VOLATILITY PERSISTENCE:

A GARCH Application to Jamaican Stock Returns

by

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This paper provides evidence that the observed stock price returns on the Jamaican Stock Exchange are autocorrelated and that the volatility in the series can be modelled as a generalised autoregressive conditional heteroskedastic process.

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1. Introduction

Stock markets in developing countries are typically characterised as fragmented and thin. They generally have high transactions costs (especially high minimum commissions) which tend to deter small investors and leave the market under the operation of a small number of large, dominant operators who can affect market prices substantially. Bourne (1988) argues that these markets tend "to exhibit stock price volatility, stock price manipulation, and market inefficiency in that some investors have a systematic tendency to gain from stock price movements".

At the end of 1988, the Jamaica Stock Exchange, which started operations in 1969, had a listing of 41 companies with a market capitalisation of $4.3 billion. Total trading volume in 1988 was down to 43.5 million (value $136.7 million) compared with 71.9 million (value $400 million) in 1987. The low volume of transactions relative to gross domestic product and the relatively small number of market participants are characteristic of a thin market. During the first two decades of stock market operations, the Jamaican economy experienced long periods of both declining and growing investment climates as the administrations' ideological stance shifted from predominantly socialist to predominantly private enterprise regimes. There was a prolonged decline in output growth, general economic uncertainty, high inflation, financial sector regulation and a series of stabilisation/ adjustment programs with the International Monetary Fund (See Bank of Jamaica (1985) and Sharpley (1984)). As a result, the market experienced periods of both large and small price changes.

Research on developed country stock markets have suggested that rates of return are approximately uncorrelated over time, but characterised by tranquil and volatile periods (Bollerslev (1986)). Black's (1976) finding that stock returns are negatively correlated with changes in volatility is consistent with Pindyck's (1984) explanation that increases in relative riskiness of investors net returns from holding stocks contributed to the observed market decline in equity prices in the US. Poterba and Summers (1986) argued that volatility fluctuations did not explain a large fraction of the variation in prices and that volatility impacts on stock prices only if shocks to volatility persist for a long time; else, market agents do not adjust future discount rates.

This paper employs the GARCH technique (Engle (1982), Bollerslev (1986)), which recognises that both conditional means and variances may be time dependent, to model the dynamic behaviour of stock return volatility of the Jamaica Stock Exchange. The GARCH-in-Mean extension (See Engle, Lilien and Robins (1987)) is used to examine the relationship between volatility and market return. The exact relationship between the mean and the variance of stock returns depends on the utility functions of agents and the existing supply conditions in the market. Section 2 introduces the model, and the empirical analysis is discussed in Section 3. The conclusions and directions for further research are stated in Section 4.

2. Model

Chou (1988) shows that the Poterba and Summers (1986) framework can be used to evaluate the impact of stochastically changing risk (volatility) on the stock price. The equity premium is modelled as a linear function of the market return variance (V_t), which is assumed to be generated by a GARCH(p,q) process. The model estimated in this paper is defined as

$$R_t | \Phi_{t-1} \sim f(M_t, V_t)$$

$$M_t = \theta_o + \sum_{j=1}^{p} \theta_j R_{t-j} + \theta_{p+1} V_t + \epsilon_t$$

$$V_t = \alpha_o + \sum_{i=1}^{q} \alpha_i \epsilon_{t-i}^2 + \sum_{j=1}^{p} \beta_j V_{t-j}$$

and $\epsilon_t | \Phi_{t-1} \sim N(0, V_t)$

where $\alpha_o > 0$, α_i, $\beta_j \geq 0$, $i = 1,2$ and $j=1,2$

and the R_t is the stock return.

In the GARCH-M, both the conditional mean (M) and variance (V) are time dependent, and the variance, defined as a linear function of past forecast errors and past conditional variances, is an explanatory variable in the conditional mean. The impact of a shock to the current volatility is measured by the decay factor $\Sigma(\alpha_i+\beta_j)$ for stationary processes. Alternative GARCH(p,q) processes can be obtained as coefficient restrictions on the least restricted model.

