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Tail-Fatness in Equity Returns.

The Case of Athens Stock Exchange

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Ioannis A. Venetis
Research Fellow
Centre of Planning and Economic Research

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ABSTRACT

The standard Hill and the modified Hill estimator of Huisman et al., (2001) are applied to a large number of individual daily stock returns from the Athens Stock Exchange for the period 1993-2003. We find that the Hill estimator significantly overestimates risk in both tails. In addition, recently constructed tests for structural change are applied. The test results provide strong evidence of time variation in the tail index. The tests are able to propose breakdates that appeared to be clustered shortly after a particular historical period of Athens Stock Exchange, namely the surge of stock prices during 1998-1999. The direction of change is “fat to thin to fat tails” pointing to a significant flattening in the return distributions during the aforementioned period. Such flattening is consistent with noise trading. The fact that small capitalization firms appeared to be more susceptible to such breaks only reinforced the noise trading hypothesis.

1 Introduction

There is substantial empirical evidence that the distribution of returns on equities and other assets is typically leptokurtic, that is, the unconditional return distribution shows high peak and fat tails (for an early example see Mandelbrot, 1963) and Fama, 1963, 1965). The latter phenomenon is of particular importance as the magnitude and frequency of outliers - compared with the typical Gaussian distribution - increase as the "tail becomes fatter". The growing importance attached to risk management, particularly in relation to the banking system, to exchange rate risk and generally to portfolio risk, as well as recent events like the October 1987 stock market crash, the Asian financial crisis of 1997-1998, the LTCM crisis in 1998, the Russian debt default in 1998, underscore the relevance of outlier activity and provide justification for the interest on issues relating to the behavior of extremes. In the words of Kearns and Pagan (1997) *"Ultimately, risk measures must relate to the probabilities of having either a large positive or negative realization of the random variables underlying the portfolios..."*.

Additional importance, on a theoretical level, is attached to the tails of returns' distributions in recent work by Lux and Sornette (1999). These authors find that rational bubbles a la Blanchard and Watson (1982) are hardly reconcilable with empirical regularities of financial data. In order for rational bubbles to appear the unconditional return distribution should be so fat-tailed as to imply non-existence even of the first moment.

Although information about the precise magnitude of tail fatness is crucial for applications (such as risk analysis) little consensus exists in this respect due to estimation difficulties. Typically, empirical estimation of tail-fatness could be conditional on specific assumptions regarding the underlying distribution. One would choose the Student-t or the stable distribution or some other fat-tailed distribution and then would estimate a statistic that quantifies the fatness of the distribution. Unfortunately, these alternatives are non-nested and analysis based on them is prone to misspecification error. Furthermore, traditional parametric econometric methods are ill-suited for tail estimation and for the assessment of statistics like extreme quantiles and event probabilities since the estimation procedure is based on estimation of entire densities. As such, it produces good fit in the middle region of the distribution where the majority of observations belong, potentially at the expense of good fit in the tails of the distribution. The same appears to be valid for nonparametric methods, such as density estimation based on various kernels (See Silverman, 1986).

In recent years, extreme value theory (EVT[1]) offers an alternative approach that overcomes this modelling difficulty. EVT employs only a subset of the data, the upper or lower extreme percentile, in the estimation problem thereby fitting the tail, and only the tail. Diebold et al. (1998) summarize the attractive features of the approach into

- **(i)** *the estimation is tailored to the object of interest, the tail of the distribution, rather than the center of the distribution*
- **(ii)** *an arguably-reasonable functional form for the tail can be formulated from a priori considerations*

EVT is based on the Fisher-Tippett theorem, formally proved by Gnedenko (1943), that gives the limit distribution of location and scale standardized extremes. As the sample from which the maximum is drawn tends to infinity, the cumulative distribution of the standardized maximum converges to what is known as the generalized extreme value (gev) distribution. The shape of the gev distribution depends crucially on a parameter named *tail index* and it can admit three distinct types. The one type that is relevant for fat-tailed data is the Frechet distribution type. A sufficient condition on the cumulative distribution of the data for the Frechet type limit to obtain is that the cumulative distribution varies regularly at infinity implying that the right tail of the distribution exhibits the same hyperbolic decline as that of a Pareto distribution. The advantage of using EVT is that no detailed knowledge of the underlying distribution is needed. The condition of fat-tailedness is compatible with a large number of random variables, such as Pareto, Cauchy, Burr, loggamma, Frechet, Stable or Student-t

[1] Several textbooks deal with EVT, for example Embrechts et al. (1997) or Reiss and Thomas (1997).

random variables, as well as GARCH processes. Thus, the tail index measures fat-tailedness of the underlying distribution and summarizes the behavior of extremes. Furthermore, the tail index, denoted by a from now on, corresponds one-to-one with the number of existing moments.

The best known and most often applied extreme value estimator for a is the non-parametric estimator proposed by Hill (1975). Hill's method has been widely used since it combines nice empirical features, it is very easy to implement, with strong theoretical properties, it is consistent and asymptotically normal. However, the method has two important drawbacks. **(a)** First, the small-sample properties of the estimator are likely to be affected by the choice of a certain threshold. As a result, although asymptotically unbiased, the estimator suffers severely from small sample bias. Recently, alternative estimators have been proposed. Pictet, Dacorogna and Muller (1996) studied the performance for a number of these estimators. They concluded that all suffer severely from small sample bias. On the other hand, the modified (Hill) estimator proposed by Huisman et al., (2001, HKKP) overcomes significantly this problem. In addition, HKKP showed that their estimator performs adequately even for processes exhibiting GARCH(1,1) type dependence, a result that fits in the next (second) drawback[2] **(b)** Second, tail-index estimators are likely to be severely biased in small samples when the i.i.d assumption for the underlying series is violated while conventional measures of the precision of the Hill estimator could be greatly exaggerated (Kearns and Pagan, 1997). Indeed, for linearly dependent data, Hsing (1991) showed convergence in distribution of the Hill estimator with a noncentral term entering the limiting distribution. Nevertheless, in large samples, the consistency of the Hill estimator has been known under a wide range of dependent processes. Resnick and Starica (1995) showed consistency for fat tailed infinite order moving averages while Resnick and Starica (1998) show consistency when certain types of nonlinearity are present. These include the Bilinear and GARCH cases.

[2] In this context, McNeil and Frey (2000) have proposed to focus on the conditional behavior of the tails, once the series has been filtered by a GARCH process.

The latter, is particularly important for financial econometric applications. Typically, daily returns are a stationary strongly leptokurtic series that possibly exhibit low order serial correlation while strong dependence in conditional second moments (GARCH effects) is widespread. These "empirical regularities" impose serious questions regarding the accuracy of assessments with respect to the likelihood of large fluctuations in, say, portfolio returns (see Kearns and Pagan, 1997) when the standard Hill estimator is applied. This issue is further accentuated by the overlooked possibility of structural breaks in the distribution tails.

Notice that, applications of EVT to stock-market returns are abundant. While few papers focused on low-frequency data (e.g. Longin and Solnik, 2001), most studies considered daily data (e.g. Jansen and de Vries, 1991; Loretan and Phillips, 1994; Longin, 1996) while Lux (2001) investigated tick-by-tick data of the German DAX stock index. Very few papers, however, focus on the tail behavior of returns in emerging markets. The only papers, to our knowledge, which explicitly investigated the behavior of extreme returns in emerging markets are the papers by Quintos et al. (2001) who considered the behavior of extreme returns on three Asian stock markets and Jondeau and Rockinger (2003) who test for differences in the tails of stock-market returns in five mature markets (US, Japan, Germany, France, and the UK) as well as fifteen emerging markets (Asian indices: Hong Kong, Singapore, South Korea, Taiwan, and Thailand, Eastern European indices: Hungary, Poland, Russia, the Slovak Republic and Slovenia, Latin American indices: Brazil, Chile, Colombia, Mexico and Peru).

Furthermore, the possibility of breaks in the tail index has been rarely investigated although there is favorable econometric evidence when the breakdate assumed to be exogenous or known (see Phillips and Loretan, 1990, Koedjick et al., 1990, Pagan and Schwert, 1990a,b). The innovative paper by Quintos et al. (2001) assumes that the break occurs at an unknown point and by construction it allows estimation of the possible breakdate. In addition, the structural break tests allow inspection of a sequence of tail estimates. Such an inspection could be of particular interest for reasons that goes beyond historical assessment on the effects of institutional reforms on the relative frequency of extremes. Evaluation in real time of the amount of risk is vital to practitioners and it would be interesting to see how fast changes can be identified. In addition, the theoretical results of Lux and Sornette (1999) mentioned earlier imply a tail index estimate $a < 1$. Although, this does not pose as a plausible full sample estimate, it would be interesting to see if rational bubbles can be reconciled for specific time periods.

This study adds to the aforementioned literature in a number of ways. First, we analyze a new data set which corresponds to the Athens Stock Exchange (ATHEX from now on), a small market that was recently characterized as developed. As such, it distinguishes from the frequent developed stock markets analysis that focuses on major international stock markets. Our objective is to provide guidance for researchers that are interested in tail behavior of returns in similar peripheral stock exchanges. Of course the same line of research can be adopted if the focus is major stock markets. Second, we abstract from the typical composite stock index analysis or foreign exchange markets analysis and we estimate the tail index directly for individual stock returns. In this way variations in the distributions among equities can be investigated. Third, to the best of our knowledge, an application using the HKKP method appears only in Huisman et. al. (2002) despite its promising properties regarding unbiasedness of the tail index estimate and its behavior under GARCH dependencies. Note that the results in that study point towards overestimation of riskiness by the standard Hill estimator. Fourth, the structural breaks tests of Quintos Fan and Phillips (2001) have also not widely applied. To the best of our knowledge they appear only recently in the following studies, Galbraith and Zernov (2002) with an application on U.S index returns, Werner and Upper (2002) who investigated the Bund futures returns series and Candelon and Straetmans (2003) who applied the tests on emerging currency returns. These studies manifest the ubiquitous presence of structural changes (albeit for different reasons). Thus, we intend to provide further insight on the empirical aspects of those methods.

The paper is organized as follows. Section 2 gives a short account of the popular

Hill estimator and its recent modification by Huisman et. al. (2001) in order to correct small sample bias problems. Section 3 presents the procedure we followed in order to test for structural changes in the tail index. Section 4 contains our empirical application on Athens Stock Exchange data. It is divided in three subsections. Subsection 1 presents descriptive statistics on our returns data set. Subsection 2 discusses our findings regarding the tail index of individual stock returns. Subsection 3 discusses our findings regarding structural breaks in the tail indices. Section 5 concludes the paper offering possible routes for future research.

2 The Hill and modified Hill tail-index estimator

Rather than specifying the underlying true parametric distribution, we directly estimate the tail index or maximum exponent based on the Huisman, Koedijk, Kool and Palm (2001, HKKP thereafter) method which is a weighted average of the well known Hill (1975) estimator.

Application of the Hill and other tail-index estimators requires a priori selection of the number m_T of tail observations (threshold) to include. The "typical" problem of (a) relative low variance but biased estimate if too many observations are included and (b) large variance but relative small bias if few observations are included applies here. It is common in estimation to use a proportion of the sample size such as $m_T = [kT]$ with $k = 10\%$ (see DuMouchel, 1983). Hall (1990) showed that the bias of $\hat{\gamma}_T = \hat{a}_T^{-1}$ increases in m_T (the variance decreases in m_T). As a result, a small m_T is preferable from the perspective of unbiasedness while an important observation from Hall (1990) is that for any $m_T > 0$ one always faces a bias. The HKKP method we adopt, exploits information obtained from a set of Hill estimates each based on a different number of thresholds correcting the small sample bias. We briefly present the Hill estimator and then we proceed to discuss the HKKP tail index estimator.

Let $\{x_i\}_{i=1}^{T}$ an i.i.d sequence denoting a realization of a random variable X whose distribution $F(x)$ is fat-tailed fulfilling the regular variation condition[3]:

$$\lim_{t\to\infty}\frac{1-F(tx)}{1-F(t)}=cx^{-a} \tag{1}$$

Then the Fisher-Tippett theorem applies and the properly normalized sample maximum converges to a non-degenerate distribution, namely the Frechet distribution. Condition (1) implies that the higher a the less fat-tailed the distribution is. The value of a and the existence of moments in X is one-to-one. Higher than a moments do not exist. The family of distributions $F(x)$ includes the Cauchy distribution $(a < 1)$ or the family of stable distributions with $a < 2$, while $a \geq 2$ corresponds to the Student-t and nonintegrated ARCH processes. The Hill estimator is a conditional maximum likelihood estimator. If the distribution under consideration is exactly Pareto then the estimator uses all available observations. If, more realistically, the underlying distribution is some unknown fat-tailed distribution satisfying (1) then the Hill estimator can be used for the outer parts of the distribution (Pareto-like behavior for the tails of the distribution). In that case, the Hill estimator applied on the full sample of available data[4] is given by:

$$\hat{a}_T=\left(\frac{1}{m_T}\sum_{i=1}^{m_T}(\log X^T_{(T-i+1)}-\log X^T_{(T-m_T)})\right)^{-1} \tag{2}$$

where $X^T_{(T-m_T+1)} \leq ... \leq X^T_{(T)}$ and $X^T_{(i)}$ denotes the i'th ordered statistic of the sample with size T, i.e., we rank observations in ascending order $X^T_{(1)} \leq ... \leq X^T_{(T)}$. Note that only the m_T largest observations are employed since the underlying distribution is unknown and only its tail behavior is assumed given. Apparently, the approximation of the tails by the Pareto distribution improves as we move further out in to the

[3]For the normal distribution, the limit in (1) renders e^{-x}, i.e., an exponentially declining tail. Distributions with this property are classified as thin tailed. Other examples are the exponential, gamma and lognormal distributuions.

[4]Sub-samples will employed later in the study and for this reason we index a with the sample size T.

tails (thus m_T decreases) but given the small number of available observation the variance increases. Under some additional assumptions on the asymptotic behavior of F, Hall (1982) showed that as long as m_T grows slowly enough then the Hill estimator converges to the normal distribution

$$m_T^{1/2}(\hat{a}_T - a) \rightarrow^d N(0, a^2) \tag{3}$$

However, if m_T does not grow slow enough there are cases where the estimator exhibits asymptotic bias or it converges to a degenerate distribution. Furthermore, there is an inherent circularity since m_T is necessary to estimate a and a is necessary in choosing m_T (the rate of increase of m_T is a function of T that includes a). Hence, the framework of EVT bypasses the distribution choice problem but has the problem of selecting the m_T largest observations.

There are a number of procedures available for calculating the optimal fraction m_T based on theoretical results with respect to minimization of the asymptotic mean square error of the estimator[5]. These procedures apply to large samples and could be computationally intense as (some) they involve bootstraping methods (Hall, 1990, Drees and Kaufmann, 1998, Danielsson and de Vries, 1997, Danielsson et al., 2001). For the sake of simplicity, and in accordance with Quintos et al. (2001), all Hill estimates will be based on the 10% rule, that is m_T will constitute the 10 percent of larger (right tail) or smaller (left tail) observations. This rule has been shown to perform well in simulations and it is widely used by practitioners.

The Hill estimates will be compared with the HKKP (modified Hill) tail estimates. The recently proposed HKKP estimator adopts a procedure that overcomes the difficulty of choosing m_T and addresses the small sample bias. It utilizes a linear approximation to the bias function to express $\hat{\gamma}_T$ $(= \hat{a}_T^{-1})$ as a function of the number of top (bottom) observations used in the estimation. It is based on the least squares estimation of the following model,

[5] A heuristic approach for large samples constitutes in plotting the estimator as a function of different m_T's (the Hill plot) and selecting the threshold in the region over which the estimates appear "constant".

$$\hat{\gamma}(m_T) = \beta_0 + \beta_1 m_T + \varepsilon(m_T), \qquad m_T = 1, ..., k \tag{4}$$

Thus, instead of computing γ_T for a single choice of m_T, we compute a range of Hill estimates $\gamma(m_T)$ corresponding to a selection of m_T from 1 to k. For example $\hat{\gamma}(1) = \log X^T_{(T)} - \log X^T_{(T-1)}$. The vector $\beta = (\beta_0, \beta_1)'$ is estimated and an unbiased estimate of γ $(= a^{-1})$ is equal to the estimated intercept parameter $\hat{\beta}_0$. k must be chosen such that the function $\gamma(m_T)$ is approximately linear in k. However, HKKP simulation results in over 2,000 samples with sizes varying from 100 to 1000 observations showed that the estimates of the tail index are quite robust with respect to the choice of k. They employed $k = T/2$, as a rule of thumb, which is also our choice for the subsequent empirical analysis of stock returns of firms listed in the Athens Stock Exchange. Figure 1 presents estimated $\hat{\gamma}(m_T)$'s as a function of $m_T = 1, ..., k$ involved in right tail estimation of the tail index of ALPHA BANK (a large capitalization stock of FTSE20). k equals 635 which was the value of $[T^*/2]$ where T^* denotes the number of returns greater than 0. The linear relationship is clearly visible. However, the large variability of $\hat{\gamma}(m_T)$ for m_T small is noticeable. This is a consequence of employing too few observations in estimating γ. In empirical applications - and given the large number of stocks we considered - it is possible for negative least squares estimates of β_0 to arise or that $\hat{\beta}_0$ is so small that renders $\hat{a}_T = \hat{\beta}_0^{-1}$ extremely large. This is the case when there is small variability on the top (bottom) observations. For example when the two highest positive returns are too close then $\hat{\gamma}(1)$ is extremely small. As a result the regression line (although weighted) is "pulled" upwards (counter clockwise) ending with negative or extremely small $\hat{\beta}_0$'s. To overcome this empirical problem we incorporated a small decision routine in the estimation of regression (4). When we obtained negative intercepts or intercepts so small as to render $\hat{a}_T$ greater than a fixed value (for example 500) we omitted recursively the first row of $\hat{\gamma}(m_T)$ and m_T. That is, initially we omitted $\hat{\gamma}(1)$ and 1. The omission step is repeated until a positive and less than 500 estimate of $\hat{a}_T$ is obtained. This practice of trimming is not unusual, especially in the literature of semiparametric estimators of the long memory parameter in time series. The effect on the properties of the HKKP estimator remain unknown. However, we must mention that whenever trimming took place, the HKKP method did not encounter problems. On the contrary, it was able to reduce extremely large estimates or to correct negative appearances of the intercept.

The simulations conducted by HKKP showed that approximately unbiased tail estimates are produced even for samples as small as $T = 100$ for a range of distributions. Overall, their simulation results provide supporting evidence of the adequacy of their method in small samples with observations drawn from Burr, Cauchy and Student-t distributions as well as for series generated through a typical GARCH(1,1) process with standard normal innovations.

Note that, the errors $\varepsilon(m_T)$ are heteroscedastic and correlated. The variance of the $\hat{\gamma}(m_T)$ estimates varies proportionally to $1/m_T$. Therefore, a weighted least squares method to extract unbiased estimates of β is developed by HKKP. The diagonal elements of the weighting matrix are given by $\sqrt{m_T}$. The authors also explain in detail how to construct a feasible GLS covariance matrix estimator for the variance-covariance matrix of $(\beta_0, \beta_1)'$. The robust variance-covariance estimator is necessary in order to account for the correlation in the estimates of $\gamma(m_T)$. The correlation arises from correlation of the order statistics and from the overlapping samples (for example, the estimated $\gamma(m_1)$ and $\gamma(m_2)$, $m_1 \neq m_2$ are based on order statistics with $1 + \min(m_1, m_2)$ common observations).

