially in both directions with good and bad news having differential impacts on volatility. Similarly, the nonlinear asymmetric GARCH model (NLGARCH) and the VGARCH model are symmetric about $\varepsilon_{t-1} = -\gamma \cdot \sqrt{h_{t-1}}$, with $\gamma > 0$ implying an axis of symmetry left of the origin. It is clear that predictions of volatility will be dependent on the model specification chosen. The models are estimated[i] by maximisation of the log likelihood function, using the Berndt, Hall, Hall and Hausman (1974) algorithm.

Mean and Alternative GARCH Processes (Standard Models)

Mean Process

$$DLR_t = \theta_0 + \sum_{j=1}^{p} \theta_j DLR_{t-j} + \mu_t$$

GARCH(1,1)

$$h_t = \alpha_0 + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1}$$

EGARCH(1,1)

$$\log(h_t) = \alpha_0 + \beta \cdot \log(h_{t-1}) + \gamma \cdot \frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} + \alpha \left[\frac{|\varepsilon_{t-1}|}{\sqrt{h_{t-1}}} - \sqrt{2/\pi} \right]$$

In the context of the present study, initial estimates of the moments suggest that the appropriate distribution applicable to each of the portfolios is non-normal. In every case, further tests of the residuals exhibited non-normality and a high degree of leptokurtosis. Moreover, auxillary regressions on the squared residuals found significant ARCH effects. Some form of mis-specification was also evident based on the results of the RESET test and the CUSUM plots. Given the inefficiency of OLS in the presence of ARCH errors the models were re-estimated by maximum likelihood. These estimates were then subjected to a series of diagnostic tests. The results of the OLS and ML estimation are presented in Table 1.

Table 1

Estimates of Risk (Beta)

ESTIMATE	DLCMBK	DLCONG	DLMANI	DLMANII	DLPROP	DLTRAD
OLS Beta (weekly)	1.11 (11.39)	1.10 (9.12)	0.43 (7.52)	0.897 (5.78)	0.17 (3.43)	0.48 (5.88)

OLS Beta (Monthly)	1.24 (17.41)	1.32 (10.16)	0.48 (7.29)	0.99 (5.83)	0.34 (2.58)	0.79 (5.17)
ML Beta (weekly)	1.11 (92.59)	0.96 (41.76)	0.51 (59.71)	0.93 (23.34)	0.01 (0.42)	0.20 (7.12)
ML Beta (monthly)	1.18 (32.58)	1.32 (17.42)	0.48 (16.67)	0.97 (9.84)	0.29 (6.51)	0.61 (7.73)
ML Beta (weekly)	1.15 (93.36)	0.97 (42.40)	0.51 (57.43)	O.49 (14.45)	0.00 (-)	0.09 (3.59)

Note: t-statistics for OLS estimates are heteroscedastic-consistent.

The estimated βeta coefficients were less than unity for the manufacturing, property and trading portfolios indicating that the various stocks which make up these portfolios were defensive and ~~mightay~~ may be perceived to have less relative risk and hence yield lower average returns. There were, however, some notable differences between the estimates obtained from maximum likelihood and OLS for the various periodicities.

By contrast, the βeta values for the commercial banks and conglomerates were generally in excess of unity indicating that the stocks in these portfolios tended to be more aggresive (i.e more risky) and were more likely to yield higher returns than the market.

Section 3: Volatility of Returns on the TTSE

The volatility of returns of the various portfolios using both monthly and weekly data are presented in ~~in~~ charts 3 to 13. In respect of the composite index, the results using weekly data indicate greater volatility in periods, 1984 to 1985, 1989 and 1993. With repect to monthly data, there is strong evisence of volatility in the 1985 to 1987 period. One reason which may account for this increased turbelence in the market was the devaluation of 1985 which may have induced greater instability in stock price movements.

The results of the sub-indicies *show quite a varied pattern over the period* 1983-1985. The weekly sub-index for Commercial Banks displayed some volatility in the years 1985, 1986 and 1989. Generally however, the sub-index was relatively stable over the period 1990-1995 and this is borne by the Sharpe ratio. A similar pattern is observed for Commercial Banks when the monthly data is utilized. With respect to Conglomerates, there is strong evidence in the weekly data of volatility in the 1985-1990 period.

Some interesting patterns emerge in the sub-index for Manufacturing II. This index was relatively stable over the periods 1983 to 1988. In the periods 1989-1990 and 1994-1995 this sub-index displayed some degree of volatility. The spikes in the conditional volatility graphs during the period 1989-1990 coincided with a series of take-over bids and mergers as well as the attempt to overthrow the incumbent administration.

The property index remained relatively stable over the entire period although there was some evidence of volatility in the periods 1983-1984 and 1991. Of all the sub-indices examined, trading displayed the greatest volatility throughout the period.

Conclusion

This preliminary investigation of the Trinidad and Tobago Stock Market has unearthed some interesting findings. Firstly, the portfolios of stocks of Commercial Banks and Conglomerates were found to be more risky and hence more liable to yield higher returns to institutional or individual investors. Secondly, in contrast , investments in portfolios of trading and property stocks were found to be less risky and hence not liable to yield above average returns. Thirdly, excess volatility was found during period of macroeconomic instability and political unrest. Further work on the individual stock indices will seek to rank companies in terms of risk return profiles. In addition, an attempt will be made to test the validity of the CAPM using the Fama-Macbeth methodology. The GARCH methodology will be extended to consider the impact of various distributional assumptions.

