

various non-parametric homogeneity-of-variance tests requiring data segmentation. Hsu (1982) also suggested a Bayesian robust inferential scheme to detect and estimate variance changepoints which assumes a symmetric, heavy-tailed exponential power distribution, and requires no data segmentation. A more comprehensive investigation using all aforementioned techniques over longer periods for individual stocks can be found in Hsu (1984). Ali and Giaccotto (1982) in their study on location-scale shifts focussed on the period 1966 through 1976 using daily, weekly, monthly and quarterly rates of return on the first 15 Dow-Jones stocks. While there was no significant evidence for change in location, scale shifts were quite pervasive during the Cambodian and Watergate eras for most stocks. Ohlson and Penman (1984) demonstrate an increase in volatility during the period surrounding stock splits whilst Lockwood and Linn (1990) employing the S and P 500 Index report high variance across the trading day from open-to-close compared with the overnight interval. The moving block methodology of Wichern *et. al.* (1976) when applied to daily returns on the Dow-Jones Index from 1897 through 1988 yielded 197 variance decreases coupled with 205 such increases (Haugen *et. al.* 1990).

For the Indian market a sharp upswing in variability is evident since the beginning of 1985 whether conceptualized as a stepchange (Broca,1933a) or a monotonic trend (Broca,1944a). Explosive growth of market existing alongside archaic trading/settlement systems encouraging speculation seem to be partly responsible for the results. The 200 trading days of 1990, forming the subject of another examination (Broca, 1993b), showed a similar step-type increase in the latter half which witnessed unusual disturbances in the shape of a massive boom-bust cycle. The Gulf crises of August 1990, that jolted most world financial systems, together with a host of country specific events lead Broca (1994b) to unearth heterogeneous variability in weekly market prices over 1990-91 for six out of 17 emerging markets identified by the International Finance Corporation. In a recent study employing "recursive" residuals from a market model regression, Broca (1995) developed a control chart model for dynamically monitoring volatility increases and decreases against statistically determined upper and lower critical limits. The application of this model to Sensex data from the Bombay bourse over 1990-1992 reveals several volatility changes which broadly correlate with major speculative build-ups witnessed in recent years or release of significant macroeconomic information.

### III Ranks Tests for Heteroscedasticity

To introduce these tests originally formulated by Hajek and Sidak (1967) let there be a sequence (time series) of independent random variables  $\{Y_i\}_{i=1}^T$ , where each observation is generated according  $Y_i = \mu + \sigma_i \varepsilon_i$ , the scale parameter varying according to  $\sigma_i = \exp(\lambda + \nu d_i)$ . In this formulation  $\mu$  is the process mean,  $\varepsilon_i$ 's are IID random variables with distribution function  $F$  corresponding to density  $f$ ,  $\nu$  denotes the rate change of the scale parameter, and  $\{d_i\}_{i=1}^T$  is a sequence of known