In what follows collect $\hat{\gamma}(.)$'s into the vector γ, let $i = 1, ..., k+1$ and

$$Z = \begin{bmatrix} 1 & 1 \\ 1 & 2 \\ \vdots & \vdots \\ 1 & k \end{bmatrix} \qquad W = \begin{bmatrix} 1 & 0 & \cdots & 0 \\ 0 & \sqrt{2} & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & \sqrt{k} \end{bmatrix}$$

Then,

$$\hat{\beta} = (Z'W'WZ)^{-1}Z'W'\gamma$$

with covariance matrix given by

$$COV(\hat{\beta}) = (Z^{'}W^{'}WZ)^{-1}Z^{'}W^{'}W\Omega W^{'}WZ(Z^{'}W^{'}WZ)^{-1}$$

where $\hat{\Omega} = A\hat{\Sigma}A^{'}$ with

$$A = \begin{bmatrix} 0 & \cdots & 0 & 0 & 0 & -1 & 1 \\ 0 & \cdots & 0 & 0 & -1 & 1/2 & 1/2 \\ 0 & \cdots & 0 & -1 & 1/3 & 1/3 & 1/3 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ -1 & 1/k & \cdots & \cdots & \cdots & 1/k & 1/k \end{bmatrix}$$

and $\hat{\Sigma}$ has elements given by (i denotes row position and j column position)

$$v(i,j) = \frac{p_i}{T\hat{a}^2(1-p_i)}, \;\; p_i = i/T, \;\; i \leq j$$

3 Structural changes in the relative frequency of extreme events.

In this section we briefly present statistical tests of the hypothesis that the tail thickness of the distribution of financial returns during the available full sample period remains constant. The null hypothesis of constancy of the tail-index a, takes the form:

$$H_0 : a_{[Tr]} = a \;\; \forall \, r \in R_\pi$$

where $r \in R_\pi = [\pi, 1-\pi]$ for some small $\pi > 0$ so that R_π is a predetermined compact subset of $(0,1)$. The tests that were developed by Quintos et al. (2001), are based on sequences of Hill tail index estimates, allow for an unknown breakpoint in the tail index and they are scaled - using Hsing's (1991) results - for serially dependent data. In particular, let w_t denote the size of a subsample and $m_{w_t} = [kw_t]$ the fixed proportion of the largest observations of the subsample used to calculate the tail index.

Again, as in Quintos et al. (2001), we chose $k = 0.10$ as the fixed proportion of the largest (smallest) observations to be employed in the Hill estimator.

We construct the following statistics,

$$\begin{aligned} Q &= \sup\left[\eta_t^{-1} Z_t\right] \qquad \text{(recursive)} \qquad (5) \\ \text{where} \quad Z_t &= \left(\frac{tm_t}{T}\right)\left(\frac{\hat{a}_t}{\hat{a}_T} - 1\right)^2 \end{aligned}$$

$$\begin{aligned} Q^* &= \sup\left[\eta_{w_t^*}^{-1} Z_t^*\right] \qquad \text{(rolling)} \qquad (6) \\ \text{where} \quad Z_t^* &= \left(\frac{w_t^* m_{w_t^*}}{T}\right)\left(\frac{\hat{a}_t^*}{\hat{a}_T} - 1\right)^2 \end{aligned}$$

$$\begin{aligned} Q^{\#} &= \sup\left[\eta_{w_{2t}}^{-1} Z_t^{\#}\right] \qquad \text{(sequential)} \qquad (7) \\ \text{where} \quad Z_t^{\#} &= \left(\frac{tm_t}{T}\right)\left(\frac{\hat{a}_t}{\hat{a}_{2t}} - 1\right)^2 \end{aligned}$$

The recursive estimator $\hat{a}_t$ is estimated from subsamples of size $w_t = t = [Tr]$, $r \in (0,1)$ (subsamples $[1, ...t]$) and $m_t = [kw_t] = [kt]$. Thus, we estimate a sequence of Hill estimators each one based on an increasing number of observations and we compare it with the full sample Hill estimate, $\hat{a}_T$. The rolling estimator $\hat{a}_t^*$ is based on a fixed subsample with size $w_t^* = [T\gamma_0]$ (the window) where $\gamma_0 \in (0,1)$ is the fixed fraction of the sample length. The window is rolled through the sample while we calculate the Hill estimate. Again this estimate is compared with the full sample Hill estimate. Note, that $w_t^* m_{w_t^*}$ is not a sequence but the fixed number. The sequential statistic (7) is constructed from a pre-break and a post-break estimator. The first is just the recursive estimator $\hat{a}_t$. The latter, denoted by $\hat{a}_{2t}$, is the reverse recursive estimator with sample size $w_{2t} = T - t$. Thus, the reverse recursive estimator employs initially the maximum sample available and drops a point from the beginning of the sample to produce each new estimate in the sequence. For example, if the recursive estimator begins from $[1, .., t_0]$ up to $[1, ..., T - t_0]$, the reverse recursive estimator is defined over $[t_0 + 1, ..., T]$ up to $[T - t_0 + 1, ..., T]$. Note that (5) and (7) are based on the same intuition as the fluctuation test of Ploberger, Kramer and Kontrus (1989). In that sense, Z_t measures the fluctuation of the recursive estimator against the full-sample estimate and the sequential quantity $Z_t^{\#}$ measures fluctuations of $\hat{a}_t$ against the reverse recursive estimator.

The introduction of the term η^{-1} corrects the statistics for dependence in the data (under the assumption of $i.i.d$ data simply omit η^{-1} which equals 1). This is a non-central term that enters the variance of the limiting distribution when the data exhibit a form of weak dependence. Hsing (1991) showed that

$$m_T^{1/2}(\hat{a}_T - a) \rightarrow^d N(0, \eta a^2) \tag{8}$$

In what follows, $I()$ is the indicator function, $x_+ = \max(x, 0)$, $y_t = x_t^2$ and $\bar{a}_T$ denotes the full sample Hill tail index estimate for y_t, the squares of the data. In what follows, w_t, m_{w_t} denote the subsamples size and upper (lower) number of observations employed in estimation. When the full sample Hill estimate is employed, simply substitute w_t, m_{w_t} with T and m_T respectively.

For the case where x_t is a (stationary) GARCH(1,1) process, define

$$c_{w_t,i} = (\log y_i - \log y_{w_t - m_{w_t}+1})_+ \tag{9}$$

$$d_{w_t,i} = I(\log y_i > \log y_{w_t - m_{w_t}+1}) \tag{10}$$

and construct

$$\hat{\chi}_{w_t} = (2\bar{a}_{w_t}^2)\frac{1}{m_{w_t}}\sum_{i=1}^{w_t-1} c_{w_t,i}c_{w_t,i+1} \tag{11}$$

$$\hat{\psi}_{w_t} = \bar{a}_{w_t}\frac{1}{m_{w_t}}\sum_{i=1}^{w_t-1}(c_{w_t,i}d_{w_t,i+1} + c_{w_t,i+1}d_{w_t,i}) \tag{12}$$

$$\hat{\omega}_{w_t} = 2\frac{1}{m_{w_t}}\sum_{i=1}^{w_t-1} d_{w_t,i}d_{w_t,i+1} \tag{13}$$

Then, the asymptotic variance correction is given by

$$\hat{\eta}_{w_t} = 1 + \hat{\chi}_{w_t} + \hat{\omega}_{w_t} - 2\hat{\psi}_{w_t} \tag{14}$$

The critical values of the tests are tabulated in Appendix A (page 662) of Quintos et al. (2001). The same critical values apply for the non-scaled statistics in the case of i.i.d data. The recursive test is consistent only under the alternative "*tails varying from thinner to thicker*" therefore we should be careful in its application since it can only be used as an one-sided test. In the opposite case, "*tails varying from thicker to thinner*", the statistic is bounded in probability. The intuition behind this result relies in the nature of the recursive estimator and theorem 3 of Quintos et al. They show that if we divide the sample into two subsamples with tail indices $a_1 \neq a_2$ then the full sample estimate $\hat{a}_T$ converges in distribution to the minimum of a_1, a_2. Thus, asymptotically, thick tails dominate the full sample estimate. Recursive updating of the sample does not remove "early" outliers from the selected subsamples. On the contrary, the rolling statistic does not admit such problems while the sequential statistic is based on the recursive and reverse recursive estimators which are both consistent in opposite directions. Of course the latter holds true under the assumption of a single break.

4 Empirical application

4.1 Data description

The initial data set comprises closing price daily observations (adjusted for dividend payouts) of all stocks traded in the Athens Stock Exchange (ATHEX) from January 2, 1986 to December 31, 2003 creating in total (when a stock traded for the entire period) 4475 observations. The data were purchased from ASYK[6] S.A, a member of the Hellenic Exchanges Group. Returns are defined as 100 times the logarithmic first difference of the share price of each stock. Our research focuses in the subperiod 1993-2003 in order to account for ATHEX's adoption of electronic quote trading in

[6]System Development & Support House of the Capital Market. Website: http://www.asyk.ase.gr/en/mainen.htm

September 1992 and the introduction of circuit breaks (price limits) in August 1992. The central limit order book (CLOB) introduced continuity and smoothed trading activity. As a result, the post-1993 period is less comparable to the pre-1993 period but more comparable to other small European continuous auction markets. The 11-year subperiod 1993-2003 consists of 2748 daily price observations (or 2747 daily return observations). It includes the "surge" in stock prices during 1998 and particularly during 1999 and the subsequent drop of the prices during the years 2000, 2001 and 2002. The ATHEX general index reached an all times high in 17/09/1999 (6633.92 units). Apparently, the surge was shared by the vast majority of traded stocks. Thus, during the examined period and in the late 1990's stock prices experienced violent 'fluctuations', rendering the resulting daily return series particularly recalcitrant. The examination of the tail index, as a measure of risk, during turmoil periods has a noteworthy appeal. Figures 1 and 2 will provide a visual aid towards understanding the typical movement of stock prices in ATHEX during the period 1993-2003 and in particular during the years 1998 and 1999. Typical movement does not refer to any predictable patterns but to the unprecedented increase of stock prices in 1998-1999. Figure 1, plots the stock price of ETHNIKI (National Bank of Greece), the largest company (in market capitalization) traded in ATHEX during December 2003 along with its (%) log-difference return as the representative, at least for large firms, stock price movement during the period. Notice that, smaller firms admitted even larger fluctuations although the peak in prices was short-lived compared with large capitalization firms. Figure 2 plots the price and return for ELCAN[7], a small capitalization firm.

To ease the presentation of our results, a representative sample of 140 stocks was considered. The primary guide on the selection process were concerns for thin trading which although not intense it appears in some small capitalization firms. Still, some of the small cap firms might exhibit 2 or 3 consecutive days with constant prices but the amount of those instances is very small. Zero returns do not persist. The stocks have

[7] ELCAN was randonly chosen from small capitalization firms.

been classified in terms of capitalization according to FTSE's classification criteria in the first half of 2004. Hence, we construct three groups each with a maximum of 2748 daily price observations per series, corresponding to the three ATHEX FTSE capitalization indices: Group 1: FTSE20, the largest 20 firms (large cap or "blue chips"), group 2: FTSE40, the next 40 largest firms (medium cap), group 3: FTSE80, the next 80 largest firms (small cap). Appendix A details the indices composition in terms of market capitalization.

The arrangement of the stocks into these three groups is of further interest as an investigation on whether size and trading has any impact on the likelihood of extreme returns. Intuitively, one would expect the tail index getting larger as we move from FTSE80 to FTSE20 (a probable cause could be distractions in the information flow regarding small companies that would surprise the market).

A feature of ATHEX, characterizing also many other stock markets during that period, is the increasing introduction of new issues. However, the new issues were not primarily consisting of cross-listings of US firms but rather of domestic firms which decided to diversify shareholdings raise capital by going public. Given that in most of the new issue cases the price seems to significantly deviate in either direction from their issue price, we chose to omit, on a case-by-case basis, new issue price observations for trading days prior to the issue date corresponding to the trivial transaction of delivering the new securities against payment.

Figure 3, is divided in three panels (top, middle and bottom) each consisting of two sub-figures (right, left) and plots several descriptive statistics through time for the chosen dataset and groupings. We preferred the visual presentation due to the amount of calculated statistics. All descriptives were calculated on a year-by-year basis allowing inspection of variation of sample moments through time. Mean and median returns are concentrated, as expected, around zero. The erratic movements of the mean coincide with the after-1998 period although the median sub-figure (top right) suggests that the movement might have been exaggerated by individual large price increases or drops, particularly for the FTSE80 firms. The standard deviation sub-figure suggests an increase in volatility in 1998 and 1999 with the FTSE80 firms being almost always more volatile as expected. It is distinctive though that the volatility differences vanish in 1997 and in 1998. The middle right sub-figure plots skewness, a signed measure of the behavior of extreme returns. For mature markets, this statistic is generally found to be negative, suggesting that crashes cause an asymmetric return distribution. For emerging markets, the picture is less clear-cut, since many markets are characterized by a positive skewness (see for example Jondeau and Rockinger, 2003). Our estimates produced negative as well as positive skewness with no apparent sign preferences given the firm size. Nonetheless, it seems that in general, skewness is on the positive half. The bottom panel plots the fourth sample moment (left sub-figure) and the first order autocorrelation of returns (right sub-figure). Evidently, the fourth moment. kurtosis, seems to vary significantly in time. On average, there is a large decrease of the amount of kurtosis as we move away from 1993. In 1998 and in particular in 1999, kurtosis estimates are almost equal to the number suggested by the normal distribution implying significant tail thinning. This could be associated with the gradual liberalization and development of the market easing the diffuse of information or with the adoption of circuit breaks[8]. However, we point that the existence of circuit breaks continues through out the period under investigation while the kurtosis estimates are getting larger catching up with the pre 1998-1999 period and reflecting apparent fat-tailedness.

To glean further insight in the behavior of extreme returns, we standardize all return series and consider percentiles. Table 1 reports the average, across firms, estimated percentile per group where Qx denotes the xth percentile. Comparison of the absolute value of Q1 and Q99, for standardized returns, with the value that should hold, under normality, -2.325 and 2.326, reveals for all groups, that the extreme 1 percentiles are too large to be compatible with a normal distribution. The same conclusion is reached when comparing Q5 and Q95 with the associated normal critical values, -1.645 and

[8] Since August 1992 there exist price limits on highly active shares that restrict daily variation. These are (a) $\pm 8\%$ for the period up to 6/2/00 ($\pm 4\%$ for less active shares) (b) $\pm 10\%$ for the period 7/2/00 - 30/7/00 (c) $\pm 12\%$ for the period 31/7/00 - 30/5/01 and (d) $\pm 18\%$ for the period 1/6/01- today.

1.645,. However, when comparing Q10 and Q90 with the associated normal critical values, -1.28 and 1.28, we find that there are not enough realizations compatible with a normal distribution. This confirms that distributions of returns are fat-tailed. It is this type of observation that motivates our investigation. The size of the extreme return realizations shows that the study of the distribution followed by extreme returns is important. In addition, we notice that size has an effect on the quantiles estimates. Apparently, larger firms exhibit heavier tails that smaller firms when we look at the furthest end of the tail. As we move towards the middle of the distribution the relationship reverses. The FTSE80 firms, on average, have more realizations from the FTSE20 firms in the upper 10% and 5% percentiles but less realizations than the FTSE20 in the upper 1% percentile. Possibly, this "peculiar" behavior could be ascribed to ATHEX microstructure effects and to psychological factors but to the best of our knowledge there is no similar observation in the literature and we do not desire to further conjecture on it.

Finally, when we compare the absolute values of Q1, Q5, Q10 with Q90, Q95 and Q99 we notice differences in the coefficients. The difference is particularly high at the 5% percentile for all firms. This observation offers motivation for the calculation of both right and left tail indices.

4.2 Empirical results

4.2.1 Full sample unconditional tail-index estimates.

In this subsection, we present tail-index estimates for the 140 stock returns described in the previous section. Using the full sample length, we will compute Hill and HKKP estimates for all stocks in the FTSE20, FTSE40 and FTSE80 indices and we will report them individually as well as succinctly using the median of estimates across groups. The choice of the median statistic was made after obtaining some "aberrant" estimates that could inflate the mean. Subsequently, we compare the estimates obtained from the HKKP estimator with those obtained from the Hill estimator. Note that the HKKP method will provide the standard error of $s.e(\hat{\gamma})$ and not of $\hat{\alpha} = \hat{\gamma}^{-1}$. Using the delta method the standard error of the tail index is $s.e(\hat{\alpha}) = s.e(\hat{\gamma})\frac{1}{\hat{\gamma}^2}$. A word of caution should be added here. The method uses a linear approximation of the function which may be inaccurate if the curvature of the function is high (as in our case). Thus we expect the standard error to be relatively underestimated.

Tables 2,3 and 4 tabulate results on each firm separately. Table 5 reports the median across firms in each group. The tables immediately reveal substantial differences in measured tail thickness due to small sample bias. The Hill and HKKP estimates are consistently different with the Hill estimator being smaller in most of the cases. This is evident in both the left and right tails although it seems more pronounced in the right tail of the FTSE40 and FTSE80 groups. Hence, the Hill estimator overestimates risk in all cases. For this reason, all discussion thereafter will be based on the HKKP estimator. In detail:

- Regarding FTSE20 (table 2), the HKKP left tail estimates vary from 3.04 for ATE to 10.04 for PPC. The HKKP right tail estimates vary from 2.08 for MOH to 45.83 for EUROB (the latter value is high enough to resemble the normal distribution tail). The estimates in both tails are such that in many cases the finiteness of the fourth moments can be rejected and in total the median estimate is only slightly above 4 in both tails.

- Regarding FTSE40 (table 3), left tail estimates vary from 1.59 (VOVOS) to 12.59 (DESIN) while right tail estimates vary from 2.26 (VOVOS) to 61.48 (OLYMP). We notice that point estimates associated with the left tail tend to be smaller and in some cases the difference is noticeable. The median tail estimates imply finiteness of fourth moments particularly for the right tail.

- Regarding FTSE80 (table 4), the smallest left tail estimate is 1.76 (NEWS) and the largest 32.15 (HYGEIA). Respectively, for the right tail, we obtained 2.09 (NEOCHI) and 61.37 (KYRM). We notice again that the point estimates associated with the left tail tend to be smaller.

A question that emerges is whether extreme negative returns behave like extreme positive returns. Most investors would affirm that the left tail of the return distribution of stocks is heavier than the right one, according to the idea that ‘defaults’ are more likely to occur than booms[9]. Notice that, indeed, the FTSE40 and FTSE80 tail estimates exhibit asymmetry with heavier left than right tails. As capitalization decreases and we move from FTSE40 to FTSE80 firms, we observe relatively heavier left than right tails. The larger estimates of the right tail indicate lower probabilities for extreme positive returns relative to extreme negative returns. The FTSE20 group is the only one with apparent symmetry in the median of HKKP in both tails. Nevertheless, individually some of its constituent firms exhibit large tail index asymmetries whereas in only three cases (ARBA, CHIP, EYDAP) the left tail estimate is larger than the right tail estimate.

Overall, the dispersion of extremes differs across firm capitalization. Returns, belonging to large capitalization firms, have in general little variability across extremes, whereas there is more variability as capitalization decreases. The standard deviation of the left tail estimates is 1.58, 1.58 and 3.34 for the FTSE20, FTSE40 and FTSE80 groups. Respectively, for the right tail, the standard deviation was 9.63, 12.48 and 13.65. Thus, left tails appear to be more uniform and this is indifferent to which group of firms we observe. The authors suspect that the turmoil during 1998-1999 and the adoption of circuit breaks is largely responsible for the appearance of an almost normally distributed right tail in many of the returns. The surge of stock prices occurred in a relatively brief time period and the circuit breaks would impose the clustering of a large number of near +8% returns in that period. Indeed, as the following table suggests, large right tail $\hat{\alpha}_{HKKP}$ estimates appear in firms with a large number of extreme positive returns in the period 1998-1999 or 1997-1999. The table reports the number of times -in the year - a positive return exceeded 7%, across the period we examine. The stocks correspond to the FTSE20 firms that gave the larger right tail HKKP estimates.

[9] Hartmann et al. (2001) found that, in the French and US stock markets, the left tail index is significantly larger than the right tail index.

FTSE20 Right tail Number of times -in the year - a positive return exceeded 7% Parentheses report $\hat{\alpha}_{HKKP}$			
	ELTEX (14.59)	EUROB (45.83)	HDF (13.75)
1993	-	7	-
1994	-	8	-
1995	1	5	-
1996	0	8	-
1997	9	30	-
1998	12	46	-
1999	43	16	28
2000	9	1	6
2001	5	0	2
2002	0	0	3
2003	1	0	4

This argument is further reinforced by the following table regarding the FTSE40 stocks that exhibited the larger right tail indices. For comparison purposes we include in square brackets the respective number of times that negative returns were larger (in absolute terms) than -7%. Analogous results were obtained for the FTSE80 firms.