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CHART 1

Logarithms of the Sub-Indices and Composite Stock Index

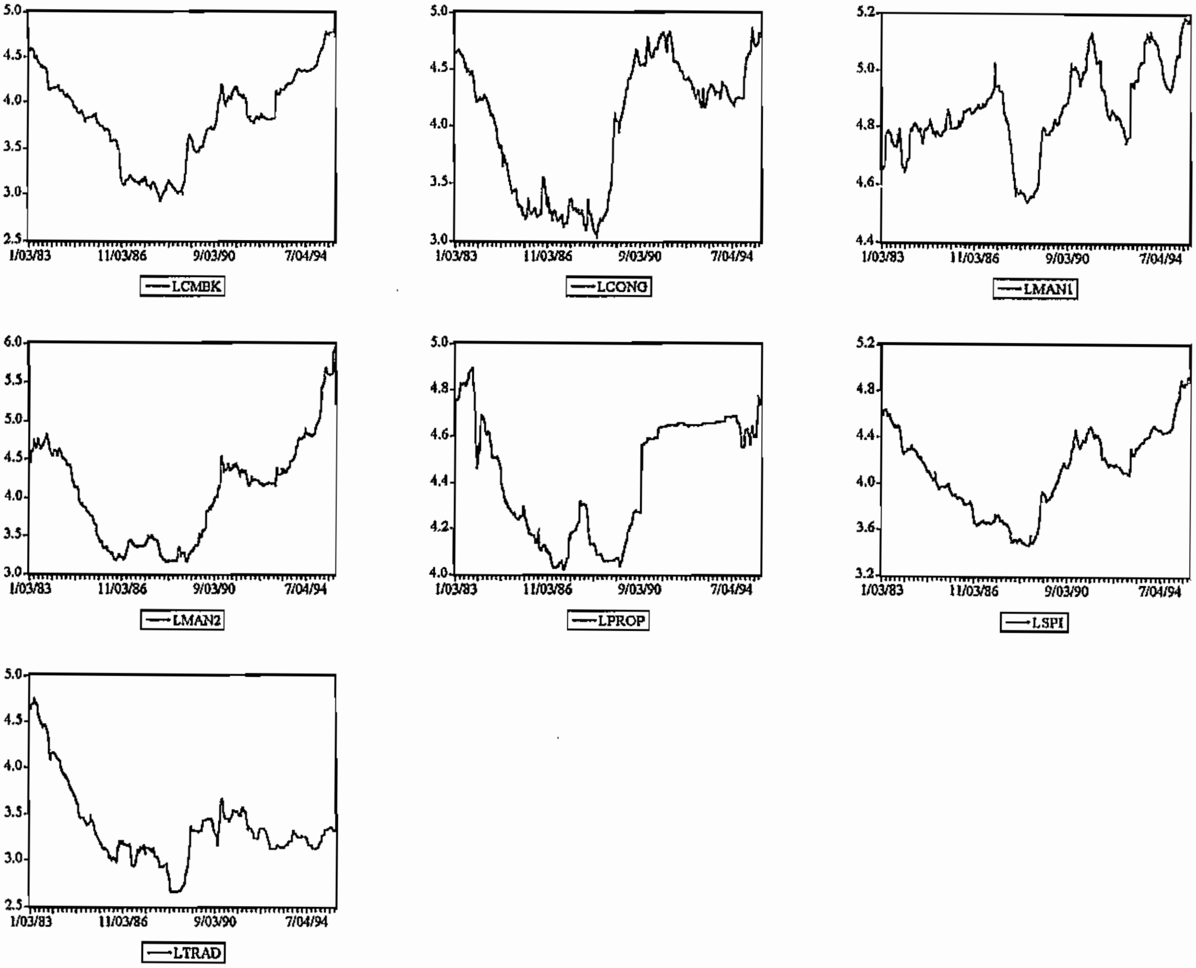


CHART 2