3. Empirical Analysis

The graph of log of the composite monthly stock price index for the period 1969:07 to 1988:12 suggested non-stationarity, possibly with a drift factor. The distinct cut off in the partial correlation function, the smooth and slowly declining autocorrelation function (value of 0.72 at lag 20) and the value of 0.99 for the first sample partial auto-correlation suggested first order non-stationarity. The Dickey-Fuller Test of a unit root*, with critical values modified to reflect drift and trend values (See Schmidt (1988) and Schmidt and Kwiatkowski (1989)), was not rejected ('t' = -1.3, coefficient = 0.99), indicating that the logarithm of the stock price index was a martingale difference process.

* A similar result obtains when weekly dependent and heterogenous innovations are allowed (Phillips and Perron (1988)).

The parameters are well determined and significant at the 5 per cent level. The conditional variance term in the mean generating process is significant and negative and the variance is nearly non-stationary ($\alpha_1 + \beta_1$ is close to unity). In fact, the integrated GARCH(1,1)-M process ($\alpha_1 + \beta_1 = 1$) was not rejected against the GARCH(1,1)-M; the likelihood ratio statistic was 0.1 versus a $\chi^2(1)$ critical value of 3.84. Thus, shocks to volatility persist for long periods into the future. The estimates of the GARCH(1,1)-M model indicate that 54% of a shock to the variance still persists after one year. If volatility relates to inflationary conditions and general economic uncertainty, a negative effect on stock returns is plausible within a portfolio selection framework. Risk averse utility maximising agents require adequate risk premia and will alter portfolios to maximise expected returns. High yields on other assets, for a given level of risk, could induce switching. This result suggests the need for a multivariate GARCH-M model to account for the implicit covariance structure.

The mean lag in the conditional variance is 1.3 months and the distribution is long tailed, with 50% of the adjustment taking less than half of one month. The unconditional variances of ϵ_t and M_t are 20.8 and 27.9, respectively and are less than but of similar magnitude to the sample variances. The autocorrelation function and partial autocorrelation function of the standardised residuals are less than two standard errors and Lung-Box test ($\chi^2(10) = 6.8$)

for the standardised residuals indicates good overall fit. The GARCH(1,1)-M Model was not rejected against higher order models, but the GARCH(1,1) model was rejected at the 5 percent level of significance [likelihood ratio statistic = 5.4]. Thus, the GARCH(1,1)-M model provides encouraging results.

Conclusion

This paper provides supporting evidence that stock returns on the Jamaica Stock Exchange are autocorrelated and exhibit time varying volatility. The linear dependence of return indicates imperfect utilisation of information flows. A GARCH(1,1)-M process fits the data adequately. The conditional variance is found to exert a negative influence on returns. Since the risk factor may vary, this may be due to the greater uncertainty experienced in the 1970s and mid-1980s. In the developing country context, it possibly points to the need for a stable macroeconomic environment to stimulate the growth of equity markets. The results point to the need for further research to identify sources of uncertainty in order to model equity returns, particularly in a multivariate asset framework.