FTSE40 Right tail Number of times -in the year - a positive return exceeded 7% In square brackets : Number of times -in the year - a negative return exceeded -7% Parentheses report $\hat{\alpha}_{HKKP}$					
	AVAX (24.26)	HSI (52.09)	MYTIL (30.57)	OLYMP (61.48)	TERNA (23.15)
1993	- [-]	- [-]	- [-]	- [-]	- [-]
1994	- [-]	13 [4]	- [-]	- [-]	- [-]
1995	3 [1]	4 [0]	- [-]	2 [0]	4 [1]
1996	1 [0]	1 [0]	0 [0]	3 [2]	1 [1]
1997	9 [6]	15 [8]	16 [3]	7 [2]	7 [3]
1998	5 [3]	30 [9]	18 [5]	18 [10]	17 [7]
1999	54 [15]	41 [12]	36 [10]	73 [29]	43 [15]
2000	7 [4]	5 [7]	11 [3]	18 [6]	22 [10]
2001	2 [4]	4 [2]	6 [8]	10 [9]	8 [9]
2002	0 [0]	2 [0]	1 [0]	4 [3]	5 [3]
2003	0 [1]	10 [1]	10 [1]	2 [2]	6 [0]

Notice that the 1998-1999 period reveals large distortions in positive extremes whereas negative extremes are not so frequent (or profound in magnitude) during the after-September 1999 adverse price movement. For example, during 1999, OLYMP in 79 out of the 250 trading days admits a positive return higher than 7% (and 29 days with less than -7%). Such findings suggest the possibility of structural changes in the tail index. Although circuit breaks do not allow us to precisely evaluate the tail index for the particular period, there are strong indications of changes in the unconditional variance of returns. The observed distributions flatten considerably to the right exhibiting noisy behavior.

In addition, an "non-intuitive" effect arises by viewing the median HKKP tail estimates of table 5. One might conclude that irrespective of the tail on which we concentrate, the probability of extreme returns is decreasing with firm capitalization. This remark arises by observing the increasing median tail estimate across the groups. In this context - (and in addition with the possibility of a structural break during the 1998-1999 period) - knowledge of the value of the tail index is interesting in itself but the question of economic interest is how likely extreme returns are. In the words of Jansen and de Vries (1991) we would like to put booms and busts into perspective. To assess the economic implications of the values the tail index admits we implement extreme quantile and tail probability estimation. This method is tantamount to the VaR analysis undertaken from portfolio managers to measure risk.

When the loss (or profit) probability p is small, the empirical quantile is estimated from only a limited number of extreme observations. Therefore, it may not be accurate. To circumvent this difficulty, we estimate the quantile for a larger probability value (say $q \approx 0.05$) and based on a parametric model of the tail[10] we can deduce the quantile of interest. The tail probability and extreme quantile estimators are given by (see Danielsson and de Vries, 1997),

$$\hat{p} = \frac{m}{T}\left(\frac{\hat{x}_q}{\hat{x}_p}\right)^{\hat{a}} \text{ (exceedance) tail probability estimator} \tag{15}$$

$$\hat{x}_p = \hat{x}_q\left(\frac{m}{Tp}\right)^{1/\hat{a}} \text{ extreme quantile estimator} \tag{16}$$

For example, with daily returns data, let $p = 0.004$ or the one in a year (one over 250 days) probability. Also, let $q = 0.05$ (one every 20 days). From the ordered statistics choose $X_{(T-m)}$ where m/T is closest to $q = 0.05$. For instance, use the ceiling function $m = \lceil Tq \rceil$ (smallest integer larger than or equal to the argument). Then $X_{(T-m)} \approx \hat{x}_q$ and the resulting tail probability $\hat{p}$ is a function of the extreme return realization we choose, namely x_p. Similarly, we can calculate the extreme quantiles $\hat{x}_p$ based on different probability levels, p.

Table 6 reports extreme quantiles $\hat{x}_p$ for the choices $p = 0.004$ (once every year), $p = 0.0008$ (once every 5 years). Table 7 reports tail probabilities converted to years[11]

[10] By 'parametric' we mean asymptotic second order expansion of the cumulative distribution function that holds for almost every fat-tailed distribution satisfying (1).

[11] Converted through $\frac{1}{\hat{p}}$ =number of days and then $\frac{number\ of\ days}{250}$=number of years.

for the choices of $\hat{x}_p = 8\%, 9\%, ..., 15\%$. Similar studies use extreme returns of up to $\pm 30\%$ but due to circuit breaks we do not employ such extremes. Currently, a day limit of $\pm 18\%$ in daily return fluctuation exists. Left tail quantiles should be multiplied with -1. From tables 6 and 7 we notice the intuitive result that lower capitalization firms imply greater risk and fatter tails. However, cautious interpretation is needed since the right tail has evident nonlinearities. For example, table 6, we see that the median negative return across FTSE20 firms will not exceed -8.51 once in a year and -13.26 once in a 5 years horizon. For the FTSE80 firms the quantiles shift to the left with 11.28% loss in a day once a year and 15.40% loss in a five year horizon. Such uniformity across large positive gains is not manifested. For example, table 6 suggests an once per year positive realization of 9.76% for the FTSE20 firms and 11.15% for FTSE80 firms, consistent with heavier tails. However, as we move outwards on the right tail, the relationship is inverted. Once every 5 years the median return will reach 14.59% for the FTSE20 firms while the respective quantile is 14.35% for FTSE80.

The results shown in table 7 provide a clearer view on nonlinearity in the right tail. Note that exceedance probabilities were converted to years to ease presentation. To begin with, observe the results for the left tail (under the LT heading). Smaller probabilities $\hat{p}$ imply less risk and higher year numbers. For example, the tail estimates imply that FTSE20 firms loose 8% a day once every 0.79 years, 9% a day once every 1.26 years and so on. Observe the uniformity of the left tail results across groups. FTSE40 firms produce lower year numbers (have higher $\hat{p}$'s). FTSE80 firms even lower. For example a loss of 8% is realized once every 0.16 years (or once every 40 days). A loss of 15% once every 4.51 years, much faster than the 7.66 years of the FTSE20 firms. Now let us consider the right tail results. For quantiles 8% to 13% FTSE80 firms exhibit fatter tails than FTSE20 firms. For example, an 8% positive return is realized once every 0.28 years (the median) for FTSE20 while it appears once every 0.07 years (once every 17 days!) in FTSE80 firms. Nevertheless, for extremes of 14% and 15% the relationship is inverted. Thus, there exists a “marked” advantage on behalf of FTSE20 firms. Not only they appear to have thinner negative tails (lower probability for observing extreme negative returns) but also fatter positive tails (higher probability of observing extreme positive returns) given that the "holding" horizon of the stock is long enough (4 year or more).

These results are not in contradiction with the median tail estimates of table 5. They rather reflect the joint effect of circuit breaks ($\pm 8\%$ during 1998-1999) and the flattening of the distributions of small cap returns, judging from the increase in standard deviation. Note that circuit breaks "artificially".truncate the distribution, introducing measurement error in asset prices. In certain periods returns would stay at the 8% maximum day limit. The existence of herding behavior[12] would only prolonged these periods. As a result, FTSE80 tail estimates, and particularly right tail estimates for the subperiod 1998-1999 are almost indistinguishable from the normal distribution. Mathematically the case where lower tail index implies lower instead of higher probability of observing some extreme quantile x_p can be shown to be consistent with[13] relative thinner low quantiles. This abnormal behavior is exemplified in the period 1998-1999. FTSE20 firms have lower 5% quantiles than FTSE80 firms that exhibited a clustering of prolonged periods of large positive returns.

Finally, we compare the implied frequency of extreme events produced by the Hill estimator and the HKKP estimator. In order to save space we do not report results for individual stocks (tables 2,3 and 4 are suggestive on the overestimation of extremes from the Hill estimator[14]). As an example, we mention only the stock of ALPHA from the FTSE20 group. Notice that for the left tail $\hat{\alpha}_H = 2.75$ whereas $\hat{\alpha}_{HKKP} = 3.90$. This difference is not to be ignored. Following the aforementioned analysis, the Hill estimate implies a daily loss of -15% for the stock once every 2.54 years while the

[12] Certain types of feedback strategies under herding behavior, such as positive feedback, assume that noise trader demand is a posisitve linear function of past returns. Thus, such an investor would buy after observing positive returns.

[13] Let two return series have different tail indices with $a_1 < a_2$. Then it can be shown that $p_1 = \frac{m}{T}\left(\frac{\hat{x}_{1,q}}{\hat{x}_p}\right)^{a_1}$ is less than $p_2 = \frac{m}{T}\left(\frac{\hat{x}_{2,q}}{\hat{x}_p}\right)^{a_2}$ if the higher quantile of the first series $\hat{x}_{1,q}$ satisfies $\hat{x}_{1,q} < (\hat{x}_p)^{(a_1-a_2)/a_1} (\hat{x}_{2,q})^{a_2/a_1}$.

[14] All results are available upon request.

HKKP estimate implies a daily loss of -15% once every 10.82 years, a significant difference. Similarly, the Hill estimator implies that at least once every year a daily loss of -10.68% will be observed while the HKKP estimate implies a loss of -8.14%. Obviously, the further we move to the tails the larger the overestimation of risk becomes based on the standard Hill estimator.

4.2.2 Testing for structural change in (Hill) tail-index estimates.

Once the tail index is known it can be used by risk managers or financial regulators to calculate unconditional extreme quantiles for very low corresponding significance levels (exceedance probabilities). Nevertheless, a familiar statistical robustness issue arises, as it does in all econometric parameter estimation problems. Is the parameter constant across time or structural breaks have occurred? In the second case averaging of different parameter levels is improper leading to ill-advised assessments regarding the index and correspondingly the risk level. This setback becomes more acute under the Quintos et al. (2001) finding that, asymptotically, fat tails dominate. Significant tail thinning (decrease in probability of extremes) could underestimated or go unnoticed. These reasons, along with the availability of a large sample, compel us to apply the Quintos et al. (2001) tests for structural change in the tail index.

We address the question, did the period under examination show a genuine change in the character of extreme return events? We calculate all three statistics of Quintos et al. (2001) with the variance correction parameter incorporated as GARCH effects are typical in stock returns. The results are summarized in tables 9-13. Four firms were not considered due to the small number of available observations, namely, PPA in the FTSE40 group and ERMIS, NEOCHI and NEWS in the FTSE80 group. Statistical significance will imply non-constancy of the tail parameter. Then, inspection of the recursive, rolling and reverse recursive Hill estimates can reveal the direction of the break.

Recursive test For the recursive test we start with a window size corresponding to 15% of the available sample observations and successively increase the sample size by a single observation. If, a priori, a change from thinner to thicker tails is suspected then the recursive test would perform well given its consistency. The test results occupy the third column of tables 9-13 under the title Q. Next to that column we report the suggested break dates. There is strong evidence for structural breaks based on this test. The majority of returns reject the null hypothesis. The right tail is the one that admits a break more often. To get a feeling on the results, note that (a) regarding the right tail estimates, the statistic suggests a rejection of constancy for 70% of the firms in FTSE20, 92% in FTSE40 and 92% in FTSE80 (b) regarding the left tail estimates, the statistic suggests a rejection of constancy for 60% of the firms in FTSE20, 53% in FTSE40 and 70% in FTSE80. Furthermore, we cannot deduce from the statistics per se if the changes of the tail index where positive (thinning) or negative (fattening). In order to consider this issue, examination of the course of the Hill estimates in time is necessary. On this basis, we report that all changes were associated either with an increase in the tail index or with a "lamda" type structural break (multiple breaks) where increases of the index were followed, after a period of time, by a decrease.

As a visual aim we include two figures in our analysis that plot the right and left tail test results respectively. The figures also plot the historic path of the Hill estimate to help identifying the direction of the break in the particular cases. We chose the FTSE40 company that exhibited the largest recursive statistic value for the right tail test, namely DOL. From table 10, Q=15564 for DOL returns. This extremely large number (compared to the critical values proposed by Quintos et al., 2001) could be considered as going against intuition. Therefore, we explain the reasons why it was observed. For comparison purposes, the second figure, discusses the left tail results for DOL. The statistic was not extremely large (Q=3.82), yet it again rejects the null of constancy in the left tail. In particular:

Figure (5) shows the evolution of the right tail index of DOL, a FTSE40 company, starting from August 1999. Although, in theory, the recursive estimate is not consistent against tail thinning, its behavior is severely influenced by a large continuum of +8% returns occurring in October 1999. The estimate is "confused" by the persistent concentration of this period which does not, of course, correspond to any GARCH type clustering. From 1/10/ to 20/10 there are 14 trading days. In 12 out of these 14 days, the return is +8%, in one day is +6% and in one day is 2.14%. This is the outcome (a) of imposing circuit breaks and (b) probably of the functioning of a large number of herd traders in the market. The extremely large recursive estimate produces the explosive value for the statistic. The direction of the break is positive with the change being so large as to render the right tail of the stock equivalent to that of the normal distribution.

Figure (6) shows the contrast between right and left tails. It plots the evolution of the left tail Hill estimate. The absence of intense pressures on the negative spectrum of returns produced a 'well-behaved' tail index estimate. It varies (significantly as suggested by the statistic) between 5 and 7.5. The break is located at November 2000 almost 6 months after the break in the right tail following a large negative return.

Rolling test For the rolling statistic each subsample has fixed length of $[T\gamma_0]$ with $\gamma_0 = 30\%$ and is rolled through the full sample by eliminating one past and adding one future observation. The test results occupy the fifth column of tables 9-13 under the title Q^*. Next to that column we report the suggested break dates or the set of suggested dates. Note that the rolling statistic is able to produce more flat surfaces due to its construction so that it can reach its maximum on multiple dates. Again, there is strong evidence for structural breaks in the tail behavior of returns. In the majority of cases the null hypothesis of tail constancy is rejected. The right tail admits breaks more often. Note that (a) regarding the right tail estimates the statistic suggests a rejection of constancy for 80% of the firms in FTSE20, 84% in FTSE40 and 79% in FTSE80 (b) regarding the left tail estimates, the statistic suggests a rejection of constancy for 35% of the firms in FTSE20, 43% in FTSE40 and 67% in FTSE80. As with the recursive statistic, the direction of the change appear to be fat-thin-fat tails, especially with regards to the positive side.

The right tails of two stocks, KLONK and NAOYK were chosen as examples (based on large sample and large rolling statistics) and figures (7), (8) will give some insight on the workings of the rolling test. Both figures suggest that the large values of the statistics are produced by extreme changes in the rolling Hill estimate (it reaches a maximum value of around 211 from a low of 3.5) caused by positive returns being "stuck" at the +8% limit[15]. Such increases are again associated with the adoption of circuit breaks and the existence of noise traders that follow herd or feedback investing strategies. The positive circuit break suppresses the market when it would move upwards and the existence of noise traders prolongs the presence of returns at the +8% limit.

Sequential test The test results occupy the seventh column of tables 9-13 under the title $Q^{\#}$. Next to that column we report the suggested break dates. There is strong evidence for structural breaks based on the sequential test. The majority of returns reject the null hypothesis. Yet again, it is the right tail that admits the most frequent rejections. To get a feeling on the results, note that (a) regarding the right tail estimates the statistic suggests a rejection of constancy for 65% of the firms in FTSE20, 76% in FTSE40 and 92% in FTSE80 (b) regarding the left tail estimates, the statistic suggests a rejection of constancy for 40% of the firms in FTSE20, 38% in FTSE40 and 59% in FTSE80. The direction of the change in all cases points to either an increase in the tail index or to the aforementioned "lamda" shape of time variation in the tails magnitude.

As in the previous subsection, two figures are included as further visual aims towards understanding the statistical results. Figure (9) plots details regarding the statistic for the right tail of ALPHA stock returns. For this firm, and in contrast to the recursive and rolling statistics, the sequential statistic suggests a structural break, albeit at the 10% significance level. Looking at the figure, we attempt to identify proba-

[15] At the time, the term "limit up" was used by practitioners for this observed behavior. And, of course, at the time there was no reason to deter potential buyers.

ble causes. As predicted by theory, the recursive estimator is unable to quantify the thinning of the tail near the end of the period considered (the thinning becomes apparent by inspecting the bottom sub-figure with the reverse recursive estimator). The recursive Hill estimate remains almost constant throughout while the reverse Hill estimate discovers a progressive increase in the tail index as we move towards May 2002. The sequential statistic reaches its maximum at May 8th 2002. The rolling statistic uses a subsample of size 824 (30% of data) which is twice the length of the last subsample on which the reverse recursive estimator is based (412 observations or 15% of data). It seems that the difference is large enough to obscure the index estimates from the rolling procedure by allowing contamination from past ‘large observations’. This result indicates the necessity for cautious judgement of the statistics while visual observation of their time variation can be proven useful.

Figure (10) plots details on the statistic for the right tail of EUROB stock returns. We chose the particular stock since the extremely large statistic of 142041 might appear non-conventional. First, we notice that all three statistics find a structural break. While Q and Q* “agree” more or less on the date (around summer 2000) the sequential statistic suggests it happened one year earlier in July 1999 (apparently prior to the correction the ATHEX indices). The figure is once again indicative of why such large values for the statistic where obtained. Both the recursive and reverse recursive estimators start with large tail index estimates above 20 that correspond to a distribution not so fat tailed. It seems that large “episodes” with prolonged concentrated deviations of almost $\pm 8\%$ in the summer of 1994 (observations just before 400 in figure) inflate the estimates. Apparently, this type of behavior is repeated across the entire sample. Observe the returns series just after observation 1000 (beginning of 1997) and just before observation 1400 (spring 1998). Each episode is related to extreme increases of the recursive or reverse recursive hill estimates. Their standardized difference (the sequential statistic) reaches its maximum at July 1999. The very large values of the recursive Hill estimate along with extreme increases of the tail index produced the large value of the sequential statistic. The recursive and rolling statistics were largely influenced by the aberrant observations in April and September 2000 (near observations 1800 and 1900 in the figure). The recursive responds faster with an immediate drop while the rolling statistic delays to signal the drop due to contamination of the rolling window from the noisy behavior of the stock return.

Compact presentation of individual tail index break dates In total, the vast majority of stocks admits a structural break in the tail index. Figure (11) attempts to give a compact presentation of the break dates suggested by the tests for the left and right return tails. There are six horizontal panels with three sub-figures each. The top 3 panels present the left tail results while the bottom 3 panels present the results with respect to the right tail. The acronyms LT and RT stand for left and right tail whereas 20,40 and 80 stands for the respective groups of firms. The vertical axis measures number of firms that rejected the null hypothesis of parameter constancy at the particular date given at the horizontal axis (01/93 - 12/03). We observe that: (a) the tail break is mostly associated with the right tail (b) right tail breaks are heavily clustered in the late 1999 and 2000 periods whereas, when they occur, left tail breaks are more scattered. An exception is the FTSE80 group with left tail indices that experience breaks clustered in the 1999 - 2000 period (c) examining only the rolling statistic (mid-panel of six sub-figures from top to bottom) we see it produces the larger number of rejections across all groups (compare the vertical axis). Based on detailed examination of the time variation of the tail index estimates, we reached the conclusion that the most suitable statistic in our study in the rolling statistic. This is due to the presence of multiple structural changes of the tail index. In particular, in our dataset, the breaks admit a “lamda shape” (low-high-low tail index values). In that case the sequential statistic produces poor results since both the recursive and reverse recursive estimators will be misguided. This is probably the reason of the small number of rejections produced by the sequential statistic in our study. We expect that in the opposite case of breaks with an inverted “lamda shape” (high-low-high tail index values) the sequential statistic will achieve better results.

5 Concluding remarks

This study examines the tail behavior of stock returns for a large number of individual stocks listed in the Athens Stock Exchange. The so called tail index is the primary instrument of our inference. It is a single parameter that expresses the rate of decay of a distribution function as we move towards the further ends of the distribution. The index is directly associated with risk. Lower tail index imply slower decay rates thus extended tails and nonzero probabilities for extreme realizations of the underlying series (returns in our study). Two methods have been applied in the estimation of the index. The standard Hill estimator and the modified (by Huisman et al., 2001) Hill estimator that addresses the small sample bias problem of the former. We found that the Hill estimator significantly overestimates risk since the Hill tail index estimates are, in almost all cases, much lower than the corresponding estimates of the HKKP modification.

In addition, we found evidence of structural breaks in the unconditional distribution of log returns. The breaks are manifested by structural changes in the tail index. The possibility of such changes has not been unnoticed in the relevant literature. Mikosch and Starica (2002) using data from the S&P500 index argue that *"long financial time series could display complicated volatility structure for which the simplifying assumption of constant unconditional variance and constant higher moments is too rigid"*. In our case, the statistical evidence is clear indicating very strong rejections of the hypothesis of constant tail behavior. The dating of significant statistics are compatible with the importance of a certain historical period. We find that individual break dates are strongly related and mostly coincide with the turbulent period of 1998-1999. During that period, Athens Stock Exchange prices experienced an unprecedented increase[16]

[16] The average annual percentage change of the General Index in ATHEX from 1997 to 1998 was 85.1% and from 1998 to 1999 was 102.2% according to data from the Hellenic Capital Market Comission. The average annual percentage change of the value of transactions in the Main market was 215,7% for 1998 and 200.3% for 1999 while for the Parallel market (small size firms) 284.6% and 539.3% respectively.

fueled by the entrance of thousands of new investors. Unfortunately, there is a common conception that these investors (a) were not properly informed (b) their decision to enter the market was based solely on levels of past returns and (c) they were investing mostly for speculative reasons, thus acting as noise traders. This becomes evident in the distribution of returns and particularly in the distribution of positive returns. A general consequence of these results is that the post-1993 equity return series should not be treated as belonging to a single distribution, at least where we are concerned with extreme tail behavior.