Returns of the Sub-Indices and Composite Stock Index

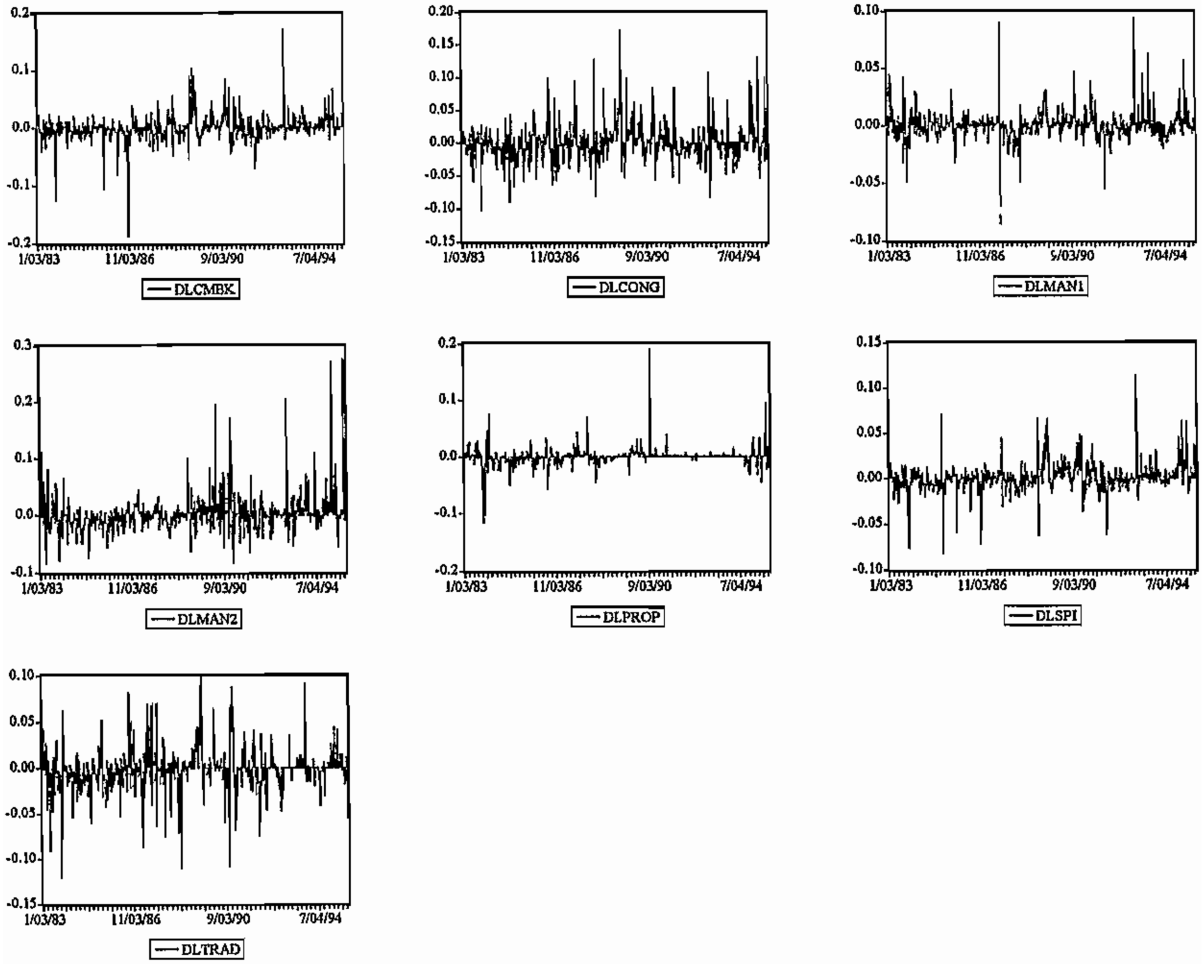
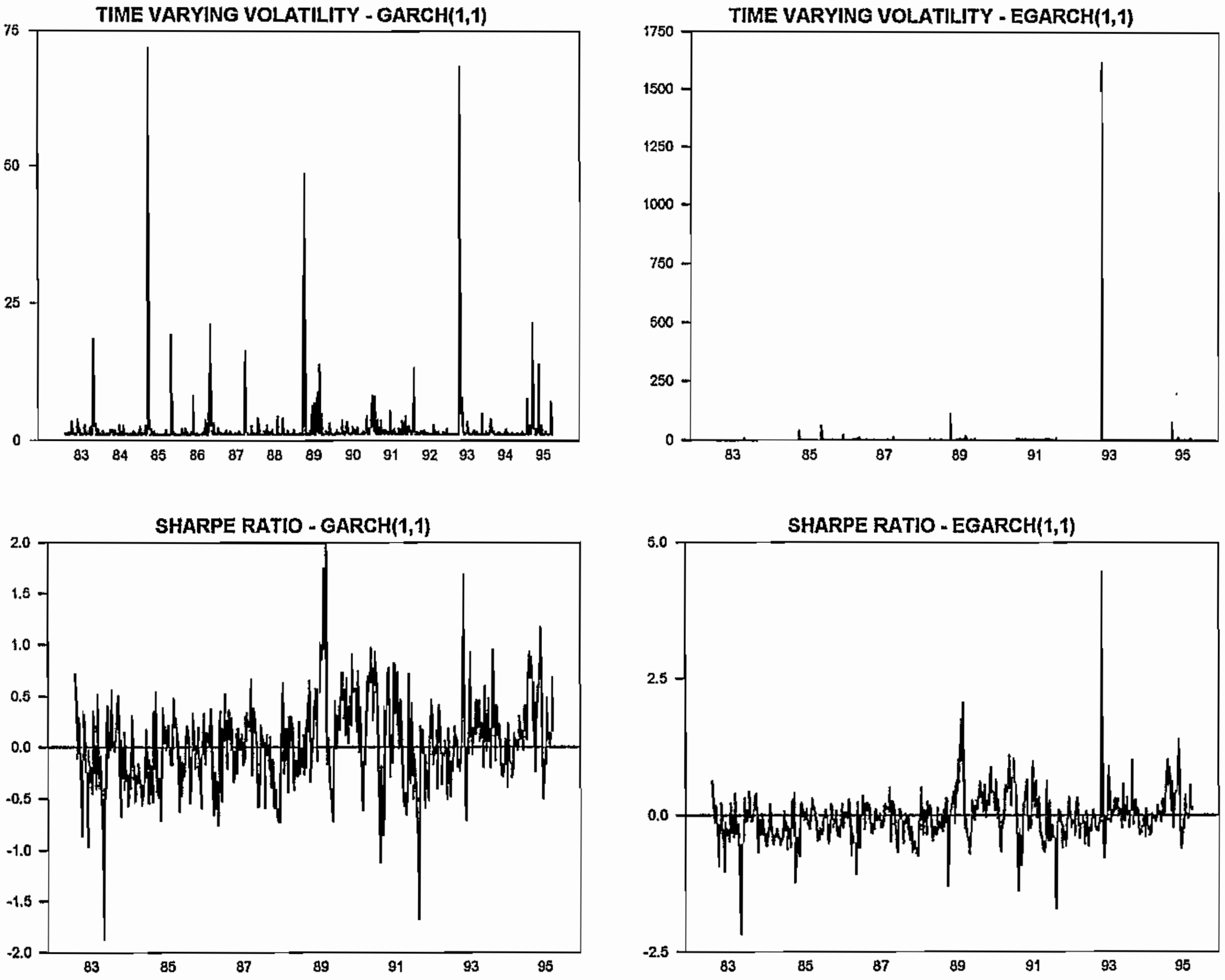
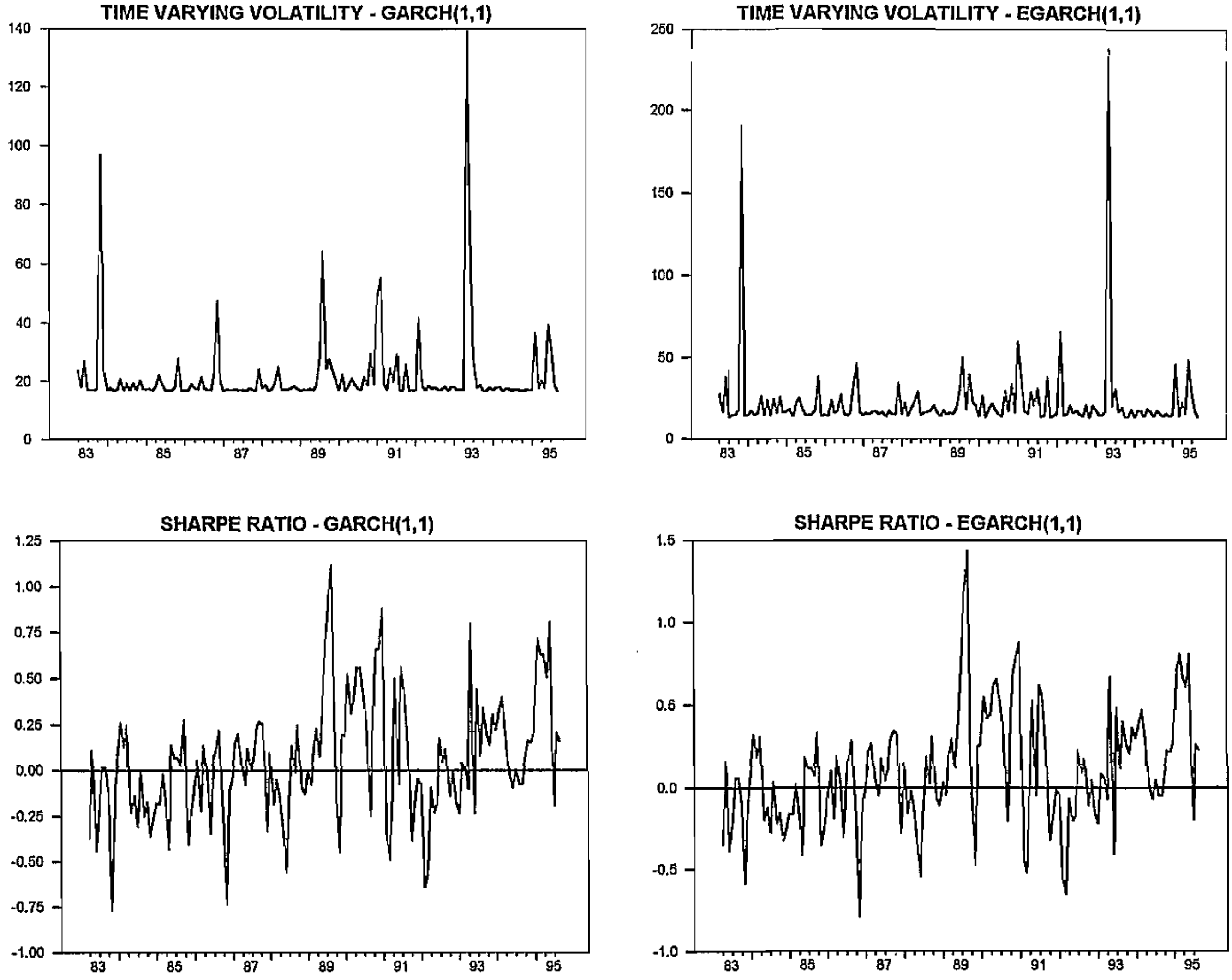