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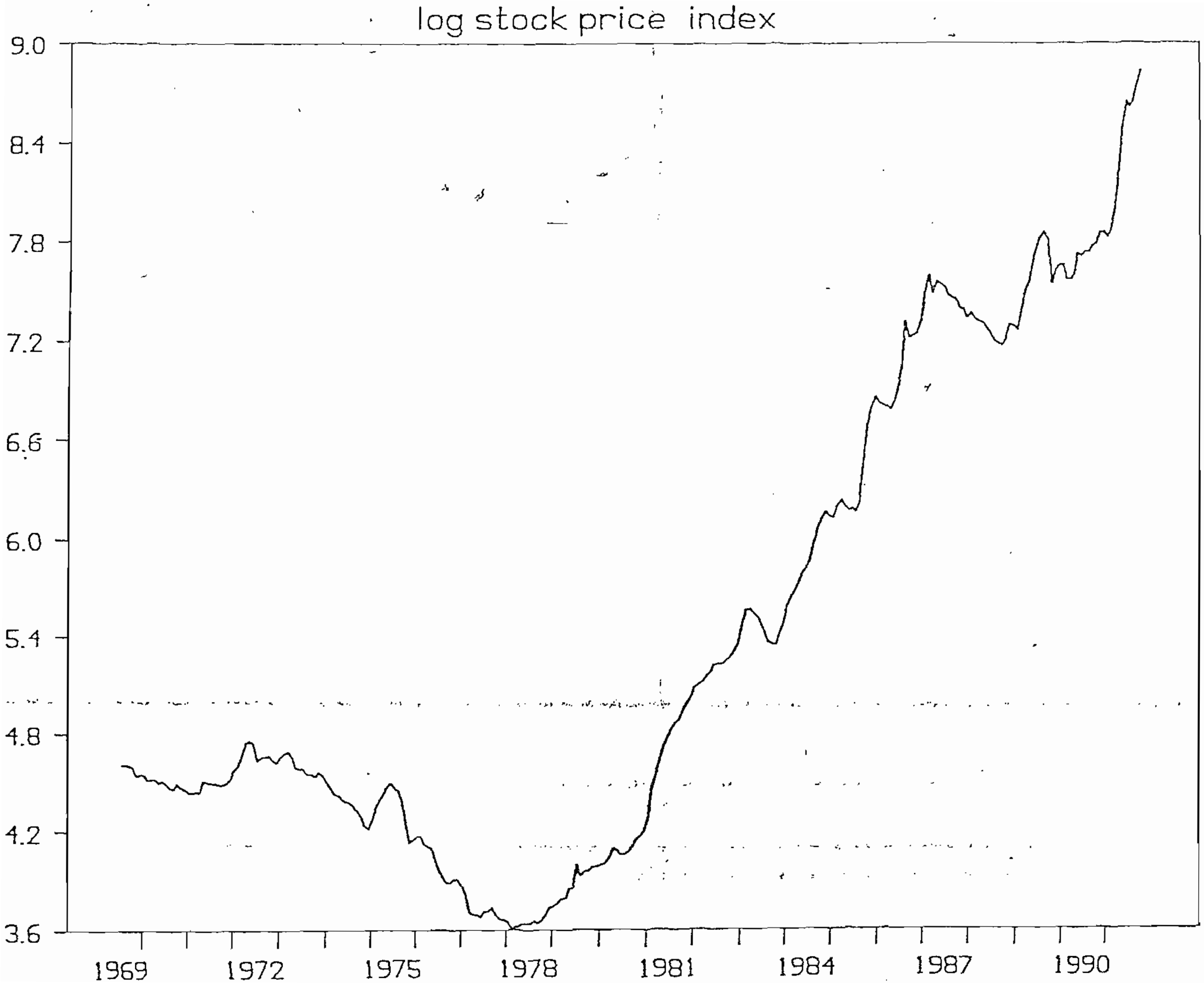
log stock price index
9.0
8.4
7.8
7.2
6.6
6.0
5.4
4.8
4.2
3.6
1969
1972
1975
1978
1981
1984
1987
1990

```
NT LSPI
e: 11-23-1991 / Time: 18:39
L range: 1969.08 - 1991.10
ber of observations: 267
===============================================================================
    Autocorrelations          Partial Autocorrelations           ac       pac
===============================================================================
          . |*************|           . |*************|  1  0.988   0.988
          . |*************|           . | .           |  2  0.976  -0.027
          . |*************|           . | .           |  3  0.963  -0.002
          . |************ |           . | .           |  4  0.951  -0.011
          . |************ |           . | .           |  5  0.938  -0.026
          . |************ |           . | .           |  6  0.926   0.023
          . |************ |           . |*.           |  7  0.915   0.047
          . |************ |           . |*.           |  8  0.905   0.048
          . |************ |           . | .           |  9  0.896   0.018