The implications are immediate. If tail indices are found to be time varying, extreme value analysis may be less suitable for application on turbulent periods, at least in peripheral stock markets. Updating the probability of extremes appears necessary. Note that, inherently, the proposed structural break tests depend on past variation extracting information on the tail index movement. Further research on the topic could be directed towards forecasting the tail behavior. A theoretical model predicting tail behavior or connecting the tails of the return distribution with the market structure and functioning is still missing.

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APPENDIX A

- Constituent firms of ATHEX FTSE indices.
- OASIS is the domestic listing abbrevatiation
- ISIN Code is the International Securities Identification Code
- MARKET CAP = Euro total market value at close of 31/12/2003.
- $\%w_p$ = market capitalization (or participation) weight as of 31/12/2003

FTSE20 - "Blue chips" or the largest 20 listed firms in terms of market cap.

OASIS	NAME	ISIN CODE	MARKET CAP	%w_p
ALPHA	ALPHA BANK . (CR)	GRS015013006	5,637,511.64	12.1%
ATE	AGRICULTURAL BANK OF GREECE S.A. (CR)	GRS414013003	54,286.28	0.1%
BIOX	VIOHALCO (CB)	GRS085101004	377,235.96	0.8%
COSMO	COSMOTE -MOBILE TELECOMMUNICATIONS S.A. (CR)	GRS408333003	276,904.06	0.6%
EEEK	COCA-COLA . S.A. (CB)	GRS104111000	4,088,521.6	8.8%
ELPE	HELLENIC PETROLEUM S.A. (CR)	GRS298343005	698,831.5	1.5%
ELTEX	ELLNI TECHNODOMIKI TEB (CR)	GRS191213008	272,670.22	0.6%
ETE	NATIONAL BANK OF GREECE S.A. (CR)	GRS003013000	13,083,617.82	28.1%
EUROB	EFG EUROBANK ERGASIAS BANK S.A. (CR)	GRS323013003	3,014,671.16	6.5%
GERM	GERMANOS IND. & COM. CO S.A. (CR)	GRS363333006	318,947.6	0.7%
HDF	DUTY FREE SHOPS S.A. (CR)	GRS294183009	286,280.32	0.6%
HTO	HELLENIC TELECOM. ORGANISATION (CR)	GRS260333000	5,126,204.14	11.0%
HYATT	HYATT REGENCY S.A. (CR)	GRS338163009	507,434.8	1.1%
INTRK	INTRACOM S.A. (CR)	GRS087103008	1,203,661.64	2.6%
MOH	MOTOR OIL (HELLAS) REFINERIES SA (CR)	GRS426003000	122,908	0.3%
OPAP	OPAP S.A. (CR)	GRS419003009	1,612,651.48	3.5%
PPC	PUBLIC POWER CORPORATION SA (CR)	GRS434003000	5,025,814.72	10.8%
TEMP	COMMERCIAL BANK OF GREECE S.A. (CR)	GRS006013007	1,249,633.98	2.7%
TITK	TITAN CEMENT COMPANY S.A. (CR)	GRS074083007	321,314.4	0.7%
TPEIR	PIRAEUS BANK S.A. (CR)	GRS014013007	3,312,580.36	7.1%
	Total market value (cap) as of 31/12/2003:		46,591,681.68	100.0%

FTSE40 - "Mid-cap" or the next largest 40 listed firms in terms of market cap.

OASIS	NAME	ISIN CODE	MARKET CAP	%w_p
AKTOR	AKTOR S.A. (CR)	GRS185213006	450,635.92	2.0%
ALEK	ALUMINIUM OF GREECE S.A. (CR)	GRS081103004	47,634.72	0.2%
ALLH	ALPHA LEASING S.A. (CR)	GRS032043002	10,938.08	0.0%
ARBA	S & B INDUSTRIAL MINERALS S.A. (CR)	GRS228003000	45,855.4	0.2%
ASETH	ETHNIKI S.A. GENERAL INSURANCE CO (CR)	GRS018023002	224,343.4	1.0%
ASTIR	ASTIR PALACE VOULIAGMENI S.A. (CR)	GRS388163008	53,736.6	0.2%
ATTEN	ATTICA ENTERPRISES HOLDING S.A. (C)	GRS144161007	85,405.4	0.4%
AVAX	J. & P. - AVAX S.A. (CR)	GRS213213002	293,170.6	1.3%
CHIP	CHIPITA INTERNATIONAL S.A. (CR)	GRS203003017	54,759.8	0.2%
DELTK	DELTA HOLDINGS S.A. (CB)	GRS102111002	457,569.28	2.0%
DESIN	DELTA SINGULAR S.A. (CR)	GRS192313005	182,182.09	0.8%
DOL	LAMBRAKIS PRESS S.A. (CR)	GRS306293002	964,330	4.2%
EGNAK	EGNATIA BANK S.A. (CR)	GRS306293002	170,877.56	0.7%
ELBA	ELVAL S.A. (CB)	GRS271101008	45,194.3	0.2%
ELBI	ELBISCO HOLDING S.A. (CB)	GRS172111007	61,252.2	0.3%
EXAE	HELLENIC EXCHANGES HOLDINGS S.A.(CR)	GRS395363005	1,309,388.28	5.7%
EYDAP	ATHENS WATER SUPPLY & SEWERAGE S.A. (CR)	GRS359353000	288,397.84	1.3%
FOLLI	FOLLI - FOLLIE S.A. (CR)	GRS287003016	420,094.7	1.8%
GEAPK	N.B.G. REAL ESTATE DEVELOPMENT CO. (CR)	GRS136243003	907,847.6	4.0%

FTSE40 (continued)				
GEK	GENERAL CONSTRUCTION COMPANY S.A. (CR)	GRS206213001	103,127.6	0.4%
GOODY	GOODYS S.A. (CB)	GRS230111007	N/A	0.0%
HRAK	HERACLES GEN.CEMENT COMPANY S.A. (CR)	GRS073083008	160,751.4	0.7%
HSI	HELLENIC SUGAR INDUSTRY S.A. (CB)	GRS181111006	33,733.06	0.1%
IASO	IASO S.A. (CR)	GRS379233000	416,338.8	1.8%
IATR	ATHENS MEDICAL C.S.A. (CR)	GRS147233001	193,918.04	0.8%
INLOT	INTRALOT S.A. (CR)	GRS343313003	141,774.8	0.6%
MAIK	M. J. MAILLIS S.A. (CR)	GRS198503005	92,148.6	0.4%
METK	METKA S.A. (CR)	GRS091103002	34,725.2	0.2%
MYTIL	MYTILINEOS HOLDINGS S.A. (CR)	GRS393503008	177,031.3	0.8%
NOTOS	NOTOS COM HOLDINGS S.A. (CR)	GRS266003003	335,535.18	1.5%
OLYMP	TECHNICAL OLYMPIC S.A. (CR)	GRS403103005	1,030,676.76	4.5%
PPA	PIRAEUS PORT AUTHORITY S.A. (CR)	GRS470003013	240,657.0	1.0%
SEFOR	SEX FORM S.A. (CR)	GRS390193001	2,522,638.2	11.0%
SIDE	SIDENOR S.A. (FORMER ERLIKON) (CB)	GRS283101004	117,876.3	0.5%
TATT	BANK OF ATTICA S.A. (CR)	GRS001013002	395,808.34	1.7%
TELET	TELETIPOS S.A. (CR)	GRS212293005	35,013.7	0.2%
TERNA	TERNA S.A. (CR)	GRS187213004	9,414,855.2	41.0%
TGEN	GENERAL BANK OF GREECE S.A. (CR)	GRS002013001	289,031.4	1.3%
VOVOS	BABIS VOVOS INTER/NAL TECHNICAL S.A. (CR)	GRS421003005	1,121,579	4.9%
XAKO	HALKOR S.A (FORMER VECTOR) (CB)	GRS281101006	28,131.2	0.1%
Total market value (cap) as of 31/12/2003:			22,958,964.85	100.0%

FTSE80 - “Small-cap” or the next 80 largest listed firms in terms of market cap.				
OASIS	NAME	ISIN CODE	MARKET CAP	%w$_p$
AEGEK	AEGEK (CR)	GRS182213009	2,202,332.30	9.96%
AGRAS	AGROTIKI INSURANCE COMPANY S.A. (CR)	GRS318023009	21,874.00	0.10%
ALATK	ALFA ALFA HOLDINGS S.A. (CR)	GRS080103005	320,775.00	1.45%
ALCO	ALCO HELLAS SA (CR)	GRS276103009	1,508,516.50	6.82%
ALMY	ALUMIL MILONAS ALUM. IND. S.A. (CR)	GRS289103004	102,184.00	0.46%
ALTE	ALTE S.A. (CR)	GRS232213009	123,578.44	0.56%
ALTEC	ALTEC S.A. (CR)	GRS242003002	279,724.91	1.26%
ANEK	ANEK LINES S.A. (CR)	GRS316273002	25,817.97	0.12%
ASFOI	PHOENIX METROLIFE S.A.(CR)	GRS020023008	152,491.20	0.69%
ASPT	ASPIS BANK S.A. (CR)	GRS304013006	625,638.28	2.83%
ASTAK	ALPHA ASTIKA AKINHTA S.A. (CR)	GRS331043000	67,444.60	0.30%
ATEK	ATTICA PUBLICATIONS S.A. (CR)	GRS340263003	63,534.40	0.29%
ATERM	ALMA-ATERMON S.A. (CR)	GRS321263006	1,075,374.90	4.86%
ATHINA	ATHENA S.A. (CR)	GRS233213008	138,674.50	0.63%
ATTIK	ATTI-KAT S.A. (CR)	GRS205003007	1,743,328.84	7.88%
AXON	S.A. HOLDING (CR)	GRS197233000	40,979.00	0.19%
BABY	JUMBO S.A. (CR)	GRS282183003	45,181.00	0.20%
BIOT	VIOTER S.A. (CR)	GRS135213007	128,334.15	0.58%
BYTE	BYTE COMPUTER S.A. (CR)	GRS368313003	1,309.40	0.01%

FTSE80 (continued)				
DAIOS	DAIOS PLASTICS SA (CR)	GRS382073005	71,037.40	0.32%
DOMIK	DOMIKI KRITIS S.A. (CR)	GRS364253005	819,386.20	3.70%
ELATH	ILEKTRONIKI ATHINON S.A. (CR)	GRS352503007	9.946.50	0.04%
ELCAN	HELLAS CAN (CB)	GRS125151001	0.00	0.00%
ELGEK	ELGEKA S.A. (CR)	GRS329503007	608.186.40	2.75%
ELME	ELMEC SPORT A.B.E.T.E. (CR)	GRS141183004	215.590.60	0.97%
ELTON	ELTON S.A.(CR)	GRS397003005	77.638.60	0.35%
EMPED	EMPEDOS S.A. (CR)	GRS193003001	217.912.59	0.99%
ERMIS	HERMES REAL ESTATE S.A.	GRS145221008	490.555.20	2.22%
ESC	F.G. EUROPE S.A. (CR)	GRS083003012	530.562.20	2.40%
ETEM	ETEM S.A. (CB)	GRS195101001	4.103.40	0.02%
EVER	EVEREST S.A.(CR)	GRS336113006	92,220.00	0.42%
EYAPS	THESSALONIKA WATER & SEWERAGE SA (CR)	GRS428003008	58,890.60	0.27%
FORTH	FORTHNET S.A. (CR)	GRS406313007	212,725.20	0.96%
FOYRK	FOURLIS S.A.(CR)	GRS096003009	134,219	0.61%
FRIGO	FRIGOGLASS S.A.(CR)	GRS346153000	118,347.00	0.54%
GIAN	LAN-NET S.A. (CR)	GRS292503000	2,822,280.26	12.76%
HATZK	CHATZIIOANNOU HOLDINGS S.A. (CR)	GRS290063007	81,231.10	0.37%
HYGEIA	DIAGNOSTIC&THERAPEUTIC CENTER OF ATHENS YGEIA (CR)	GRS445003007	23,316.00	0.11%
INFO	INFORMER S.A. (CR)	GRS376313003	18,709.80	0.08%
INFOM	INFORMATICS S.A. (CR)	GRS361313000	261,420.10	1.18%

FTSE80 (continued)				
OASIS	NAME	ISIN CODE	MARKET CAP	%w$_p$
INKAT	INTRACOM CONSTRUCTIONS S.A. (CR)	GRS432003002	133,141.1	0.60%
KAMP	REDS S.A. (CB)	GRS106111008	47,385.24	0.21%
KARD	C. CARDASSILARIS & SONS - CARDICO S.A. (CR)	GRS269003000	290,168.2	1.31%
KATHI	KATHIMERINI PUBLISHING SA (CR)	GRS365263003	24,536.2	0.11%
KATSK	KATSELIS SONS S.A. BREAD IND. (CR)	GRS107003006	168,378.2	0.76%
KLEM	KLEEMAN HELLAS S.A. (CR)	GRS324253004	9,727.12	0.04%
KLONK	KLONATEX GROUP OF COMPANIES S.A. (CR)	GRS048003008	1,060,147.9	4.79%
KOTSV	P. KOTSOVOLOS S.A. (CR)	GRS358503001	45,379.72	0.21%
KYRM	F.H.L. H. KYRIAKIDIS MARBLES - GRANITES S.A. (CR)	GRS309083004	103,816.94	0.47%
LAMDA	LAMDA DEVELOPMENT S.A. (CR)	GRS245213004	26,099.6	0.12%
LAMPS	LAMPSA HOTEL S.A. (CR)	GRS128003001	58,565.5	0.26%
LAVI	LAVIPHARM S.A. (CR)	GRS246073001	17,784.85	0.08%
LYK	INFORM P. LYKOS S.A. (CR)	GRS208303008	285,972.8	1.29%
MHXAK	MICHANIKI S.A. (CR)	GRS153213004	406,089.94	1.84%
MINOA	MINOAN LINES(CR)	GRS296273006	116,229.52	0.53%
MOYZK	EL. D. MOUZAKIS S.A. (CB)	GRS054061007	21,182.1	0.10%
MPENK	CH.. BENRUBI S.A. (CR)	GRS154183008	131,987.56	0.60%
NAOYK	NAOUSSA SPINNING MILLS S.A. (CR)	GRS196003008	569,281.66	2.57%
NEOCHI	NEOCHIMIKI S.A. (CR)	GRS463003012	338,526.4	1.53%

FTSE80 (continued)				
NEWS	NEWSPHONE HELLAS S.A. AUDIO-TEX (CR)	GRS457003002	1,152,454.8	5.21%
NIKAS	P.G. NIKAS S.A. (CR)	GRS111003000	57,193.2	0.26%
OLTH	THESSALONIKI PORT AUTHORITY S.A. (CR	GRS427003009	42,502.8	0.19%
OTOEL	AUTOHELLAS S.A. (CR)	GRS337503007	81,208.8	0.37%
PEGAS	PEGASUS PUBLISHING & PRINT-ING S.A.(CR)	GRS370263006	10,727.2	0.05%
PLAIS	PLAISIO COMPUTERS S.A. (CR)	GRS320313000	112,818	0.51%
PLAKR	CRETE PLASTICS S.A. (CB)	GRS326071008	988.8	0.004%
PLAT	THRACE PLASTICS S.A.(CB)	GRS239071004	77,528.3	0.35%
POUL	POULIADIS ASSOCIATES S.A.(CR)	GRS264313008	124,441.86	0.56%
PTEX	PANTECHNIKI S.A. (CR)	GRS317003010	79,870.57	0.36%
QUEST	Info-Quest S.A. (CR)	GRS310313002	59,570.29	0.27%
ROKKA	CH. ROKAS S.A. (CR)	GRS170103006	39,324.4	0.18%
SANYO	SANYO HELLAS HOLDING S.A. (CB)	GRS155001019	193,294.55	0.87%
SAR	GR. SARANTIS S.A.(CR)	GRS204003008	111,736.8	0.51%
SELMK	SHELMAN S.A. (CR)	GRS132003005	33,624.4	0.15%
SPID	SPIDER METAL IND. N.PETSIOS & SONS S.A.(CR)	GRS353103005	99,143.4	0.45%
STRIK	STRINTZIS LINES S.A. (CB)	GRS199271008	92,187.2	0.42%
STTHK	UNCLE STATHIS S.A. (CR)	GRS109003004	88,689.2	0.40%
TEGO	CH.C. TEGOPOULOS PUBLISHING S.A. (CR)	GRS312293004	85,542.6	0.39%
THEME	THEMELIODOMH S.A. (CR)	GRS183213008	135,089.1	0.61%
USYST	UNISYSTEMS S.A. (CR)	GRS356313007	49,835.16	0.23%
Total market value (cap) as of 31/12/2003:			22,117,543.52	100.00%

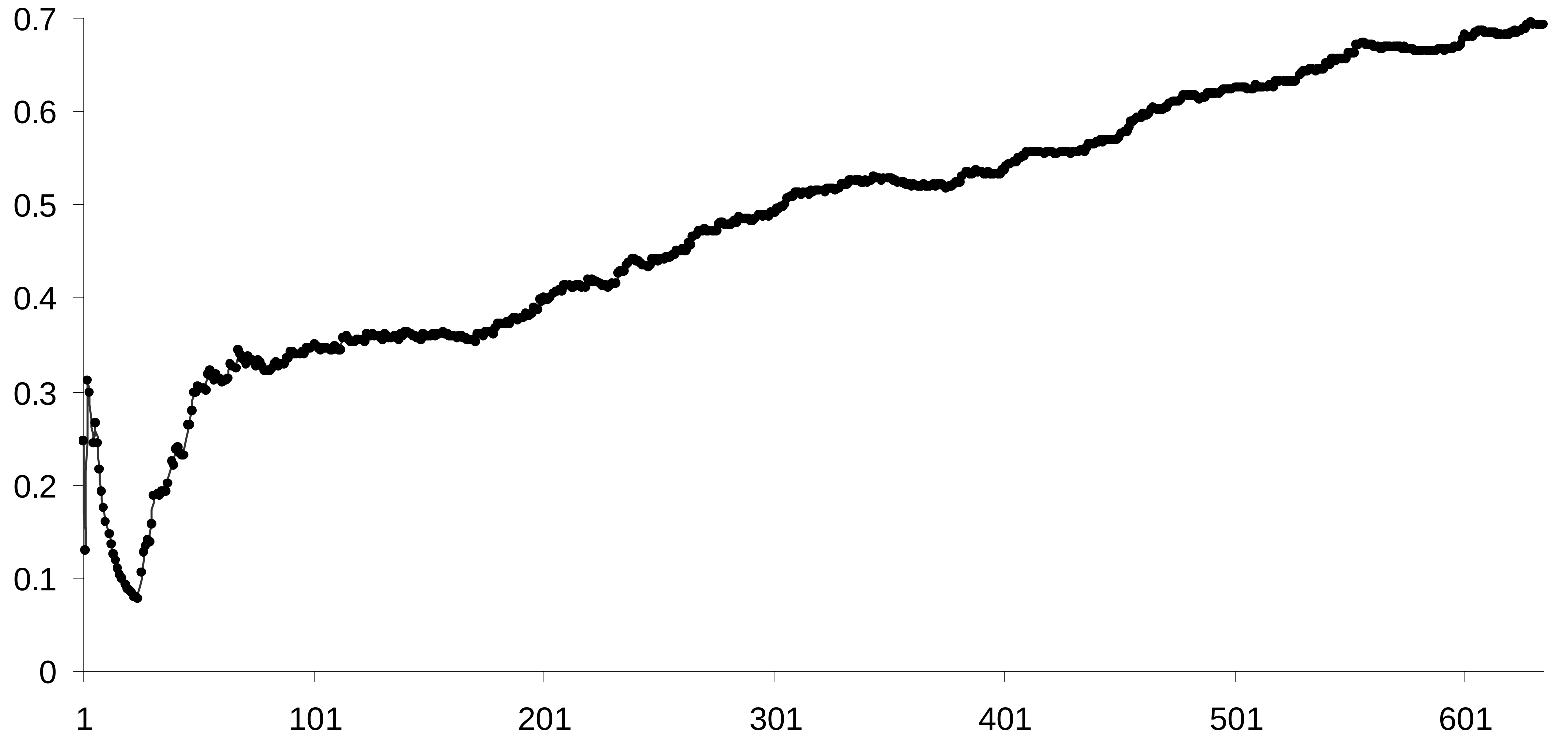

Figure 1. ALPHA (OASIS code) returns dataset. Hill estimator $\hat{\gamma}(m_T)$ as function of $m_T = 1, 2, .., [T^*/2]$ where T^* denotes the number of positive returns.