CHART 3



COMPOSITE STOCK INDEX — WEEKLY

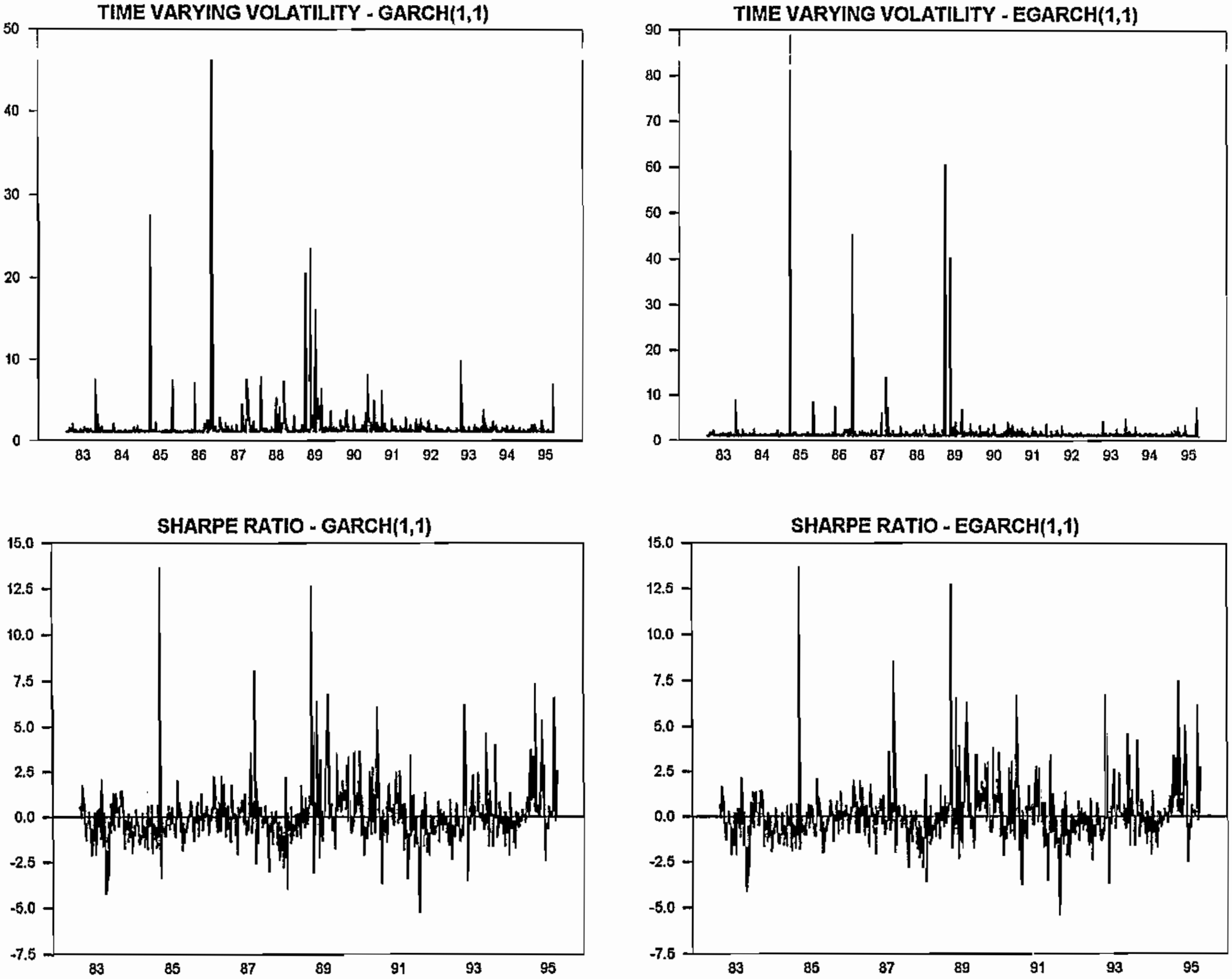
CHART 4



COMPOSITE STOCK INDEX — MONTHLY

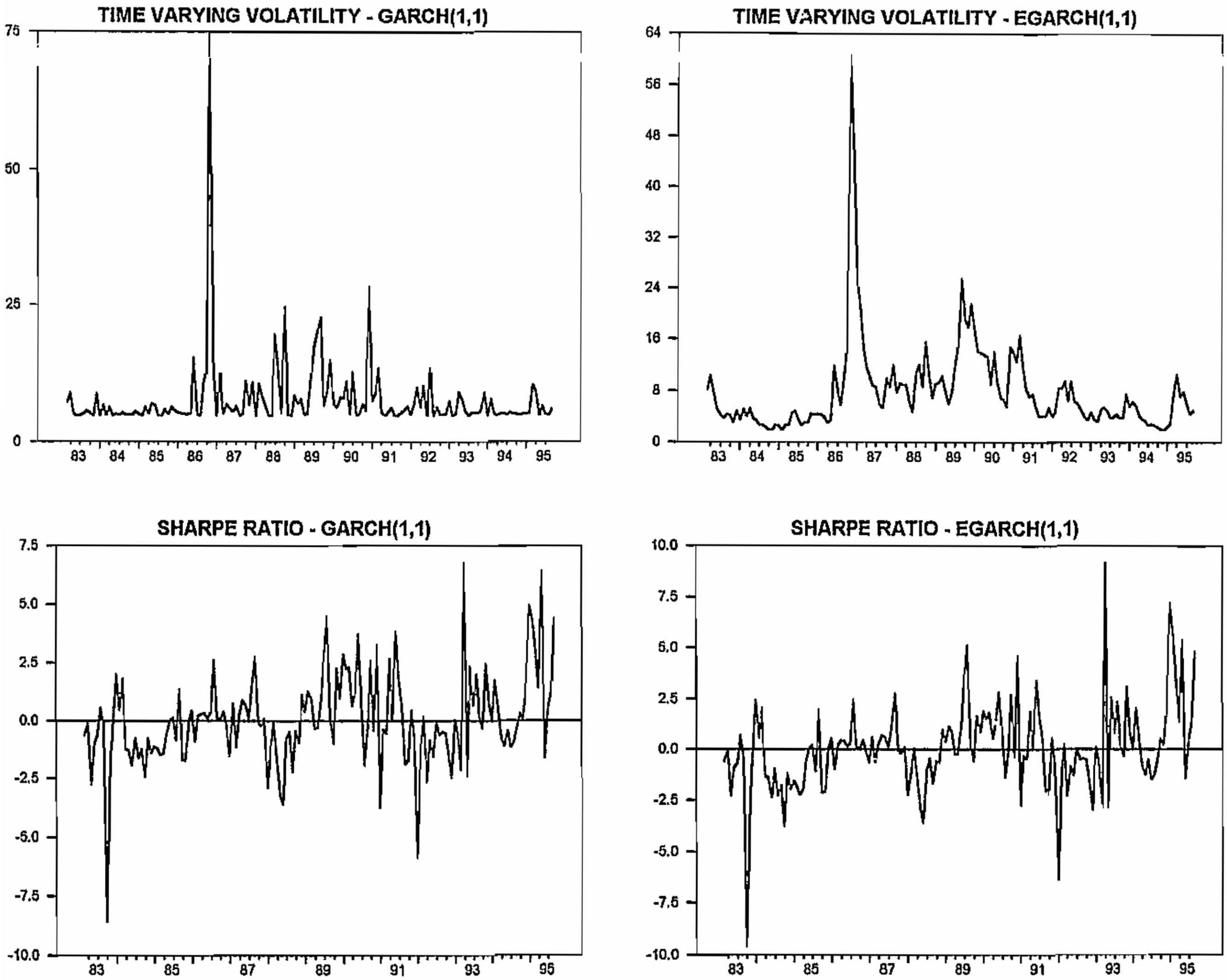
SPI

CHART 3



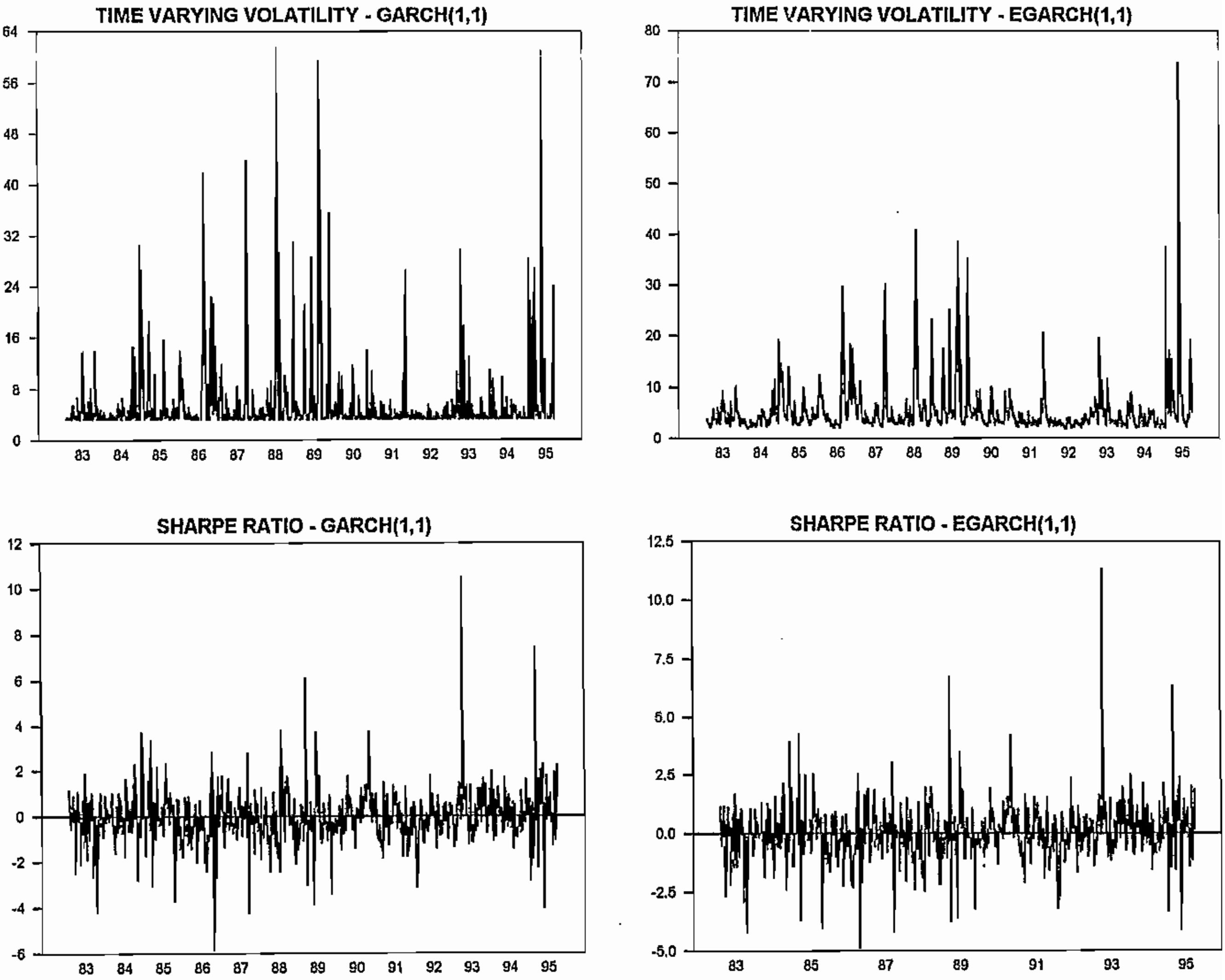