          . |************ |           . | .           | 10  0.887  -0.012
          . |***********  |           . | .           | 11  0.877  -0.030
          . |***********  |           . | .           | 12  0.867  -0.015
          . |***********  |           . | .           | 13  0.857   0.007
          . |***********  |           . | .           | 14  0.847  -0.004
          . |***********  |           . | .           | 15  0.838   0.007
          . |***********  |           . | .           | 16  0.827  -0.017
          . |***********  |           . | .           | 17  0.817  -0.013
          . |**********   |           . | .           | 18  0.807  -0.023
          . |**********   |           . | .           | 19  0.797   0.022
          . |**********   |           . | .           | 20  0.787   0.001
===============================================================================
-Statistic (20 lags) 4185.486                S.E. of Correlations  0.061
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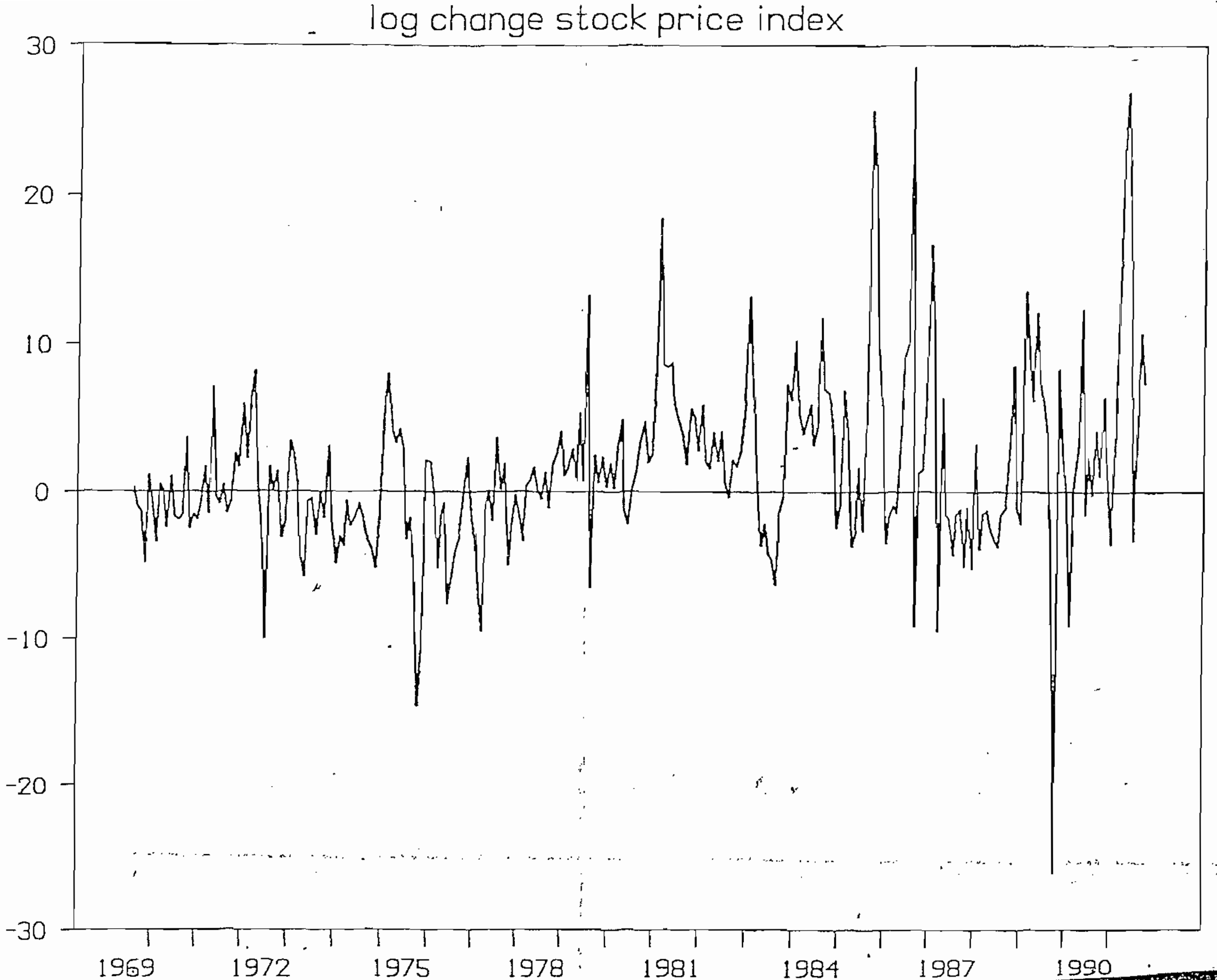
log change stock price index
30
20
10
0
-10
-20
-30
1969
1972
1975
1978
1981
1984
1987
1990