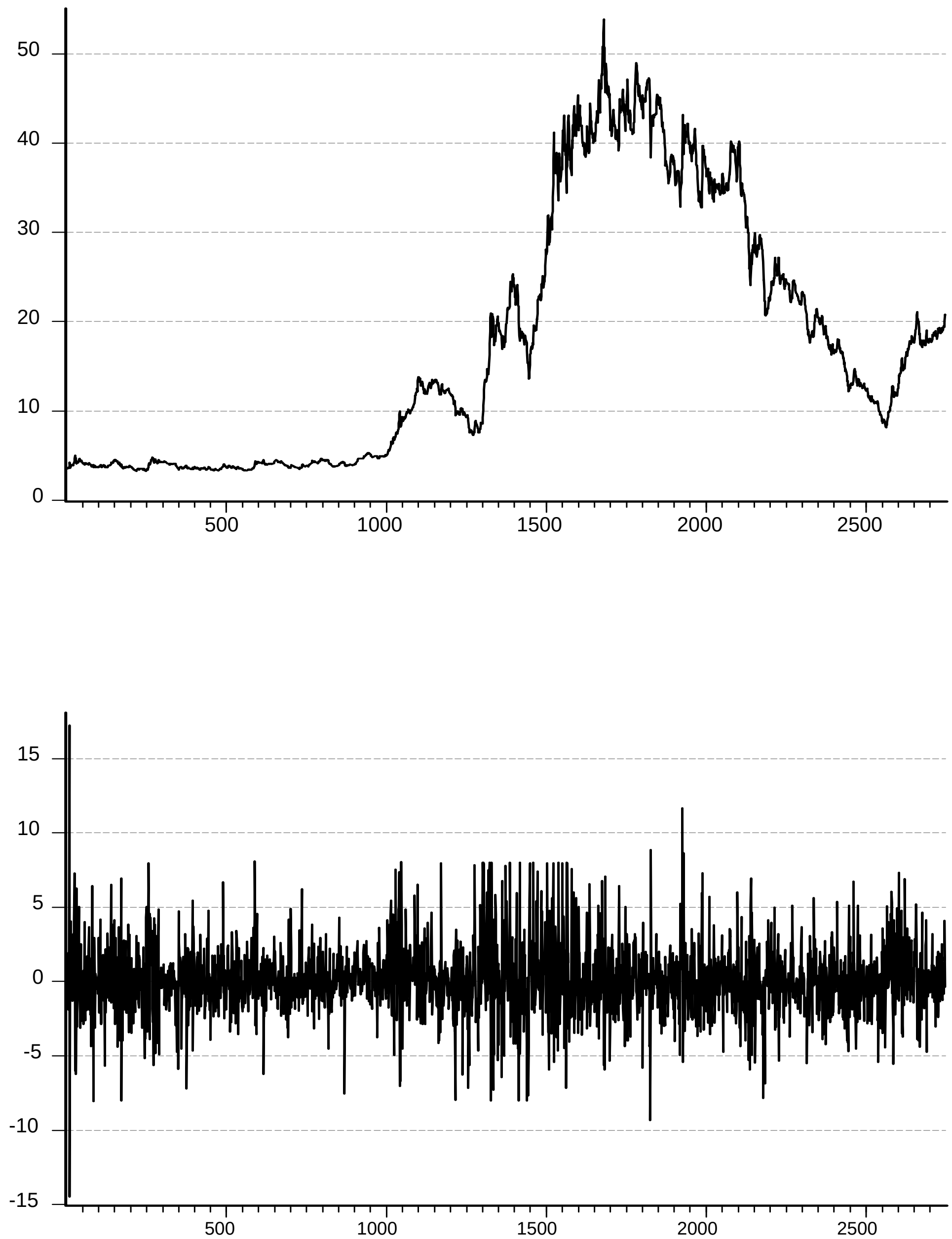

Figure 2. (Top Plot) Stock price of ETHNIKI. Vertical axis values denote price in Euros. Horizontal axis values denote time points corresponding to the sample size 4/1/1993 - 31/12/2003. (Bottom Plot) ETHNIKI log-difference (%) returns.

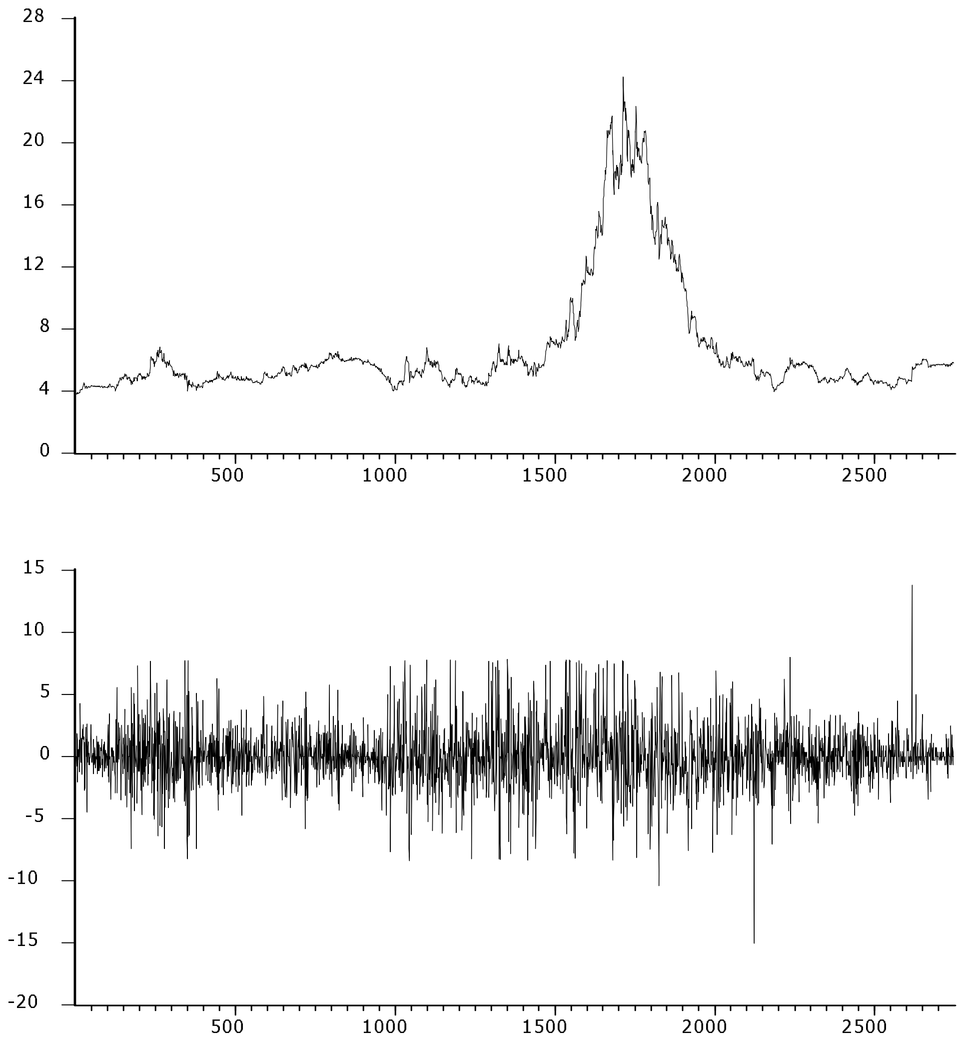

Figure 3. (Top Plot) Stock price of ELCAN. Vertical axis values denote price in Euros. Horizontal axis values denote time points corresponding to the sample size 4/1/1993 - 31/12/2003. (Bottom Plot) ELCAN log-difference (%) returns.

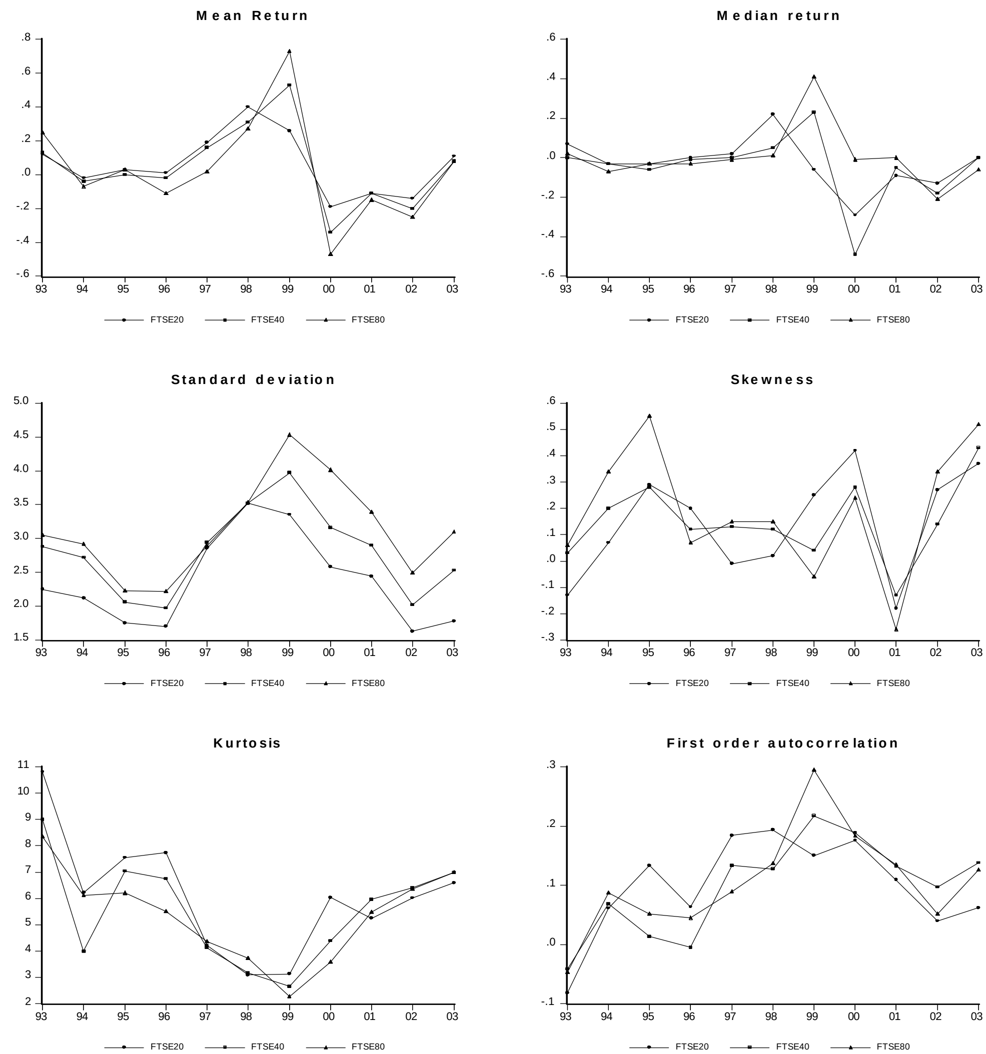

Figure 4. Year by year descriptive statistics of stock returns. Sub-figures plot averages (over listed firms in each group) of the corresponding statistics.

Percentile:	Q1	Q5	Q10	Q90	Q95	Q99
Normal Distribution:	-2.325	-1.645	-1.280	1.280	1.645	2.325
FTSE20 group:	-2.734	-1.518	-1.069	1.132	1.703	2.852
FTSE40 group:	-2.663	-1.524	-1.086	1.192	1.814	2.753
FTSE80 group:	-2.575	-1.584	-1.100	1.222	1.838	2.675

Table 1. Sample period 1993-2003. Average (across firms) quantiles for each group of firms.

FTSE20	Left tail				Right tail			
	$\hat{\mathbf{a}}_H$	*(s.e)**	$\hat{\mathbf{a}}_{HKKP}$	*(s.e)***	$\hat{\mathbf{a}}_H$	*(s.e)**	$\hat{\mathbf{a}}_{HKKP}$	*(s.e)***
ALPHA	2.75	*(0.24)*	3.90	*(0.04)*	2.78	*(0.25)*	3.74	*(0.04)*
ATE	2.46	*(0.45)*	3.04	*(0.07)*	2.10	*(0.47)*	3.96	*(0.11)*
BIOX	3.87	*(0.39)*	7.07	*(0.09)*	3.47	*(0.35)*	8.95	*(0.11)*
COSMO	3.44	*(0.55)*	4.84	*(0.10)*	3.78	*(0.64)*	5.33	*(0.11)*
EEEK	2.54	*(0.23)*	3.75	*(0.04)*	2.42	*(0.22)*	4.08	*(0.04)*
ELPE	3.13	*(0.38)*	4.56	*(0.07)*	3.31	*(0.43)*	3.72	*(0.06)*
ELTEX	2.96	*(0.28)*	4.06	*(0.05)*	5.40	*(0.54)*	14.59	*(0.19)*
ETE	3.05	*(0.27)*	4.21	*(0.04)*	2.75	*(0.24)*	4.01	*(0.04)*
EUROB	4.52	*(0.45)*	5.35	*(0.07)*	36.25	*(3.74)*	45.83	*(0.90)*
GERM	2.25	*(0.33)*	3.63	*(0.07)*	2.57	*(0.39)*	3.41	*(0.06)*
HDF	3.43	*(0.42)*	4.34	*(0.06)*	4.74	*(0.57)*	13.75	*(0.21)*
HTO	3.35	*(0.34)*	4.69	*(0.06)*	3.26	*(0.35)*	5.46	*(0.07)*
HYATT	2.96	*(0.41)*	4.89	*(0.08)*	2.47	*(0.36)*	3.27	*(0.06)*
INTRK	3.30	*(0.29)*	4.12	*(0.04)*	4.26	*(0.39)*	6.91	*(0.08)*
MOH	2.75	*(0.53)*	3.70	*(0.09)*	1.58	*(0.32)*	2.08	*(0.05)*
OPAP	2.41	*(0.45)*	3.32	*(0.08)*	2.66	*(0.47)*	3.25	*(0.07)*
PPC	4.20	*(0.89)*	10.04	*(0.28)*	3.02	*(0.60)*	3.68	*(0.09)*
TEMP	2.47	*(0.21)*	3.32	*(0.03)*	2.87	*(0.26)*	4.36	*(0.05)*
TITK	2.81	*(0.25)*	3.75	*(0.04)*	2.57	*(0.23)*	3.65	*(0.04)*
TPEIR	2.82	*(0.26)*	3.34	*(0.03)*	3.46	*(0.33)*	5.10	*(0.06)*
Median	**2.96**	*(0.36)*	**4.09**	*(0.07)*	**2.95**	*(0.37)*	**4.04**	*(0.07)*

Table 2. Sample period 1993-2003. Tail index estimates for the firms of FTSE20. a_H : Hill estimator, a_{HKKP} : HKKP estimator. The last row reports mean of the respective column. Numbers in parentheses report median (across firms) standard errors. *Asymptotic standard errors were calculated from $m^{1/2}(\hat{a}_H - a) \longrightarrow_d N(0, a^2)$ [see Hall (1982) and Goldie & Smith (1987)]. **The standard error of $\hat{a}_{HKKP}$ was calculated using the delta method as $\frac{1}{\hat{\gamma}^2}\sigma_{\hat{\gamma}}$, where $\sigma_{\hat{\gamma}}$ denotes the HKKP standard error of the γ estimate.

FTSE40	**Left tail**				**Right tail**			
	$\hat{\mathbf{a}}_H$	*(s.e)**	$\hat{\mathbf{a}}_{HKKP}$	*(s.e)***	$\hat{\mathbf{a}}_H$	*(s.e)**	$\hat{\mathbf{a}}_{HKKP}$	*(s.e)***
AKTOR	3.37	*(0.31)*	4.93	*(0.06)*	7.10	*(0.69)*	10.79	*(0.13)*
ALEK	2.71	*(0.24)*	4.07	*(0.05)*	2.75	*(0.25)*	4.39	*(0.05)*
ALLH	2.81	*(0.25)*	3.97	*(0.04)*	3.09	*(0.29)*	4.27	*(0.05)*
ARBA	2.55	*(0.25)*	4.10	*(0.05)*	2.87	*(0.29)*	3.59	*(0.04)*
ASETH	3.19	*(0.28)*	4.39	*(0.05)*	4.02	*(0.37)*	6.78	*(0.08)*
ASTIR	2.69	*(0.41)*	3.73	*(0.07)*	2.48	*(0.42)*	3.84	*(0.08)*
ATTEN	3.56	*(0.32)*	5.38	*(0.06)*	3.55	*(0.33)*	6.45	*(0.07)*
AVAX	3.11	*(0.31)*	4.08	*(0.05)*	7.11	*(0.75)*	24.26	*(0.33)*
CHIP	3.24	*(0.33)*	4.93	*(0.06)*	2.77	*(0.28)*	3.99	*(0.05)*
DELTK	2.62	*(0.23)*	3.26	*(0.03)*	2.86	*(0.26)*	3.92	*(0.04)*
DESIN	3.94	*(0.41)*	12.59	*(0.17)*	8.78	*(0.95)*	18.08	*(0.25)*
DOL	3.96	*(0.49)*	6.45	*(0.10)*	5.86	*(0.78)*	8.35	*(0.14)*
EGNAK	3.18	*(0.28)*	5.80	*(0.06)*	9.99	*(0.95)*	7.22	*(0.09)*
ELBA	3.33	*(0.36)*	4.45	*(0.06)*	5.08	*(0.57)*	7.75	*(0.11)*
ELBI	2.91	*(0.31)*	3.43	*(0.04)*	3.56	*(0.37)*	6.60	*(0.08)*
EXAE	3.07	*(0.47)*	4.60	*(0.09)*	2.46	*(0.44)*	5.25	*(0.12)*
EYDAP	3.09	*(0.44)*	4.75	*(0.08)*	2.97	*(0.46)*	3.79	*(0.07)*
FOLLI	2.82	*(0.33)*	3.72	*(0.05)*	4.27	*(0.50)*	6.75	*(010)*
GEAPK	7.49	*(0.84)*	6.16	*(0.09)*	4.60	*(0.54)*	18.77	*(0.28)*
GEK	3.05	*(0.28)*	4.11	*(0.05)*	7.78	*(0.79)*	7.60	*(0.10)*

Table 3 (continues)

FTSE40	Left Tail				Right tail			
GOODY	3.33	*(0.40)*	5.55	*(0.08)*	2.85	*(0.35)*	3.91	*(0.06)*
HRAK	2.87	*(0.25)*	4.36	*(0.04)*	3.35	*(0.30)*	5.49	*(0.06)*
HSI	3.89	*(0.34)*	4.53	*(0.05)*	26.50	*(2.53)*	52.09	*(0.94)*
IASO	2.26	*(0.34)*	3.30	(0.06)	2.03	*(0.34)*	2.47	*(0.05)*
IATR	3.50	*(0.32)*	5.27	*(0.06)*	4.24	*(0.40)*	8.75	*(0.10)*
INLOT	2.68	*(0.37)*	4.06	*(0.07)*	2.25	*(0.33)*	3.23	*(0.06)*
MAIK	3.11	*(0.32)*	5.19	*(0.07)*	4.28	*(0.44)*	5.34	*(0.07)*
METK	4.02	*(0.37)*	5.31	*(0.06)*	8.26	*(0.79)*	9.30	*(0.11)*
MYTIL	3.02	*(0.31)*	4.75	*(0.06)*	9.66	*(1.04)*	30.57	*(0.42)*
NOTOS	3.36	*(0.38)*	4.66	*(0.06)*	5.08	*(0.58)*	11.16	*(0.16)*
OLYMP	5.04	*(0.53)*	5.14	*(0.07)*	8.72	*(0.94)*	61.48	*(1.46)*
PPA	2.64	*(1.32)*	3.80	*(0.25)*	2.65	*(1.32)*	3.36	*(0.23)*
SEFOR	4.15	*(0.68)*	4.37	*(0.09)*	2.50	*(0.39)*	5.26	*(0.10)*
SIDE	3.81	*(0.39)*	5.45	*(0.07)*	4.02	*(0.42)*	6.99	*(0.09)*
TATT	2.93	*(0.26)*	4.14	*(0.04)*	6.51	*(0.62)*	9.68	*(0.12)*
TELET	3.15	*(0.29)*	5.02	*(0.06)*	6.02	*(0.62)*	18.07	*(0.24)*
TERNA	4.06	*(0.38)*	5.10	*(0.06)*	12.39	*(1.20)*	23.15	*(0.29)*
TGEN	3.12	*(0.27)*	4.06	*(0.04)*	3.29	*(0.31)*	6.17	*(0.07)*
VOVOS	1.65	*(0.31)*	1.59	*(0.03)*	1.63	*(0.31)*	2.26	*(0.05)*
XAKO	4.06	*(0.45)*	6.93	*(0.10)*	5.52	*(0.65)*	7.57	*(0.11)*
Median	**3.14**	*(0.33)*	**4.56**	*(0.06)*	**4.13**	*(0.45)*	**6.76**	*(0.10)*

Table 3. Sample period 1993-2003. Tail index estimates for the firms of FTSE40. a_H : Hill estimator, a_{HKKP} : HKKP estimator. The last row reports mean of the respective column. Numbers in parentheses report median (across firms) standard errors. *Asymptotic standard errors were calculated from $m^{1/2}(\hat{a}_H - a) \longrightarrow_d N(0, a^2)$ [see Hall (1982) and Goldie & Smith (1987)]. **The standard error of $\hat{a}_{HKKP}$ was calculated using the delta method as $\frac{1}{\hat{\gamma}^2}\sigma_{\hat{\gamma}}$, where $\sigma_{\hat{\gamma}}$ denotes the HKKP standard error of the γ estimate.