COMMERCIAL BANKS SUB-INDEX — WEEKLY

CHART 6

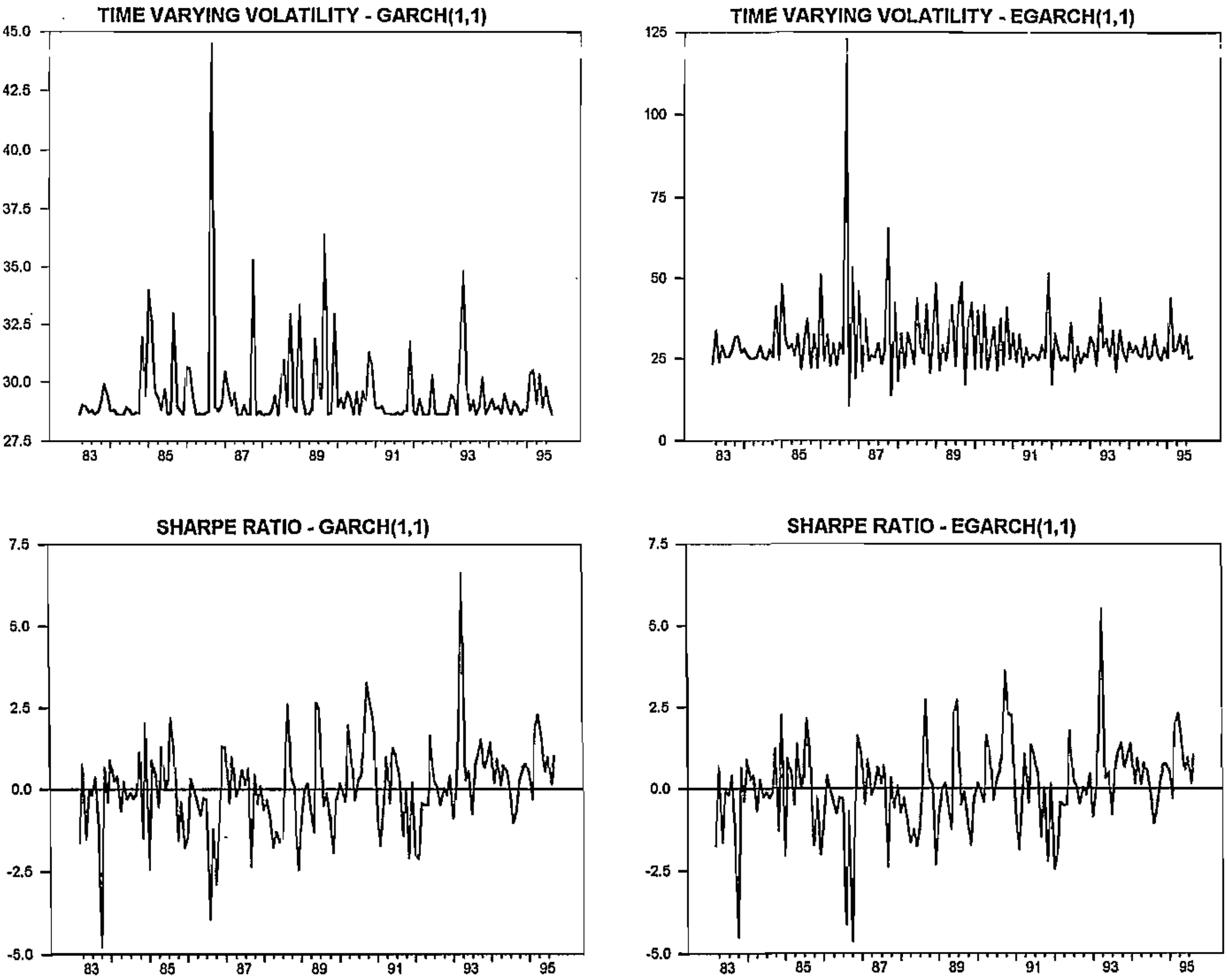


COMMERCIAL BANKS SUB-INDEX — MONTHLY

X1

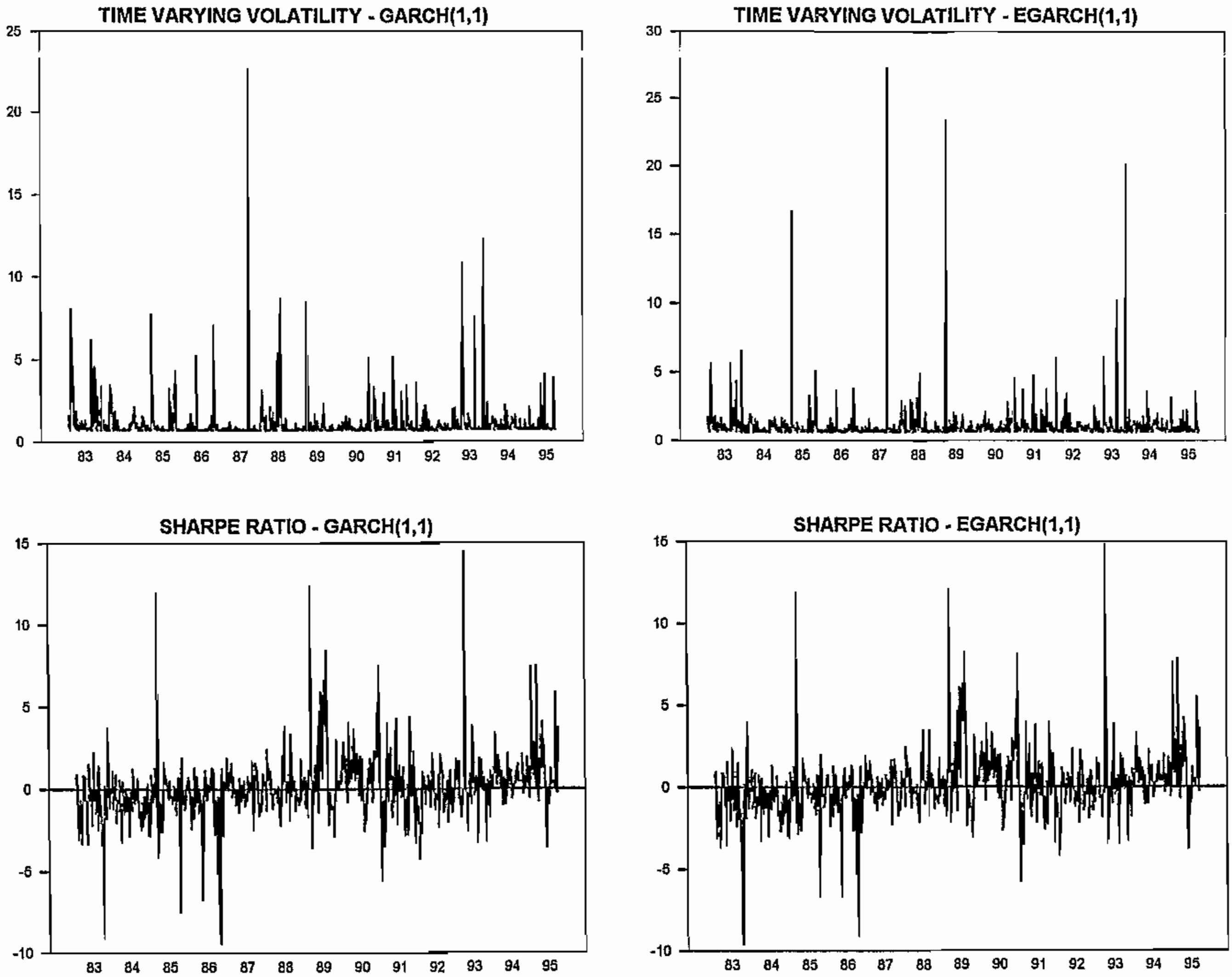


CONGLOMERATES SUB-INDEX — WEEKLY