```
ENT DLSPI
te: 11-23-1991 / Time: 18:42
pL range: 1969.08 - 1991.10
mber of observations: 267
==========================================================================
    Autocorrelations           Partial Autocorrelations          ac     pac
==========================================================================
          . |******    |            . |******      |  1  0.464  0.464
          . |***       |            . |  .         |  2  0.242  0.033
          . |*.        |            . |  .         |  3  0.102 -0.028
          . |*.        |            . |*.          |  4  0.101  0.074
          . |*.        |            . |  .         |  5  0.084  0.018
          . |*.        |            . |*.          |  6  0.111  0.066
          . |  .       |            .*|  .         |  7  0.004 -0.100
          . |*.        |            . |**          |  8  0.080  0.121
          . |**        |            . |*.          |  9  0.125  0.079
          . |**        |            . |*.          | 10  0.152  0.045
          . |*.        |            . |  .         | 11  0.108  0.003
          . |*.        |            . |  .         | 12  0.051 -0.035
          . |*.        |            . |*.          | 13  0.050  0.050
          . |*.        |            . |  .         | 14  0.039 -0.031
          . |*.        |            . |*.          | 15  0.082  0.071
          . |*.        |            . |  .         | 16  0.063 -0.006
          . |*.        |            . |  .         | 17  0.063  0.023
          . |  .       |            .*|  .         | 18 -0.014 -0.081
          . |  .       |            . |  .         | 19 -0.004 -0.008
          . |  .       |            . |  .         | 20  0.011  0.029
==========================================================================