FTSE80	Left tail				Right tail			
	$\hat{\mathbf{a}}_H$	*(s.e)**	$\hat{\mathbf{a}}_{HKKP}$	*(s.e)***	$\hat{\mathbf{a}}_H$	*(s.e)**	$\hat{\mathbf{a}}_{HKKP}$	*(s.e)***
AEGEK	3.17	*(0.29)*	5.77	*(0.06)*	11.81	*(1.15)*	36.29	(0.46)
AGRAS	2.69	*(0.34)*	3.57	*(0.05)*	3.07	*(0.46)*	4.24	(0.08)
ALATK	4.60	*(0.42)*	5.47	*(0.06)*	6.74	*(0.64)*	18.23	(0.22)
ALCO	3.91	*(0.43)*	5.41	*(0.07)*	7.64	*(0.91)*	5.14	(5.51)
ALMY	3.26	*(0.39)*	4.82	*(0.07)*	4.73	*(0.59)*	6.72	(0.10)
ALTE	5.32	*(0.51)*	6.72	*(0.08)*	7.30	*(0.74)*	21.15	(0.28)
ALTEC	3.51	*(0.36)*	5.25	*(0.07)*	6.82	*(0.76)*	10.56	(0.15)
ANEK	3.77	*(0.48)*	5.13	*(0.08)*	4.50	*(0.64)*	7.41	(0.13)
ASFOI	4.93	*(0.50)*	9.02	*(0.12)*	8.60	*(0.91)*	58.24	(1.50)
ASPT	3.59	*(0.44)*	5.14	*(0.08)*	7.55	*(1.03)*	5.48	(0.11)
ASTAK	3.10	*(0.40)*	3.95	*(0.06)*	7.19	*(1.06)*	9.54	(0.18)
ATEK	3.50	*(0.49)*	4.12	*(0.07)*	2.99	*(0.45)*	3.84	(0.14)
ATERM	4.80	*(0.63)*	7.84	*(0.13)*	4.84	*(0.68)*	22.34	(2.57)
ATHINA	4.93	*(0.49)*	6.97	*(0.09)*	8.91	*(0.91)*	21.48	(0.28)
ATTIK	5.72	*(0.55)*	6.49	*(0.08)*	8.32	*(0.85)*	13.29	(3.93)
AXON	3.91	*(0.37)*	5.02	*(0.06)*	6.35	*(0.65)*	32.76	(2.29)
BABY	3.77	*(0.44)*	5.04	*(0.07)*	7.64	*(0.93)*	24.85	(0.39)
BIOT	4.36	*(0.40)*	6.72	*(0.08)*	9.45	*(0.93)*	48.18	(1.77)
BYTE	3.37	*(0.50)*	3.97	*(0.07)*	2.90	*(0.48)*	5.44	(0.11)
DAIOS	3.99	*(0.62)*	3.73	*(0.07)*	4.49	*(0.72)*	4.96	(0.10)
DOMIK	2.79	*(0.41)*	3.38	*(0.06)*	2.21	*(0.35)*	2.83	(0.05)
ELATH	3.07	*(0.44)*	3.83	*(0.07)*	2.65	*(0.41)*	3.62	(0.07)
ELCAN	2.96	*(0.27)*	4.66	*(0.05)*	2.97	*(0.28)*	4.61	(0.05)
ELGEK	3.63	*(0.48)*	4.20	*(0.07)*	3.11	*(0.48)*	4.60	(0.13)
ELME	3.44	*(0.34)*	3.75	*(0.04)*	8.15	*(0.83)*	10.19	(0.13)
ELTON	2.30	*(0.38)*	3.07	*(0.06)*	1.89	*(0.32)*	3.27	(0.07)
EMPED	4.62	*(0.45)*	6.67	*(0.08)*	7.42	*(0.77)*	48.62	(1.63)
ERMIS	6.16	*(0.79)*	7.42	*(0.12)*	3.79	*(0.49)*	6.42	(1.78)
ESC	4.78	*(0.44)*	4.14	*(0.05)*	6.02	*(0.57)*	7.76	(0.09)
ETEM	3.16	*(0.30)*	4.83	*(0.06)*	3.88	*(0.40)*	6.04	(0.08)
EVER	3.21	*(0.44)*	5.73	*(0.10)*	2.83	*(0.43)*	3.53	(0.08)
EYAPS	3.57	*(0.71)*	5.24	*(0.13)*	2.36	*(0.48)*	3.93	(0.10)
FORTH	2.92	*(0.45)*	4.12	*(0.08)*	3.60	*(0.65)*	6.63	(0.15)
FOYRK	4.80	*(0.50)*	6.32	*(0.08)*	5.99	*(0.63)*	8.07	(0.11)
FRIGO	3.03	*(0.44)*	3.61	*(0.06)*	2.78	*(0.42)*	4.49	(0.08)
GIAN	4.07	*(0.48)*	7.35	*(0.11)*	3.35	*(0.41)*	17.83	(0.28)
HATZK	3.73	*(0.35)*	5.28	*(0.06)*	6.35	*(0.61)*	6.56	(0.08)
HYGEIA	5.67	*(1.30)*	32.15	*(0.98)*	3.94	*(1.05)*	8.29	(0.29)
INFO	2.90	*(0.43)*	3.40	*(0.06)*	2.70	*(0.44)*	3.60	(0.07)
INFOM	3.13	*(0.46)*	4.03	*(0.07)*	3.21	*(0.50)*	5.18	(0.10)

Table 4 (continues)

FTSE80	Left tail				Right tail			
	$\hat{a}_H$	(s.e)*	$\hat{a}_{HKKP}$	(s.e)**	$\hat{a}_H$	(s.e)*	$\hat{a}_{HKKP}$	(s.e)**
INKAT	4.17	(0.82)	9.42	(0.24)	2.10	(0.46)	2.70	(0.07)
KAMP	4.72	(0.43)	5.99	(0.07)	11.93	(1.19)	54.12	(1.84)
KARD	3.46	(0.39)	4.81	(0.07)	4.01	(0.45)	9.87	(0.14)
KATHI	3.73	(0.54)	5.04	(0.09)	2.81	(0.44)	4.18	(0.08)
KATSK	3.24	(0.30)	4.63	(0.05)	4.22	(0.40)	6.05	(0.07)
KLEM	2.29	(0.30)	3.41	(0.05)	3.58	(0.50)	5.05	(0.09)
KLONK	4.87	(0.43)	5.92	(0.06)	4.53	(0.42)	11.79	(0.14)
KOTSV	4.20	(0.58)	5.47	(0.10)	3.43	(0.56)	4.82	(0.10)
KYRM	3.64	(0.46)	4.86	(0.08)	13.47	(1.85)	61.37	(1.11)
LAMDA	3.97	(0.44)	6.05	(0.08)	16.99	(1.98)	5.02	(3.36)
LAMPS	5.29	(0.56)	5.88	(0.08)	15.35	(1.65)	8.62	(0.12)
LAVI	3.74	(0.38)	5.44	(0.07)	10.34	(1.12)	9.50	(0.13)
LYK	2.97	(0.28)	4.11	(0.05)	4.25	(0.41)	5.67	(0.07)
MHXAK	2.93	(0.26)	3.51	(0.04)	5.17	(0.49)	9.22	(0.11)
MINOA	3.05	(0.36)	4.07	(0.06)	3.50	(0.46)	4.71	(0.08)
MOYZK	4.37	(0.40)	5.87	(0.07)	9.59	(0.89)	26.87	(0.32)
MPENK	6.90	(0.69)	7.90	(0.10)	12.76	(1.32)	50.67	(2.37)
NAOYK	3.77	(0.35)	5.04	(0.06)	4.70	(0.47)	13.56	(0.17)
NEOCHI	2.86	(1.17)	7.84	(0.45)	1.86	(0.70)	2.09	(0.10)
NEWS	1.87	(0.66)	1.76	(0.08)	3.67	(1.16)	4.82	(0.20)
NIKAS	3.05	(0.28)	4.42	(0.05)	3.77	(0.36)	6.53	(0.08)
OLTH	2.83	(0.52)	3.66	(0.09)	2.73	(0.55)	3.40	(0.09)
OTOEL	3.23	(0.45)	3.97	(0.07)	2.91	(0.44)	3.19	(0.07)
PEGAS	3.08	(0.44)	5.29	(0.09)	3.28	(0.57)	4.47	(0.10)
PLAIS	2.62	(0.34)	4.13	(0.07)	2.88	(0.41)	3.47	(0.08)
PLAKR	3.06	(0.40)	4.33	(0.07)	4.18	(0.60)	5.65	(0.10)
PLAT	3.85	(0.39)	5.22	(0.06)	11.26	(1.22)	11.37	(0.16)
POUL	3.91	(0.42)	4.17	(0.05)	9.32	(1.05)	12.10	(0.17)
PTEX	4.38	(0.58)	6.47	(0.11)	7.80	(1.07)	15.51	(0.27)

Table 4 (continues)

FTSE80	Left tail				Right tail			
QUEST	3.82	(0.48)	5.21	(0.08)	4.53	(0.63)	8.83	(0.26)
ROKKA	3.32	(0.29)	4.84	(0.05)	6.30	(0.59)	12.11	(0.14)
SANYO	4.68	(0.43)	6.19	(0.07)	6.52	(0.64)	16.68	(0.21)
SAR	3.35	(0.32)	6.20	(0.08)	4.57	(0.46)	7.89	(0.10)
SELMK	3.93	(0.35)	5.73	(0.06)	5.57	(0.53)	8.52	(0.10)
SPID	2.62	(0.36)	3.75	(0.06)	2.46	(0.39)	3.86	(0.09)
STRIK	3.41	(0.33)	5.18	(0.06)	4.93	(0.51)	8.32	(0.11)
STTHK	3.23	(0.30)	4.72	(0.05)	5.33	(0.51)	7.39	(0.09)
TEGO	4.54	(0.58)	9.20	(0.15)	6.64	(0.91)	20.57	(0.37)
THEME	2.97	(0.28)	3.53	(0.04)	5.62	(0.56)	5.92	(0.07)
USYST	3.50	(0.49)	4.54	(0.08)	2.85	(0.45)	4.77	(0.09)
Median	**3.58**	(0.44)	**5.04**	(0.07)	**4.55**	(0.58)	**7.05**	(0.12)

Table 4. Sample period 1993-2003. Tail index estimates for the firms of FTSE80. a_H : Hill estimator, a_{HKKP} : HKKP estimator. The last row reports mean of the respective column. Numbers in parentheses report median (across firms) standard errors. *Asymptotic standard errors were calculated from $m^{1/2}(\hat{a}_H - a) \longrightarrow_d N(0, a^2)$ [see Hall (1982) and Goldie & Smith (1987)]. **The standard error of $\hat{a}_{HKKP}$ was calculated using the delta method as $\frac{1}{\hat{\gamma}^2}\sigma_{\hat{\gamma}}$, where $\sigma_{\hat{\gamma}}$ denotes the HKKP standard error of the γ estimate.

	Left tail				Right tail			
	$\hat{\mathbf{a}}_H$	*(s.e)**	$\hat{\mathbf{a}}_{HKKP}$	*(s.e)***	$\hat{\mathbf{a}}_H$	*(s.e)**	$\hat{\mathbf{a}}_{HKKP}$	*(s.e)***
FTSE20	2.96	*(0.36)*	4.09	*(0.07)*	2.95	*(0.37)*	4.04	*(0.07)*
FTSE40	3.14	*(0.33)*	4.56	*(0.06)*	4.13	*(0.45)*	6.76	*(0.10)*
FTSE80	3.58	*(0.44)*	5.04	*(0.07)*	4.55	*(0.58)*	7.05	*(0.12)*
Mean	**3.22**	*(0.37)*	**4.56**	*(0.07)*	**3.87**	*(0.47)*	**5.95**	*(0.09)*

Table 5. Sample period 1993-2003. Median (across firms) tail index estimates for each group of firms. The last row reports mean of the respective column. Numbers in parentheses report median (across firms) standard errors. *Asymptotic standard errors were calculated from $m^{1/2}(\hat{a}_H - a) \longrightarrow_d N(0, a^2)$ [see Hall (1982) and Goldie & Smith (1987)]. **The standard error of $\hat{a}_{HKKP}$ was calculated using the delta method as $\frac{1}{\hat{\gamma}^2}\sigma_{\hat{\gamma}}$, where $\sigma_{\hat{\gamma}}$ denotes the HKKP standard error of the γ estimate.

	FTSE20		FTSE40		FTSE80	
	LT	RT	LT	RT	LT	RT
$p = 0.004$	-8.51	9.76	-10.09	10.89	-11.28	11.15
$p = 0.0008$	-13.26	14.59	-14.68	13.73	-15.40	14.35

Table 6. Median (across firms in each group) extreme quantiles $\hat{x}_p$ for two different choices of p. LT, RT denote left tail and right tail respectively. The choice $p = 0.004 (= 1/250)$ corresponds to one over 250 (days) or else once in a year. Thus, $p = 0.0008$ corresponds to once in five years.

	LT			RT		
	FTSE20	FTSE40	FTSE80	FTSE20	FTSE40	FTSE80
$\hat{x}_p = 8\%$	0.79	0.32	0.16	0.28	0.09	0.07
$\hat{x}_p = 9\%$	1.26	0.57	0.29	0.61	0.29	0.21
$\hat{x}_p = 10\%$	1.88	0.96	0.49	1.17	0.61	0.49
$\hat{x}_p = 11\%$	2.62	1.35	0.88	1.67	1.08	0.92
$\hat{x}_p = 12\%$	3.45	1.96	1.27	2.31	1.89	1.57
$\hat{x}_p = 13\%$	4.67	2.90	2.10	3.11	3.43	2.99
$\hat{x}_p = 14\%$	6.03	4.01	3.18	4.26	5.63	4.50
$\hat{x}_p = 15\%$	7.66	5.54	4.51	5.47	7.85	6.99

Table 7. Median (across firms in each group) tail probabilities expressed in years for different choices of extreme return $\hat{x}_p$ ($-\hat{x}_p$ for left tails). LT, RT denote left tail and right tail respectively.

Right Tail FTSE20. Structural break tests							
	T	Q	Date	Q^*	Date	$Q^{\#}$	Date
ALPHA	2748	0.31		0.50		21.6^{**}	8/5/02
ATE	732	1.84^{**}	15/3/02	12.4^{***}	1/4/03-8/4/03	101^{***}	7/5/03
BIOX	2048	16.4^{***}	17/3/00	14.5^{***}	23/7/99-13/8/99	33.9^{***}	17/3/00
COSMO	799	0.31		3.52^{***}	19/11/02-19/12/02	4.00	
EEEK	2748	1.03		3.19^{***}	18/12/01-30/1/02	4.59	
ELPE	1377	4907^{***}	29/11/99	466^{***}	18/2/00-22/2/00	5080^{***}	26/11/99
ELTEX	2421	516^{***}	30/12/99	670^{***}	14/12/99-2/2/00	2612^{***}	3/1/00
ETE	2748	0.78		3.18^{***}	1/12/99-19/4/00	12.9	
EUROB	2727	484^{***}	8/5/00	141^{***}	31/8/00	142041^{***}	5/7/99
GERM	967	1.22		1.51		4.94	
HDF	1439	13515^{***}	24/2/00	5388^{***}	16/12/99-23/12/99	31450^{***}	24/2/00
HTO	1921	3.31^{***}	11/1/02	1.23		4.25	
HYATT	1061	63.4^{***}	24/12/01	6.57^{***}	5/1/01-17/1/01	29.1^{***}	24/12/01
INTRK	2748	28.3^{***}	3/1/00	1854^{***}	18/11/99-21/12/99	153^{***}	19/4/00
MOH	596	9.70^{***}	17/7/02	16.3^{***}	9/7/02	21.0^{**}	26/8/03
OPAP	667	4.60^{***}	4/3/02	2.32^{**}	9/6/03-11/6/03	10.8	
PPC	505	1.98^{**}	9/12/02	1.31		15.4^{*}	5/9/03
TEMP	2748	4.48^{***}	10/5/00	10.3^{***}	1/2/00	7.68	
TITK	2748	0.70		3.45^{***}	20/4/00-24/4/00	15.8^{*}	5/11/01
TPEIR	2748	50.1^{***}	28/12/99	3946^{***}	26/10/99-27/10/99	58.8^{***}	3/9/99

Table 8. T denotes the available number of return observations. Columns $Q, Q^*, Q^{\#}$ report the recursive, rolling and sequential statistics respectively. *,**,*** denote statistical significance at 10%, 5%, 1%. Critical values were taken from Quintos et al. (2001) p. 662 (The rolling test Q^* was based on $\gamma_0 = 0.30$)

Left Tail FTSE20. Structural break tests							
	T	Q	Date	Q*	Date	Q#	Date
ALPHA	2748	2.03**	4/3/97	0.69		15.9*	15/4/02
ATE	732	1.09		1.17		54.1***	21/5/03
BIOX	2048	5.40***	13/2/97	2.56**	15/10/99-8/11/99	11.6	
COSMO	799	0.48		0.20		5.12	
EEEK	2748	0.92		0.99		2.39	
ELPE	1377	0.34		0.52		7.14	
ELTEX	2421	1.48*	9/2/00	18.5***	12/1/00-28/1/00	4.90	
ETE	2748	1.72*	11/12/98	0.67		11.7	
EUROB	2727	1398***	14/5/99	596***	15/4/99-30/4/99	3158***	10/2/99
GERM	967	2.05**	22/1/01	1.04		6.19	
HDF	1439	36.1***	4/5/00	8.18***	24/12/99-13/1/00	29.3***	10/6/99
HTO	1921	0.88		1.46		2.77	
HYATT	1061	7.32***	13/12/00	2.85**	5/1/01-8/1/01	19.2**	12/1/01
INTRK	2748	2.23**	14/4/98	0.50		26.8**	27/3/02
MOH	596	0.47		20.1***	12/6/02-14/6/02	2.99	
OPAP	667	1.96**	31/10/02	0.47		7.78	
PPC	505	1.81**	6/8/03	1.40		128***	10/9/03
TEMP	2748	0.74		0.78		11.6	
TITK	2748	0.99		3.29***	20/9/00-3/10/00	3.03	
TPEIR	2748	2.58***	13/8/01	0.50		14.5*	10/4/02

Table 9. T denotes the available number of return observations. Columns $Q, Q^*, Q^\#$ report the recursive, rolling and sequential statistics respectively. *,**,*** denote statistical significance at 10%, 5%, 1%. Critical values were taken from Quintos et al. (2001) p. 662 (The rolling test Q^* was based on $\gamma_0 = 0.30$)