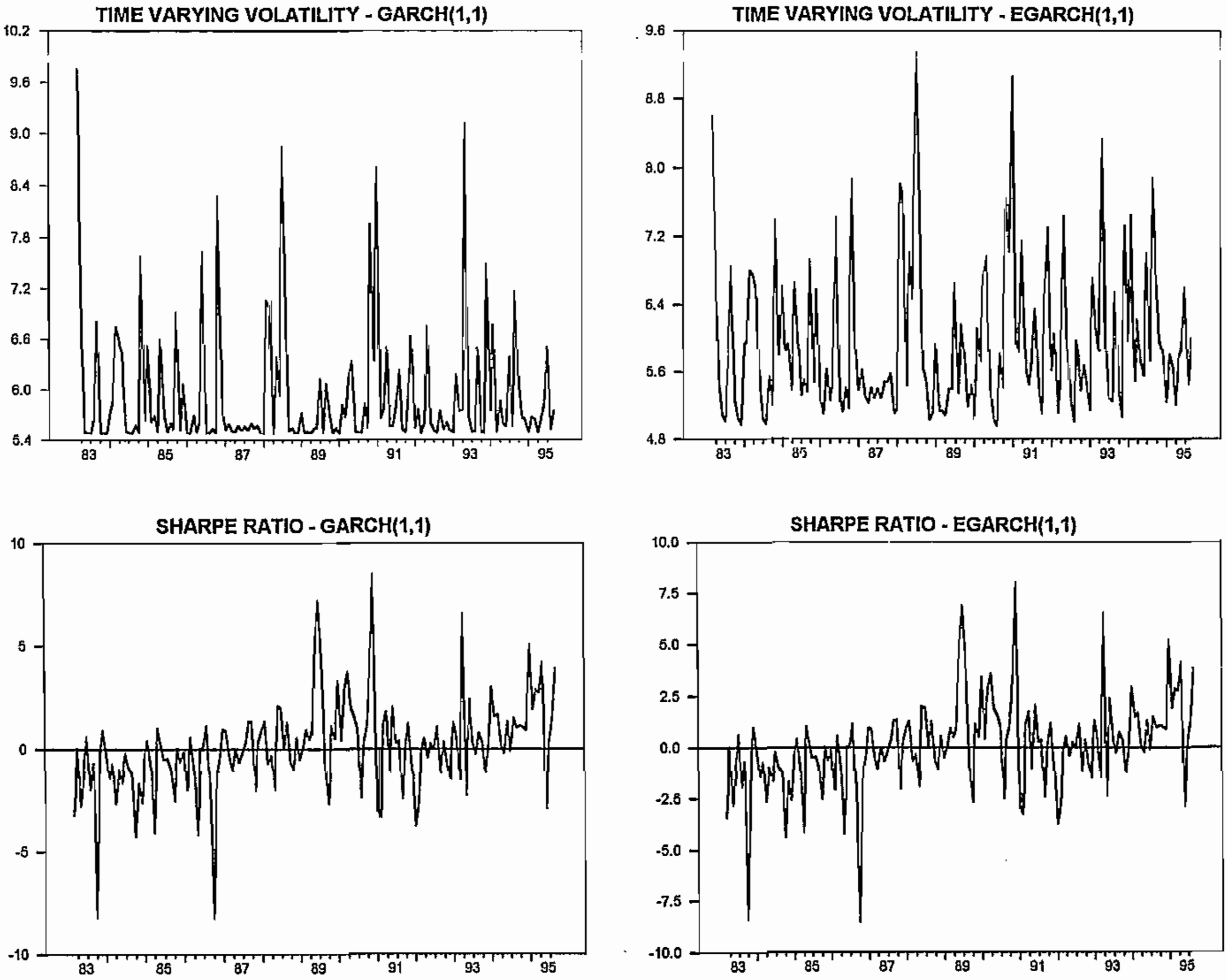


CONGLOMERATES SUB-INDEX — MONTHLY

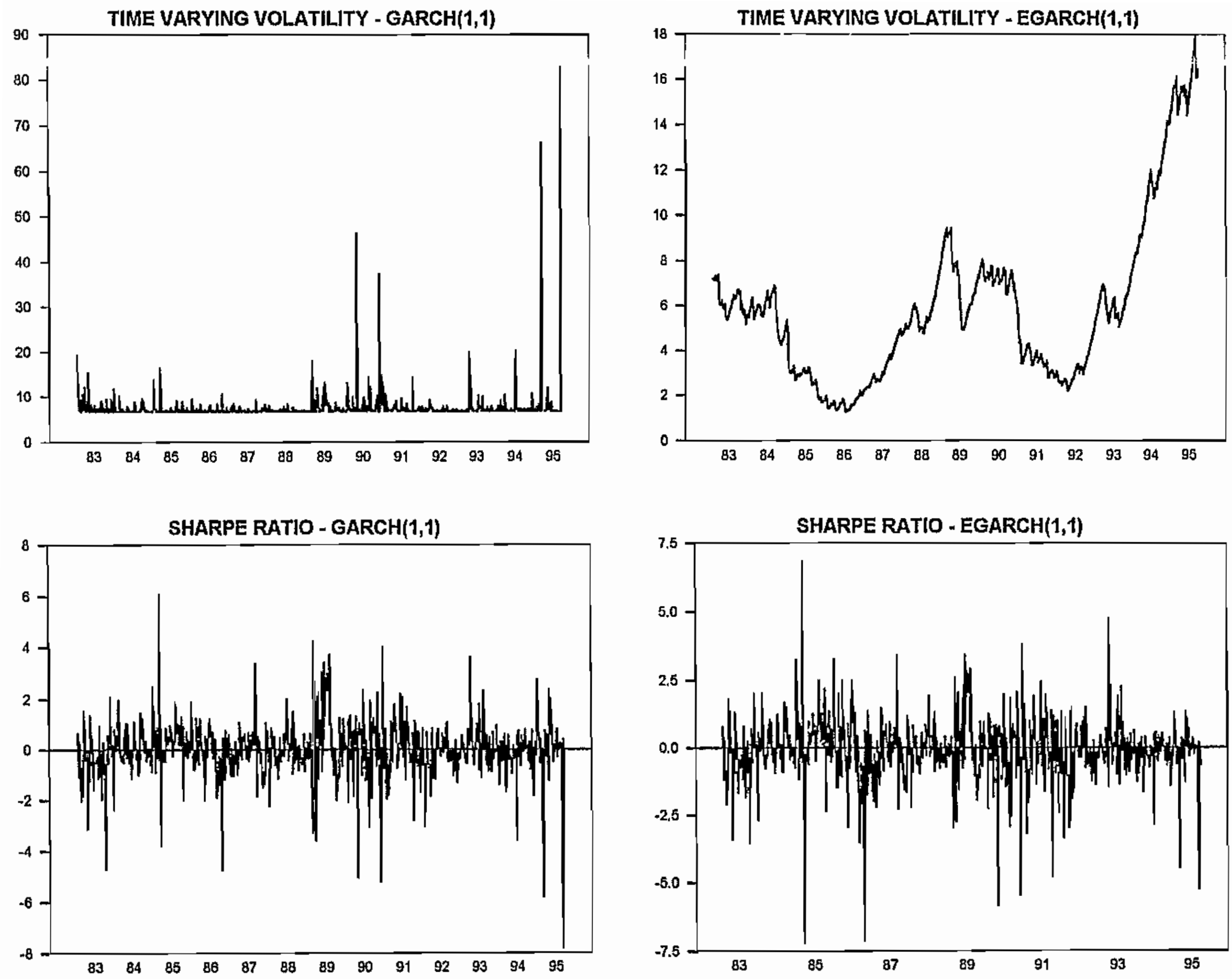
X2



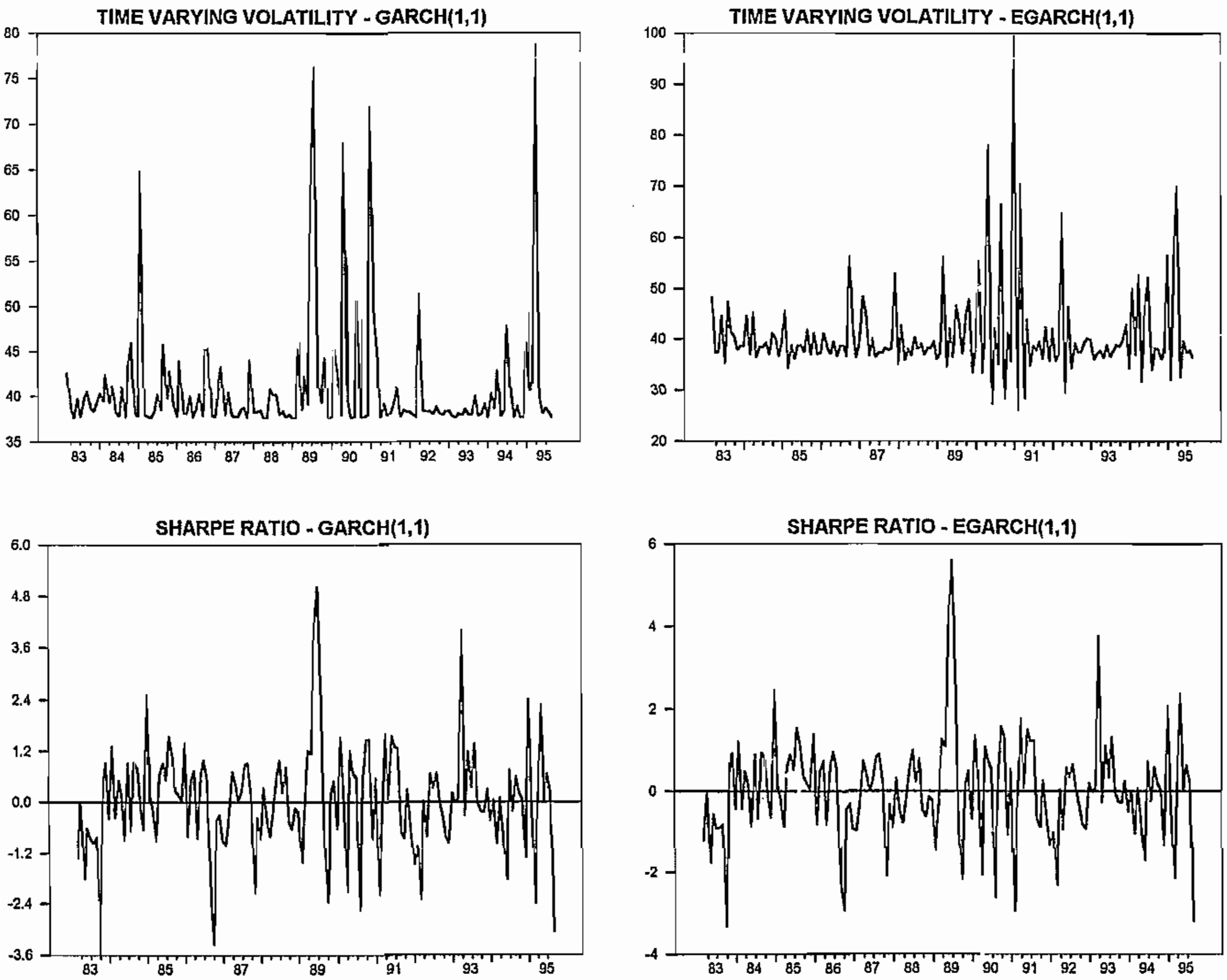
MANUFACTURING 1 SUB-INDEX — WEEKLY