Statistic (20 lags)  104.723               S.E. of Correlations  0.061
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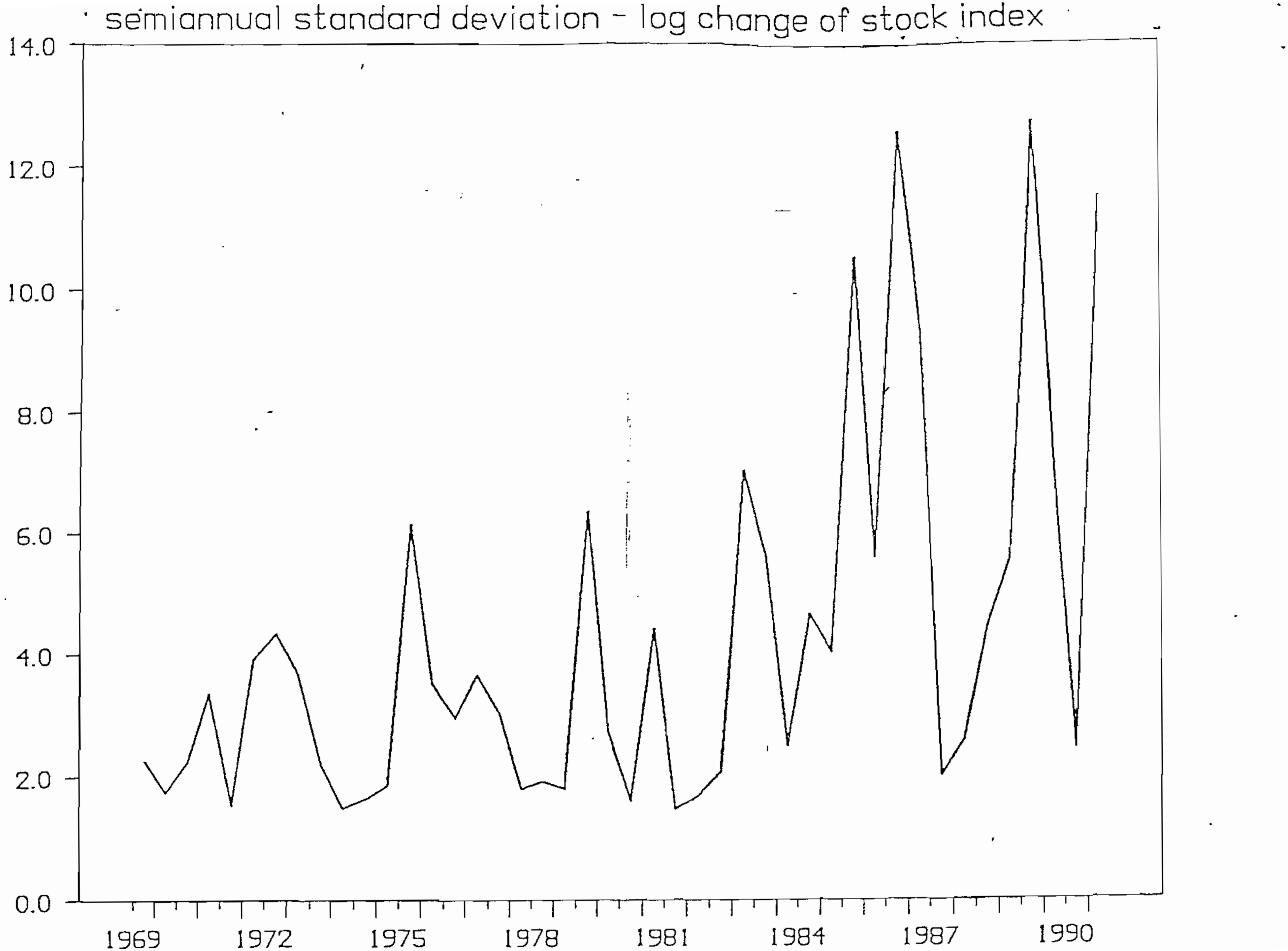
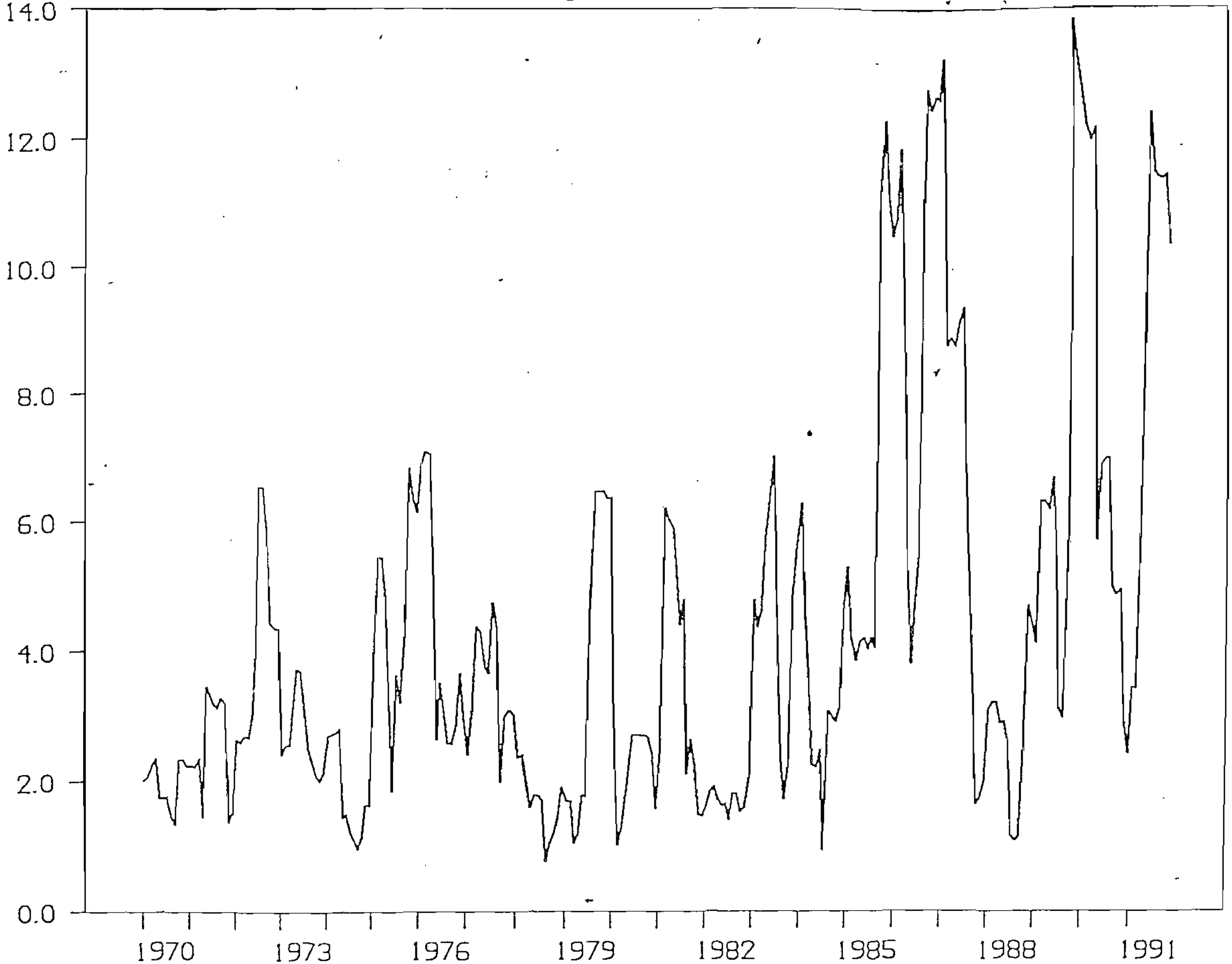
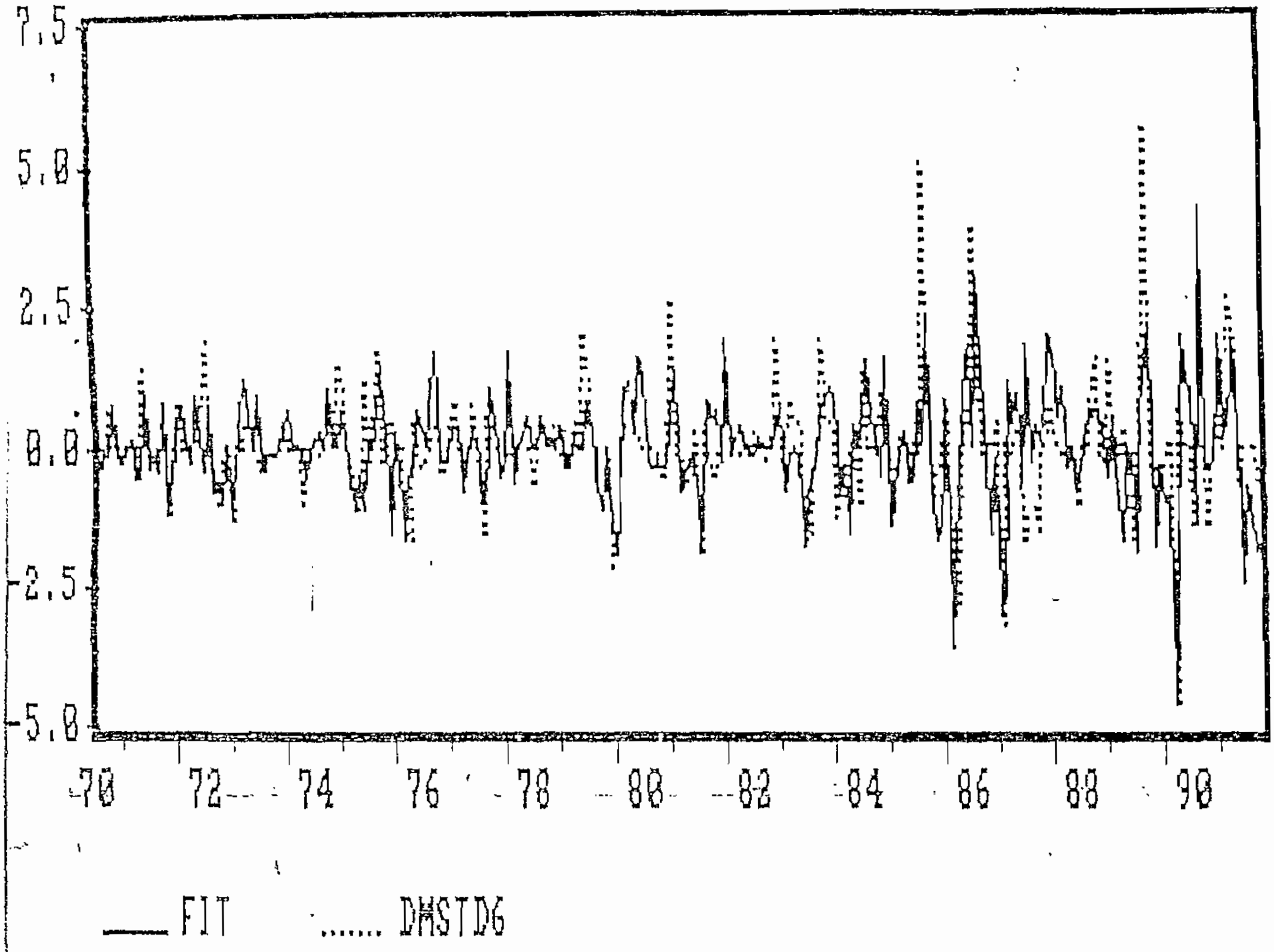
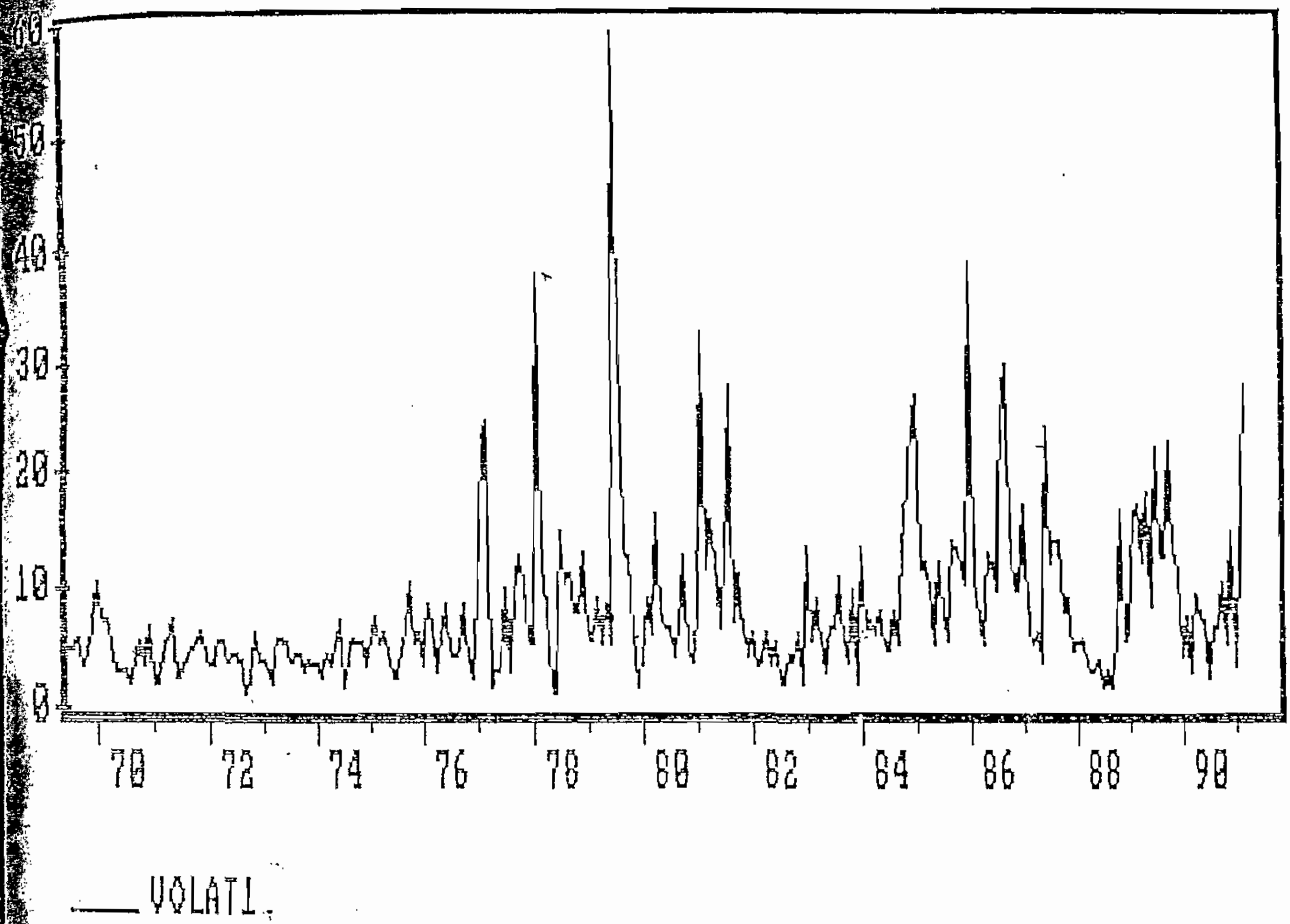

semiannual standard deviation - log change of stock index
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1969
1972
1975
1978
1981
1984
1987
1990

6-month moving standard deviation





7.5
5.0
2.5
0.0
-2.5
-5.0
70
72
74
76
78
80
82
84
86
88
90
FIT
DHSTD6



60
50
40
30
20
10
0
70
72
74
76
78
80
82
84
86
88
90
VOLATI.