Right Tail FTSE40							
	T	Q	Date	Q*	Date	Q#	Date
AKTOR	2498	1468***	24/1/00	552***	7/3/00-16/3/00	12498***	13/1/00
ALEK	2748	58.2***	29/2/00	22.9***	17/3/00-28/3/00	29.5***	20/10/99
ALLH	2748	4.06***	19/5/00	6280***	29/12/99-28/1/00	13.0	
ARBA	2251	4.89***	31/10/00	4460***	2/11/99-19/11/99	9.48	
ASETH	2748	5.51***	3/1/00	121***	29/12/99-14/1/00	90.9***	17/10/01
ASTIR	856	0.31		0.93	4/2/03-28/2/03	1.83	
ATTEN	2748	9.11***	10/2/97	53.8***	20/3/00-29/3/00	10.6	
AVAX	2336	336***	24/1/00	72.4***	24/11/99-16/3/00	4727***	24/1/00
CHIP	2369	2.48**	24/2/00	3.19***	12/1/00-13/1/00	7.68	
DELTK	2748	10.0***	17/5/00	151***	30/3/00-19/4/00	33.0***	7/2/02
DESIN	2413	1.99**	15/1/99	29.5***	19/10/00	215***	31/8/00
DOL	1285	15564***	10/5/00	21.5***	18/8/00-28/8/00	165934***	27/4/00
EGNAK	2730	334***	17/1/00	531***	30/12/99-8/2/00	16938***	30/12/99
ELBA	1887	203***	29/5/98	47.7***	17/9/98-21/9/98	251***	28/5/98
ELBI	2303	32.8***	28/7/00	96.5***	11/11/99-17/11/99	295***	6/3/01
EXAE	837	1.15		2.81**	3/10/02	51.7***	4/4/03
EYDAP	978	496***	29/9/00	0.86		149***	29/9/00
FOLLI	1536	2536***	24/2/00	1095***	3/2/00-9/2/00	5512***	24/2/00
GEAPK	2748	189***	23/9/99	36.7***	26/7/96-3/10/96	1222***	30/6/00
GEK	2367	2518***	7/2/00	1578***	7/2/00	13872***	7/2/00
GOODY	1497	10.1***	30/4/01	3.29***	20/4/00-24/4/00	118***	11/7/02
HRAK	2748	3.15***	27/1/00	5.98***	9/5/00-10/5/00	3.83	
HSI	2584	969***	29/11/99	223***	2/2/00-16/3/00	85620***	29/12/99
IASO	886	1.38		0.93		11.8	
IATR	2748	3.53***	3/1/00	1.53		14.1*	30/4/99
INLOT	1037	15.2***	19/11/01	8.81***	1/2/01-9/3/01	9.29	
MAIK	2379	2.72***	12/1/00	5.53***	20/4/00-12/5/00	23.0**	29/3/00
METK	2748	111***	16/3/00	121***	4/2/00-24/2/00	1444***	20/10/99
MYTIL	2092	225***	19/11/99	699***	10/12/99-8/2/00	4869***	29/12/99
NOTOS	1851	266***	19/11/99	172***	19/1/00-16/3/00	807***	19/11/99
OLYMP	2426	3.33***	1/2/99	1.63		147***	24/2/00
PPA	-	-	-	-	-	-	-
SEFOR	854	2.07**	7/8/02	1.76		17.1*	25/6/03
SIDE	2259	31.0***	1/2/00	12.3***	14/5/98-3/7/98	78.8***	6/9/00
TATT	2748	389***	17/1/00	865***	28/12/99-8/2/00	6761***	5/4/00
TELET	2340	611***	29/12/99	137***	29/12/99-19/4/00	2566***	21/4/00
TERNA	2483	500***	7/2/00	156***	7/2/00	6476***	7/2/00
TGEN	2748	40.4***	30/12/99	3542***	2/11/99-19/4/00	43.4***	30/12/99
VOVOS	643	10.4***	3/3/03	8.95***	16/10/02-6/11/02	9.70	
XAKO	1748	1121***	8/5/00	260***	11/5/00	2923***	19/4/00

Table 10. T denotes the available number of return observations. Columns $Q, Q^*, Q^\#$ report the recursive, rolling and sequential statistics respectively. *,**,*** denote statistical significance at 10%, 5%, 1%. Critical values were taken from Quintos et al. (2001) p. 662 (The rolling test Q^* was based on $\gamma_0 = 0.30$)

Left Tail FTSE40							
	T	Q	Date	Q^*	Date	$Q^{\#}$	Date
AKTOR	2498	4.08***	14/3/01	2.53**	12/9/00-1/11/00	20.7**	14/3/01
ALEK	2748	0.67		0.33		8.69	
ALLH	2748	1.60*	15/6/98	1.29		24.1**	8/4/02
ARBA	2251	1.66*	17/4/00	0.62		10.4	
ASETH	2748	0.96		1.53		10.6	
ASTIR	856	0.42		0.48		12.4	
ATTEN	2748	37.1***	23/1/97	13.4***	24/5/96-30/5/96	32.1***	23/1/97
AVAX	2336	9.67***	10/11/00	12.5***	9/3/00-15/3/00	49.8***	14/3/01
CHIP	2369	0.62		0.25		3.37	
DELTK	2748	0.43		1.13		4.28	
DESIN	2413	3.79***	21/10/96	1.15		12.8	
DOL	1285	3.82***	22/11/00	1.58		6.47	
EGNAK	2730	1.26		461***	20/10/99-18/11/99	13.1	
ELBA	1887	0.96		0.35		13.9	
ELBI	2303	2.49***	14/3/01	29.5***	23/5/00-24/5/00	108***	12/8/02
EXAE	837	0.93		0.41		4.14	
EYDAP	978	0.81		1.33		5.41	
FOLLI	1536	0.34		0.51		2.27	
GEAPK	2748	88.8***	22/2/00	39.5***	24/12/98-29/1/99	1261***	22/2/00
GEK	2367	5.85***	29/8/00	11.0***	22/3/00-30/3/00	18.7***	24/7/02
GOODY	1497	2.30**	18/8/00	0.90		150***	16/1/03
HRAK	2748	0.47		1.78*	19/9/03-26/9/03	24.2***	8/4/02
HSI	2584	1.81**		2.99***	12/1/00-7/3/00	7.71	
IASO	886	0.38		1.07		3.63	
IATR	2748	0.92		0.46		28.9***	18/4/02
INLOT	1037	6.47***	11/12/00	1.45		7.03	
MAIK	2379	0.80		0.25		27.9**	24/7/02
METK	2748	3.13***	16/2/99	1.57		41.3***	5/1/01
MYTIL	2092	1.70*	20/3/02	5.26***	29/2/00-7/3/00	11.4	
NOTOS	1851	5.10***	20/6/00	3.71***	12/1/00-21/1/00	21.7**	14/3/01
OLYMP	2426	44.6***	14/3/00	11.9***	2/2/00-14/3/00	182***	17/4/00
PPA	-	-	-	-	-	-	-
SEFOR	854	0.76		1.52		8.18	
SIDE	2259	1.11		0.63		6.15	
TATT	2748	0.83		5.68***	26/4/00-30/5/00	10.8	
TELET	2340	7.03***	15/3/01	2.12*	8/6/00-3/7/00	20.6**	10/7/01
TERNA	2483	5.20***	25/8/98	4.30***	15/1/01	11.4	
TGEN	2748	3.05***	8/2/00	2.26**	17/2/00-6/3/00	5.05	
VOVOS	643	2.15**	29/11/01	9.65***	11/9/02-18/9/02	8.77	
XAKO	1748	0.65		1.35		10.2	

Table 11. T denotes the available number of return observations. Columns $Q, Q^*, Q^{\#}$ report the recursive, rolling and sequential statistics respectively. *,**,*** denote statistical significance at 10%, 5%, 1%. Critical values were taken from Quintos et al. (2001) p. 662 (The rolling test Q^* was based on $\gamma_0 = 0.30$)

Right Tail FTSE80							
	T	Q	Date	Q*	Date	Q#	Date
AEGEK	2520	368***	1/2/00	96.3***	7/3/00	7284***	14/1/00
AGRAS	1204	31.5***	14/1/00	5.77***	3/8/00-29/8/00	100***	12/2/02
ALATK	2748	57.1***	25/2/00	356***	11/1/00-25/2/00	1089***	16/4/02
ALCO	1715	1158***	7/2/00	637***	4/1/00-7/2/00	7126***	1/2/00
ALMY	1482	1480***	28/1/00	667***	17/2/00-24/2/00	2849***	28/1/00
ALTE	2241	4009***	7/2/00	765***	10/1/00-7/2/00	164447***	3/1/00
ALTEC	2079	154***	16/3/00	688***	14/3/00-16/3/00	1466***	16/3/00
ANEK	1234	3096***	25/2/00	12.6***	21/7/00-27/7/00	3086***	25/2/00
ASFOI	2743	339***	16/3/00	436***	16/2/00-16/3/00	6708***	22/1/02
ASPT	1326	1423***	16/3/00	39.3***	10/4/00-19/4/00	44613***	18/2/00
ASTAK	1126	14049***	16/3/00	1.71		85428***	16/3/00
ATEK	1052	2.13**	23/10/00	0.64		41.2***	7/5/03
ATERM	1195	12604***	7/2/00	1.20		22784***	7/2/00
ATHINA	2226	207***	1/11/99	29.3***	24/11/99-15/3/00	2500***	1/11/99
ATTIK	2364	446***	16/3/00	42.2***	11/1/00-16/3/00	7258***	2/2/00
AXON	2384	2568***	16/3/00	625***	3/1/00-16/3/00	12858***	29/10/99
BABY	1629	39.5***	24/1/00	22.5***	11/1/00-8/3/00	834***	24/1/00
BIOT	2748	70.1***	24/2/00	12.6***	8/2/00-24/2/00	1771***	20/3/00
BYTE	960	9.06***	16/11/00	1.59		9.44	
DAIOS	920	0.82		71.8***	14/6/01-26/7/01	140***	6/5/03
DOMIK	966	85509***	30/10/00	903***	10/4/01-18/4/01	26275***	30/10/00
ELATH	1002	0.65		0.71		3.45	
ELCAN	2748	8.05***	12/6/01	5.83***	3/5/00-30/5/00	22.9**	5/7/999
ELGEK	1086	753***	11/4/00	1.11		635***	11/4/00
ELME	2744	68.3***	14/1/00	17.5***	24/1/00-16/3/00	903***	14/1/00
ELTON	843	64.0***	19/7/01	25.8***	23/8/01-28/9/01	13.0	
EMPED	2398	394***	16/3/00	29.3***	21/1/00-24/1/00	3811***	16/3/00
ERMIS	-	-	-	-	-	-	-
ESC	2739	467***	1/3/00	216***	15/11/99-1/3/00	460***	1/3/00
ETEM	2388	221***	7/1/00	247***	3/1/00-19/1/00	271***	7/1/00
EVER	1083	3.17***	11/10/02	1.37	5/7/01-16/7/01	37.1***	17/9/02
EYAPS	563	0.81		3.27***	22/12/03-30/12/03	12.0	
FORTH	803	4.66***	23/8/01	0.17		26.9**	11/7/03
FOYRK	2737	360***	29/12/99	81.7***	3/3/00-16/3/00	1841***	29/12/99
FRIGO	1017	12.2***	4/12/00	3.19***	19/2/01-16/3/01	48.3***	28/1/03
GIAN	1461	7971***	16/3/00	4109***	15/22/00-15/3/00	13220***	2/3/00
HATZK	2744	176***	7/2/00	276***	18/1/00-16/3/00	888***	7/2/00
HYGEIA	390	3.60***	2/7/03	4.15***	18/12/03-31/12/03	24.1**	8/10/03
INFO	914	0.34		0.43		30.6***	2/6/03
INFOM	968	13.7***	9/11/00	1.07		15.1*	2/4/03

Table 12 (continues)

Right Tail FTSE80							
	T	Q	Date	Q*	Date	Q#	Date
INKAT	513	3.68***	11/6/02	4.37***	27/9/02-11/10/02	562***	12/9/03
KAMP	2416	1649***	2/3/00	199***	23/11/99-24/2/00	46205***	2/3/00
KARD	1796	202***	2/2/00	286***	25/1/00-4/2/00	259***	2/2/00
KATHI	951	39.6***	19/2/01	10.4***	27/4/01-8/5/01	70.4***	19/2/01
KATSK	2743	13.3***	17/1/00	256***	4/1/00-10/1/00	433***	13/8/01
KLEM	1184	465***	14/1/00	11.3***	1/9/00-12/9/00	446***	14/1/00
KLONK	2743	3841***	16/3/00	2505***	4/1/00-23/2/00	4112***	27/1/00
KOTSV	980	1.81**	17/10/00	0.28		1.86	
KYRM	1257	113***	16/3/00	2.63**	17/9/02-18/9/02	3048***	16/3/00
LAMDA	2063	4.92***	6/11/98	2.96***	6/3/03-12/3/03	1639***	25/7/02
LAMPS	2744	507***	11/2/00	29.9***	7/7/99-26/8/99	62571***	1/3/00
LAVI	2031	443***	18/2/00	156***	17/1/00-18/2/00	11416***	18/2/00
LYK	2357	8.50***	20/1/00	133***	9/12/99-28/12/99	31.1***	20/1/00
MHXAK	2748	78.5***	21/4/00	1461***	3/1/00-13/1/00	843***	19/5/00
MINOA	1411	16.7***	30/12/99	38.3***	15/9/00-18/10/00	24.4**	24/2/03
MOYZK	2748	394***	16/3/00	86.6***	26/10/99-11/11/99	10897***	16/3/00
MPENK	2744	1243***	1/3/00	225***	4/2/00-24/2/00	102090***	1/3/00
NAOYK	2380	15382***	14/2/00	2889***	3/2/00-4/2/00	11013***	14/2/00
NEOCHI	-	-	-	-	-	-	-
NEWS	-	-	-	-	-	-	-
NIKAS	2743	10.3***	29/3/00	1455***	4/1/00-16/3/00	48.6***	5/11/01
OLTH	582	0.49		2.79**	16/9/02-26/9/02	27.0**	28/8/03
OTOEL	1081	31.1***	18/7/01	4.23***	12/2/12/00-18/12/00	136***	18/7/01
PEGAS	938	8.18***	31/1/01	0.76		15.9*	22/2/01
PLAIS	1197	16.1***	27/8/01	9.59***	24/8/00	45.7***	27/8/01
PLAKR	1158	3801***	6/3/00	5.14***	3/10/00-2/11/00	7063***	6/3/00
PLAT	2126	147***	16/3/00	16.8***	21/1/00-3/3/00	5870***	7/1/00
POUL	1871	308***	1/2/00	390***	2/2/00-16/3/00	3039***	16/3/00
PTEX	1228	7.32***	7/2/00	1.72		246***	18/3/03
QUEST	1255	9455***	15/3/00	22.2***	22/6/00-27/6/00	34194***	15/3/00
ROKKA	2748	132***	16/3/00	355***	10/1/00-4/2/00	1732***	29/12/99
SANYO	2744	87.8***	2/3/00	48.0***	5/1/00-2/3/00	2219***	4/5/00
SAR	2368	3.02***	19/4/00	8.58***	20/4/00-3/5/00	30.8***	12/5/00
SELMK	2743	74.1***	4/11/99	41.9***	21/10/99-27/1/00	846***	29/11/99
SPID	998	15.9***	13/2/01	1.41		17.7*	13/2/01
STRIK	2382	435***	13/1/00	289***	29/12/99-16/3/00	1819***	2/2/00
STTHK	2744	686***	16/3/00	1032***	24/1/00-9/3/00	4026***	30/12/99
TEGO	1248	756***	10/2/00	1.25		4893***	10/2/00
THEME	2505	505***	16/3/00	205***	23/2/00-16/3/00	5062***	4/4/00
USYST	995	1.31		1.16		3.73	

Table 12. T denotes the available number of return observations. Columns $Q, Q^*, Q^{\#}$ report the recursive, rolling and sequential statistics respectively. *,**,*** denote statistical significance at 10%, 5%, 1%. Critical values were taken from Quintos et al. (2001) p. 662 (The rolling test Q^* was based on $\gamma_0 = 0.30$)

Left Tail FTSE80							
	T	Q	Date	Q^*	Date	$Q^\#$	Date
AEGEK	2520	7.99***	11/12/00	33.5***	17/8/00-1/9/00	3.70	
AGRAS	1204	0.91		0.48		65.6***	19/12/02
ALATK	2748	11.3***	3/4/00	5.26***	28/3/00-3/4/00	49.1***	15/11/00
ALCO	1715	4.06***	14/3/01	21.9***	19/12/00-14/3/01	6.35	
ALMY	1482	0.28		0.35		11.0	
ALTE	2241	11.5***	14/4/00	8.08***	17/4/00	51.6***	13/9/01
ALTEC	2079	3.54***	26/1/00	5.28***	27/4/00-10/5/00	30.2***	10/9/01
ANEK	1234	101***	18/1/00	0.95		76.9***	10/2/00
ASFOI	2743	296***	5/11/96	65.3***	29/1/98-23/3/98	622***	5/11/96
ASPT	1326	6.22***	7/3/00	2.31**	10/4/00-11/4/00	8.02	
ASTAK	1126	42.9***	28/2/00	6.23***	27/10/00-30/10/00	23.8**	28/2/00
ATEK	1052	7.58***	16/11/00	2.15**	15/1/01-22/1/01	13.6	
ATERM	1195	2817***	24/1/00	0.82		2626***	13/1/00
ATHINA	2226	6.52***	25/10/00	14.1***	1/3/00-7/3/00	86.7***	28/2/01
ATTIK	2364	8.86***	28/2/00	26.0***	27/12/99-3/1/00	63.7***	16/1/01
AXON	2384	2.11**	17/4/00	21.9***	12/1/00-14/1/00	9.23	
BABY	1629	88.2***	26/1/00	20.7***	27/12/99-16/2/00	141***	26/1/00
BIOT	2748	9.87***	8/1/01	107***	12/1/00-15/2/00	40.6***	25/6/01
BYTE	960	1.04		0.66		3.65	
DAIOS	920	5711***	22/12/00	20.9***	17/9/01	9623***	22/12/00
DOMIK	966	6.37***	21/2/01	1.69		230***	8/1/03
ELATH	1002	0.70		1.08		103***	26/5/03
ELCAN	2748	0.80		0.45		4.05	
ELGEK	1086	6.32***	17/4/00	0.44		14.8*	28/1/03
ELME	2744	7.08***	5/3/01	6.00***	11/9/97-2/10/97	34.4***	26/10/00
ELTON	843	8.27***	23/3/01	20.7***	24/12/02-9/4/03	23.0***	17/6/03
EMPED	2398	14.0***	9/2/00	62.2***	7/1/00-10/1/00	88.0***	12/9/01
ERMIS	-	-	-	-	-	-	-
ESC	2739	22.9***	3/10/00	673***	20/1/00-22/2/00	463***	7/8/01
ETEM	2388	1.06		2.90***	22/12/00-15/1/01	5.22	
EVER	1083	3.59***	18/7/00	0.67		9.54	
EYAPS	563	1.45		0.42		7.14	
FORTH	803	0.45		19.0***	10/10/02-24/10/02	2.92	
FOYRK	2737	29.1***	27/1/00	4.58***	3/7/98-21/7/98	120***	8/3/00
FRIGO	1017	2.31**	14/3/01	0.91		21.2**	27/5/03
GIAN	1461	95.3***	23/2/00	289***	29/12/99-18/1/00	36.6***	3/3/00
HATZK	2744	19.4***	14/5/96	76.7***	12/1/00-25/2/00	21.4**	15/1/01
HYGEIA	390	47.1***	30/9/02	1.32		58.1***	8/10/03
INFO	914	0.94		0.43		9.01	
INFOM	968	1.57*	4/3/03	9.09***	2/9/03-9/9/03	7.10	

Table 13 (continues)