MANUFACTURING 1 SUB-INDEX — MONTHLY

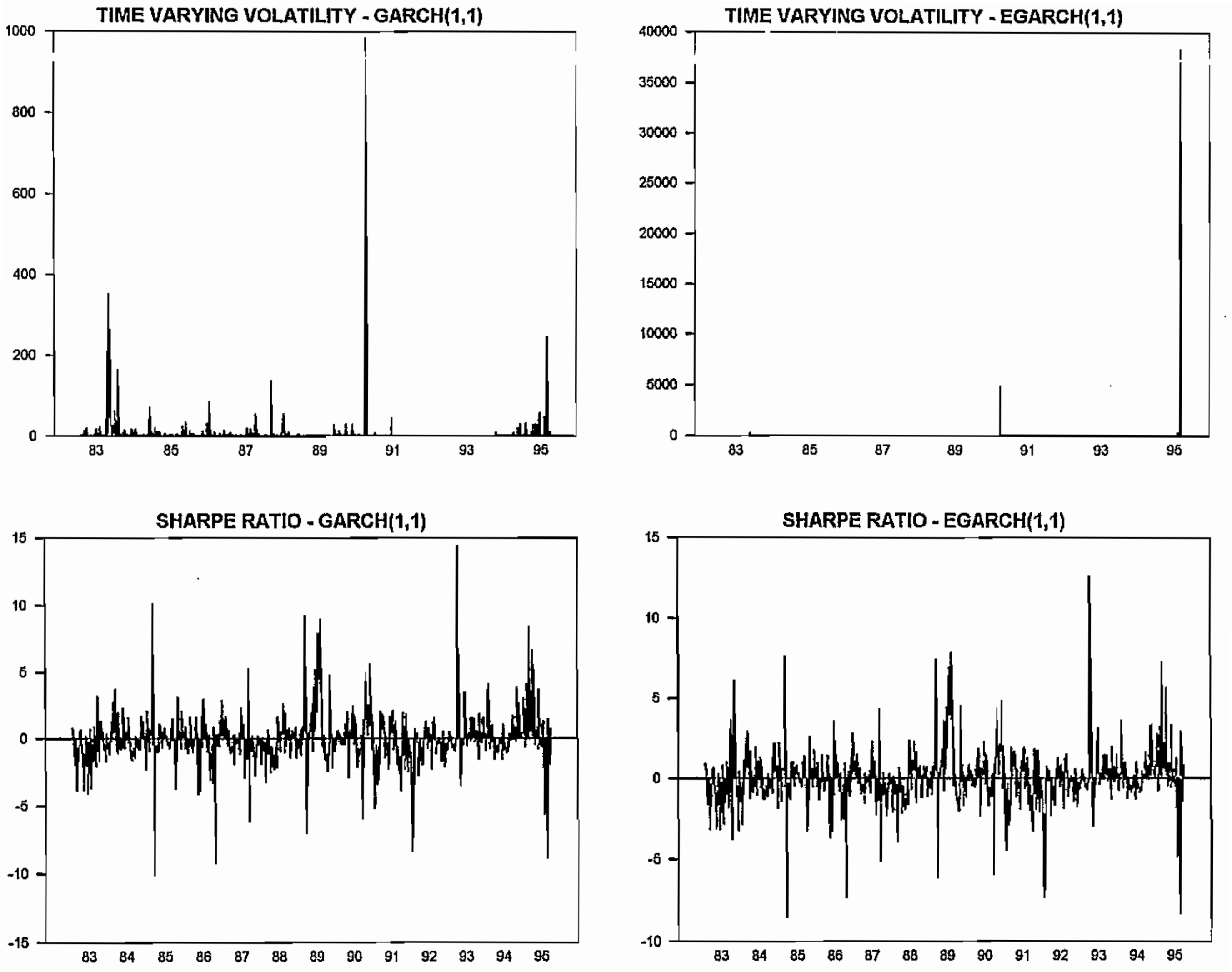


MANUFACTURING 2 SUB-INDEX — WEEKLY



MANUFACTURING 2 SUB-INDEX — MONTHLY

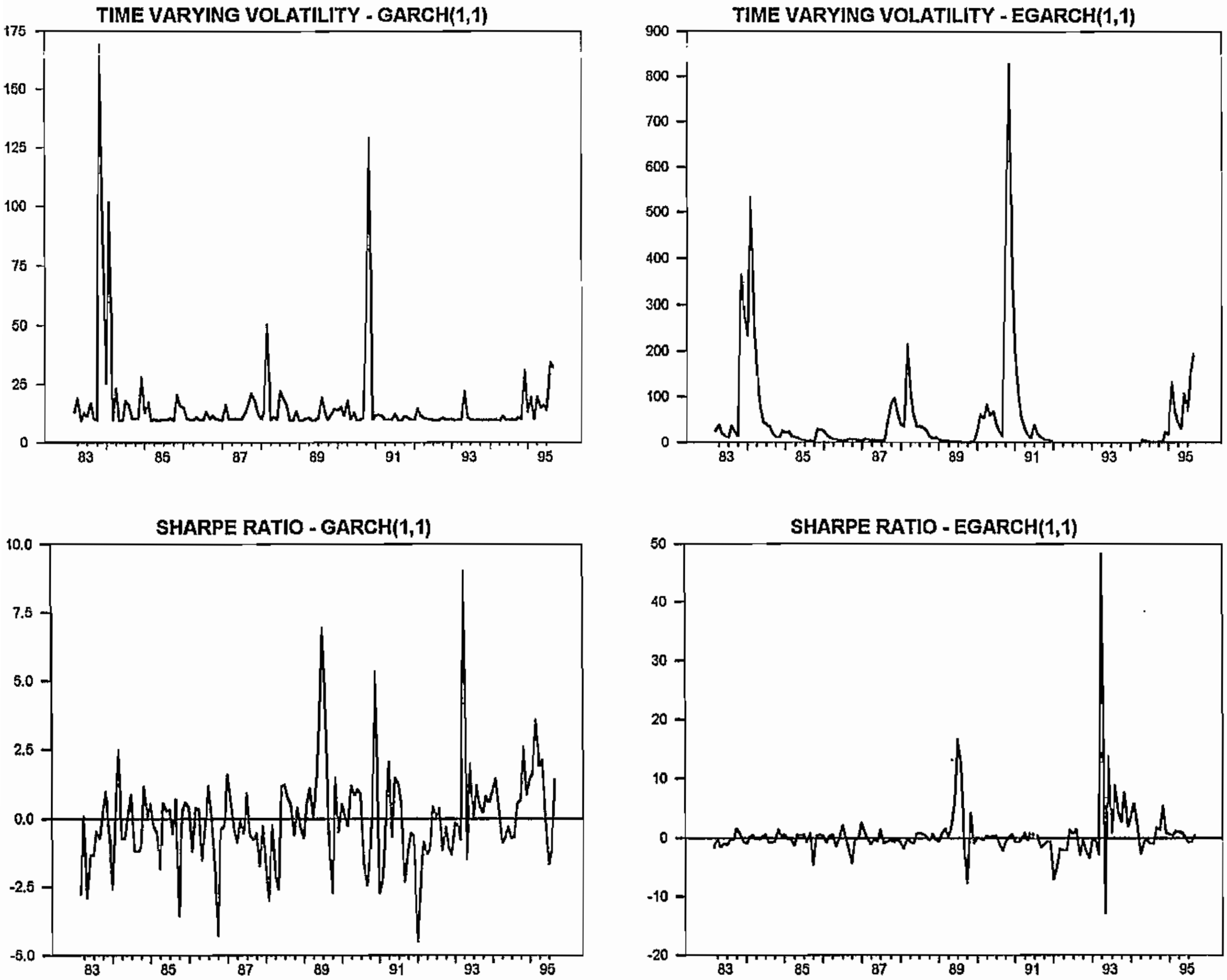
X4



PROPERTY SUB-INDEX — WEEKLY

X5

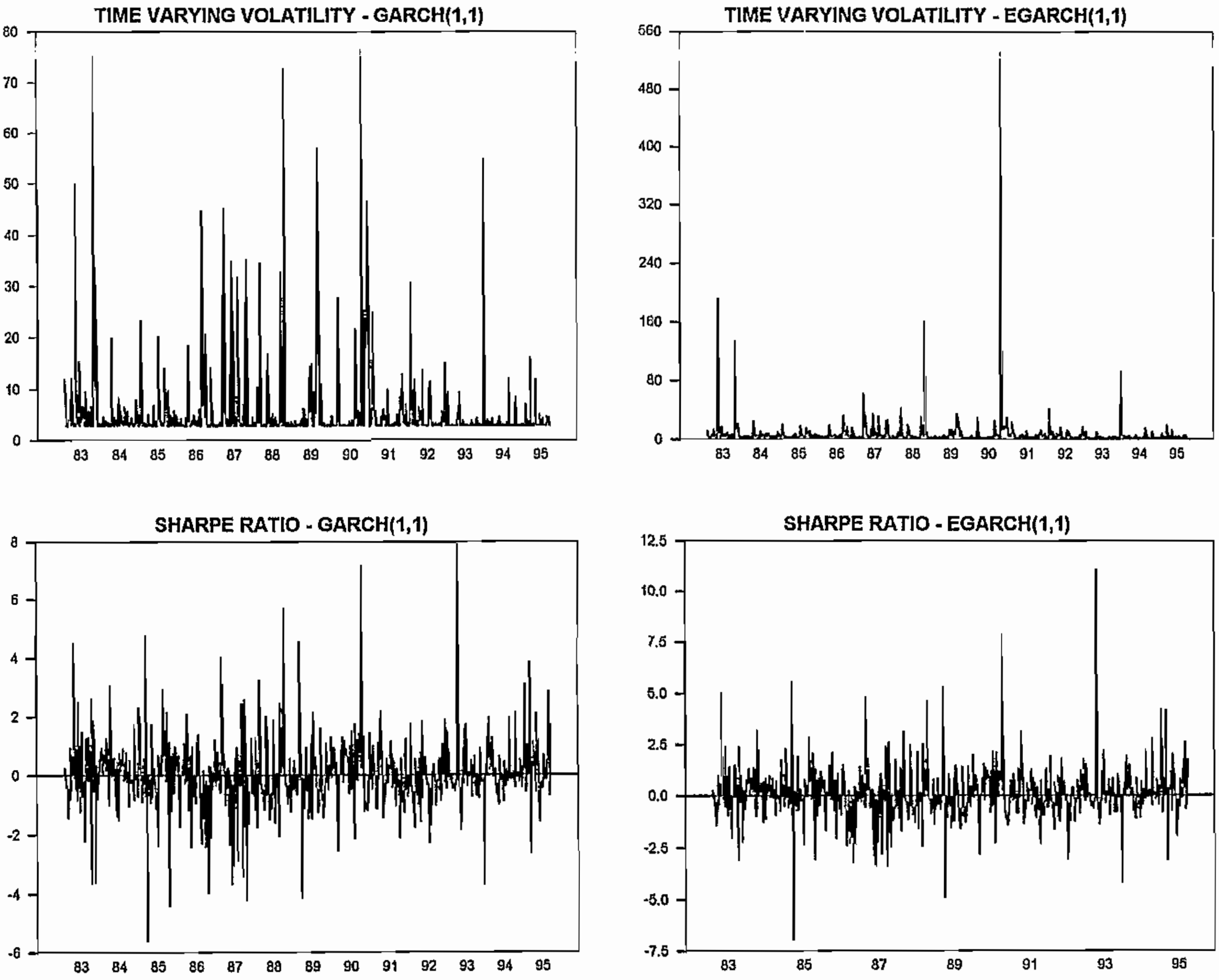
CHART 14



PROPERTY SUB - INDEX — MONTHLY

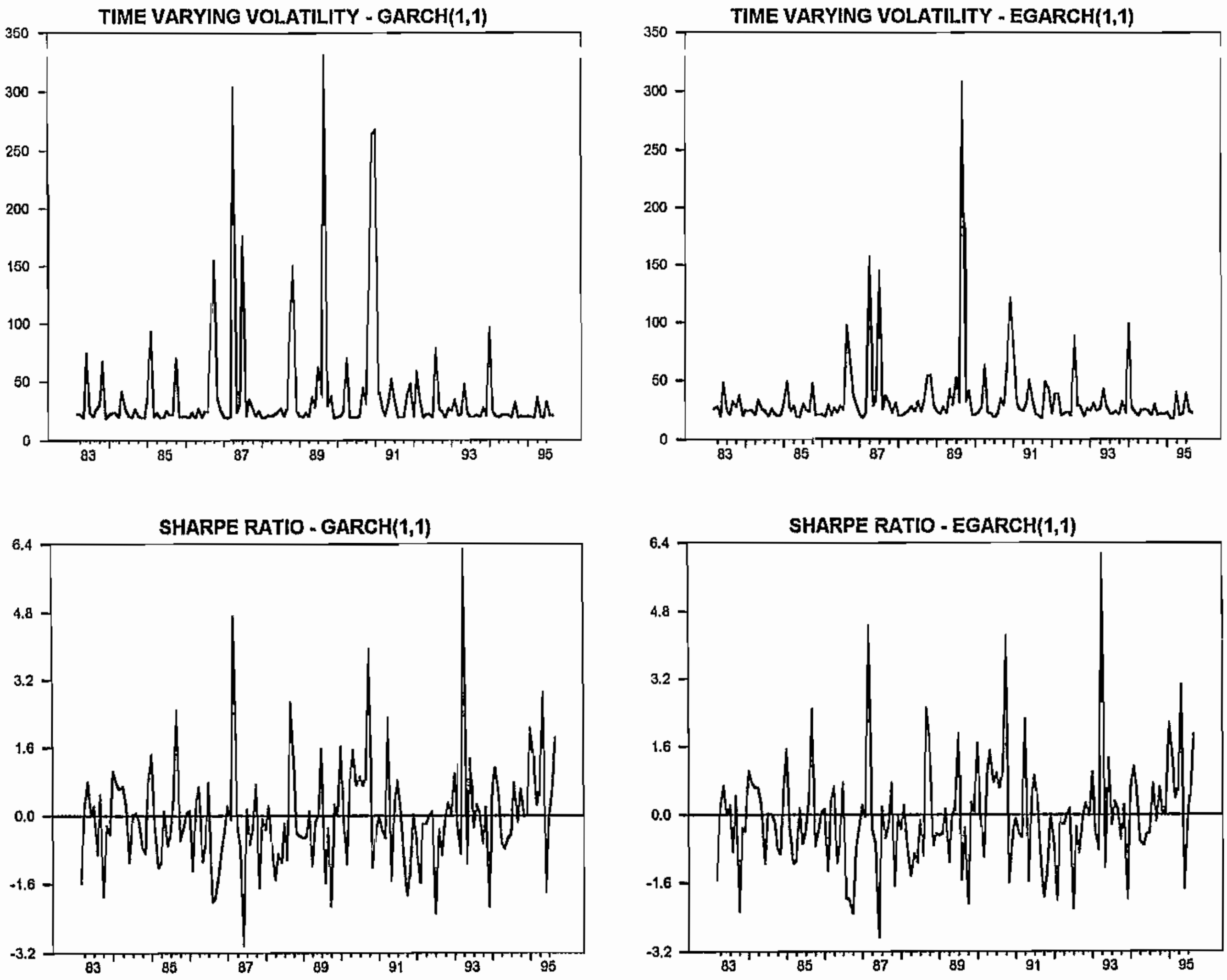
x5

CHART 15



TRADING SUB-INDEX — WEEKLY

CHART 16



TRADING SUB-INDEX — MONTHLY

X6