Left Tail FTSE80							
	T	Q	Date	Q*	Date	$Q^{\#}$	Date
INKAT	513	0.49		1.24		9.92	
KAMP	2416	6.53***	17/4/00	31.6***	17/2/00-28/2/00	62.4***	28/2/01
KARD	1796	1.24		0.68		8.20	
KATHI	951	2.25**	15/1/01	2.03*	6/3/03-11/3/03	10.7	
KATSK	2743	1.25		10.9***	24/10/00-9/1/01	35.3***	12/3/02
KLEM	1184	163***	21/3/00	17.7***	11/9/00-21/9/00	62.6***	21/3/00
KLONK	2743	8.16***	14/4/98	8.63***	10/5/00-23/5/00	138***	13/8/01
KOTSV	980	2.02**	28/5/02	2.74**	4/11/03-24/11/03	7.29	
KYRM	1257	13.7***	26/1/00	2.99***	10/8/00-12/9/00	18.2*	15/3/03
LAMDA	2063	243***	29/2/00	68.1***	24/2/00-28/2/00	1133***	29/2/00
LAMPS	2744	203***	10/2/97	1334***	27/12/99-14/2/00	608***	14/2/00
LAVI	2031	0.77		16.5***	1/2/00-25/2/00	17.5*	7/10/02
LYK	2357	0.78		0.47		9.28	
MHXAK	2748	0.50		3.03***	25/5/00-12/6/00	4.38	
MINOA	1411	0.27		0.43		5.70	
MOYZK	2748	5.33***	16/8/00	76.0***	7/1/00-28/2/00	15.3*	7/12/99
MPENK	2744	310***	16/2/00	105***	28/12/99-18/1/00	3739***	22/2/00
NAOYK	2380	2.68***	18/1/00	31.0***	24/4/00	15.7*	11/2/02
NEOCHI	-	-	-	-	-	-	-
NEWS	-	-	-	-	-	-	-
NIKAS	2743	1.10		1.55		22.2**	10/9/01
OLTH	582	0.61		0.81		10.4	
OTOEL	1081	9.77***	8/8/00	1.48		25.8***	3/8/00
PEGAS	938	4.81***	13/8/01	3.03***	8/8/01-12/9/01	7.43	
PLAIS	1197	11.4***	4/5/00	2.36**	30/8/00-31/8/00	13.7	
PLAKR	1158	70.9***	2/6/00	19.1***	27/9/00-29/9/00	26.4**	2/6/00
PLAT	2126	2.21**	6/3/01	5.38***	21/4/00-24/5/00	12.4	
POUL	1871	2.70**	22/1/01	1.40		22.1**	17/1/01
PTEX	1228	4638***	22/12/99	7.13***	7/7/00-7/8/00	8047***	22/12/99
QUEST	1255	170***	11/11/99	6.32***	29/6/00-3/7/00	114***	11/11/99
ROKKA	2748	0.54		4.55***	22/2/01-23/2/01	5.92	
SANYO	2744	3.22***	19/1/01	5.04***	17/4/00	33.8***	15/10/01
SAR	2368	0.93	3/9/99	2.32**	9/8/00-26/9/00	8.39	
SELMK	2743	4.77***	21/2/01	1.41		14.5*	8/1/01
SPID	998	1.28		1.29		7.50	
STRIK	2382	4.83***	5/10/98	2.83**	25/10/99-3/11/99	25.5**	24/7/02
STTHK	2744	6.69***	7/3/00	12.8***	10/3/00-14/3/00	14.9*	9/5/02
TEGO	1248	17.3***	7/3/00	5.06***	16/1/01-14/3/01	25.4**	17/4/00
THEME	2505	0.34		6.33***	10/11/0	11.7	
USYST	995	0.37		0.61		8.70	

Table 13. T denotes the available number of return observations. Columns $Q, Q^{*}, Q^{\#}$ report the recursive, rolling and sequential statistics respectively. *,**,*** denote statistical significance at 10%, 5%, 1%. Critical values were taken from Quintos et al. (2001) p. 662 (The rolling test Q^{*} was based on $\gamma_0 = 0.30$)

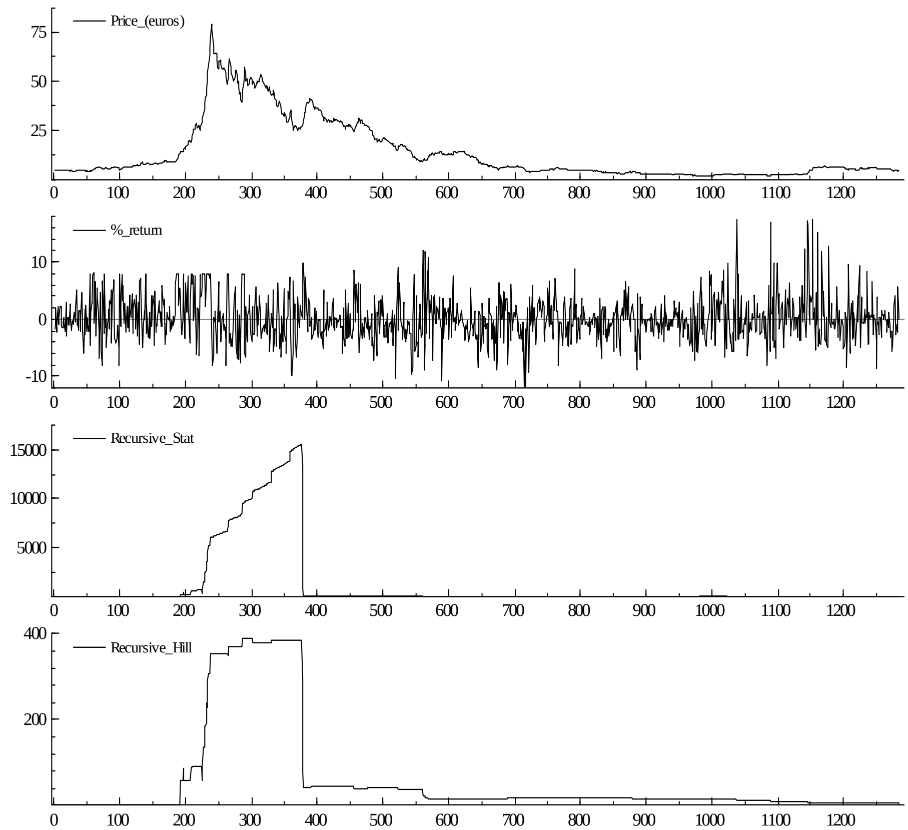

Figure 5. DOL stock. Details for the right tail recursive statistic.

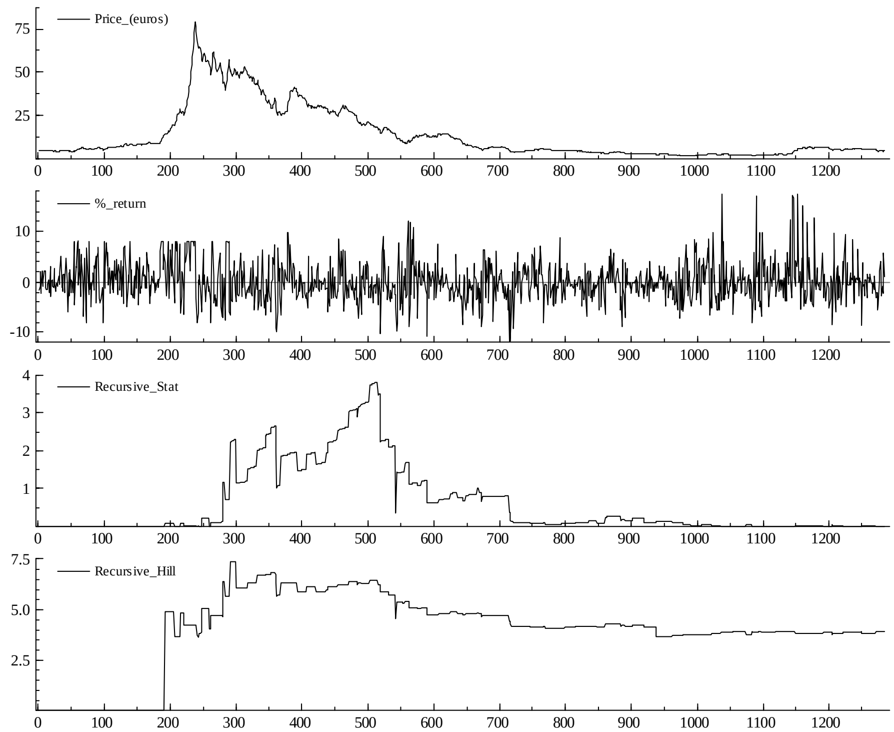

Figure 6. DOL stock. Details for the left tail recursive statistic.

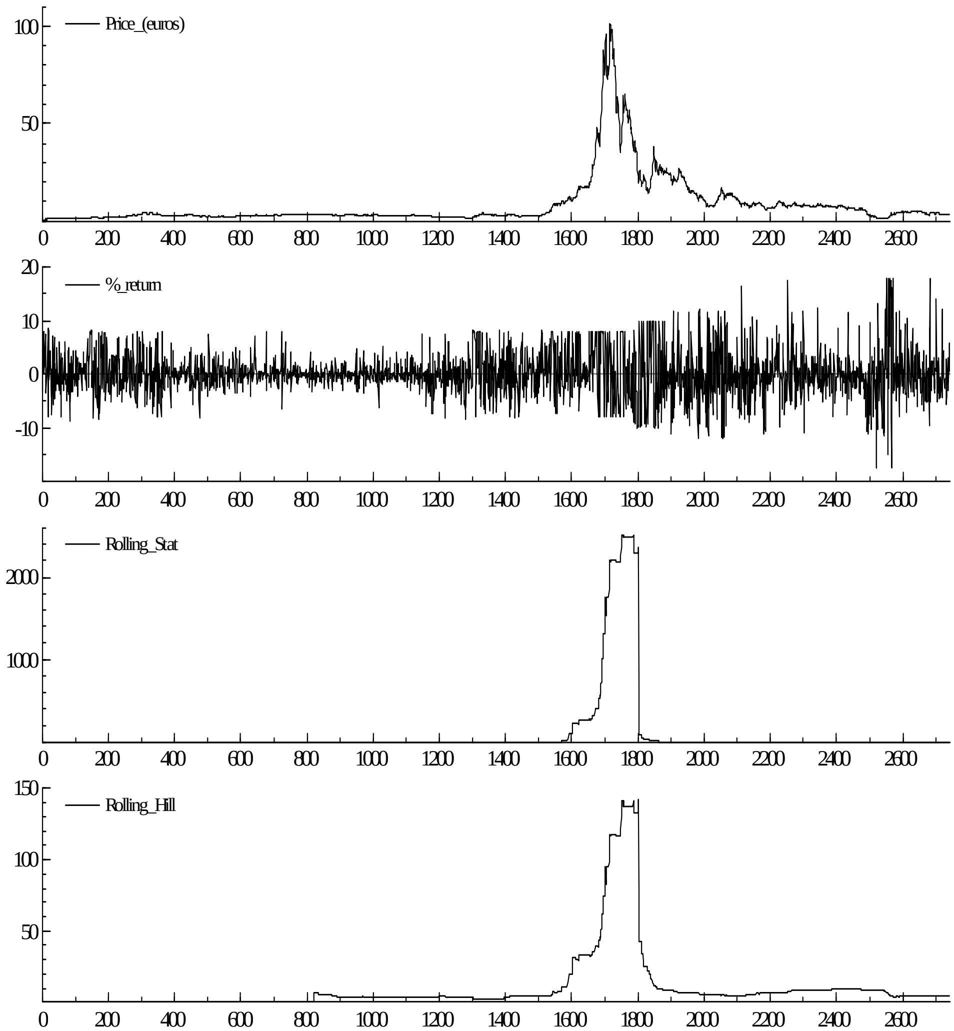

Figure 7. KLONK stock. Details for the right tail rolling statistic.

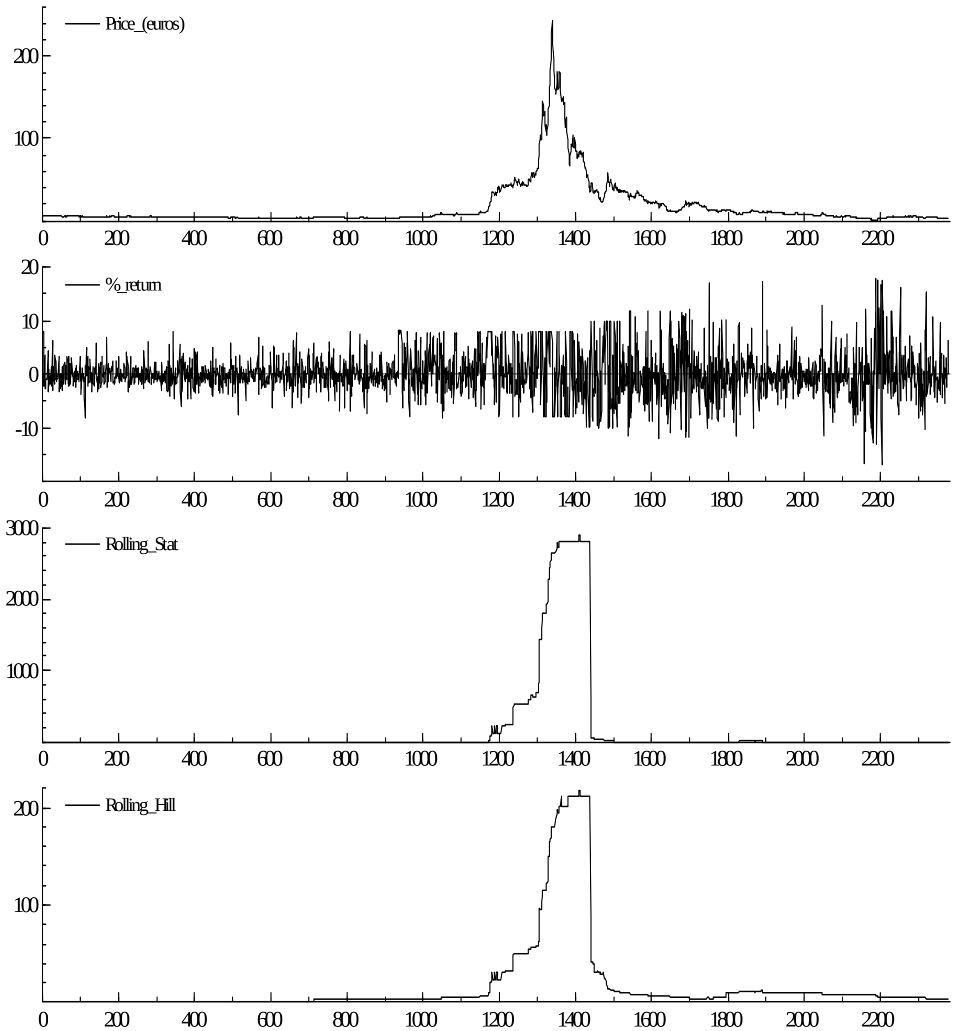

Figure 8. NAOYK stock. Details for the right tail rolling statistic.

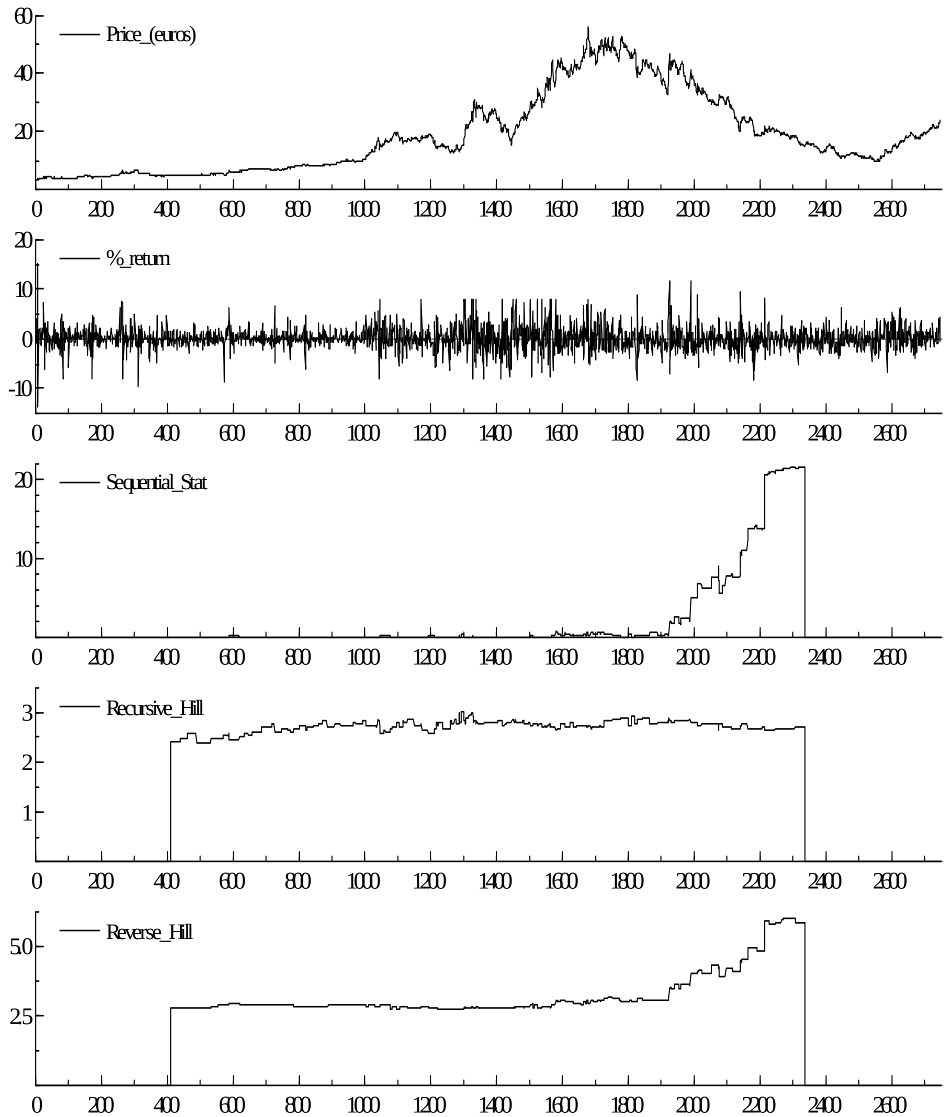

Figure 9. ALPHA stock. Details regarding sequential statistic for the right tail.

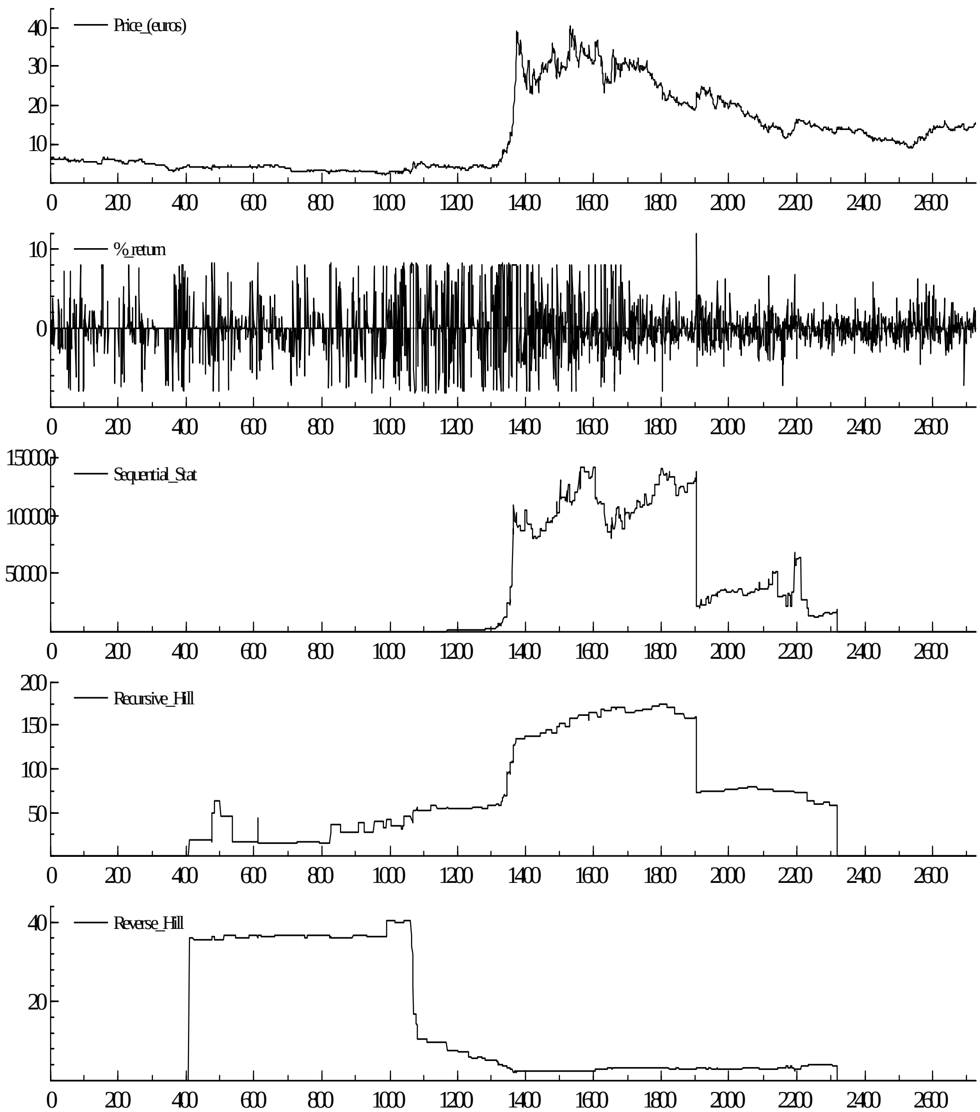

Figure 10. EUROB stock. Details regarding sequential statistic for the right tail.

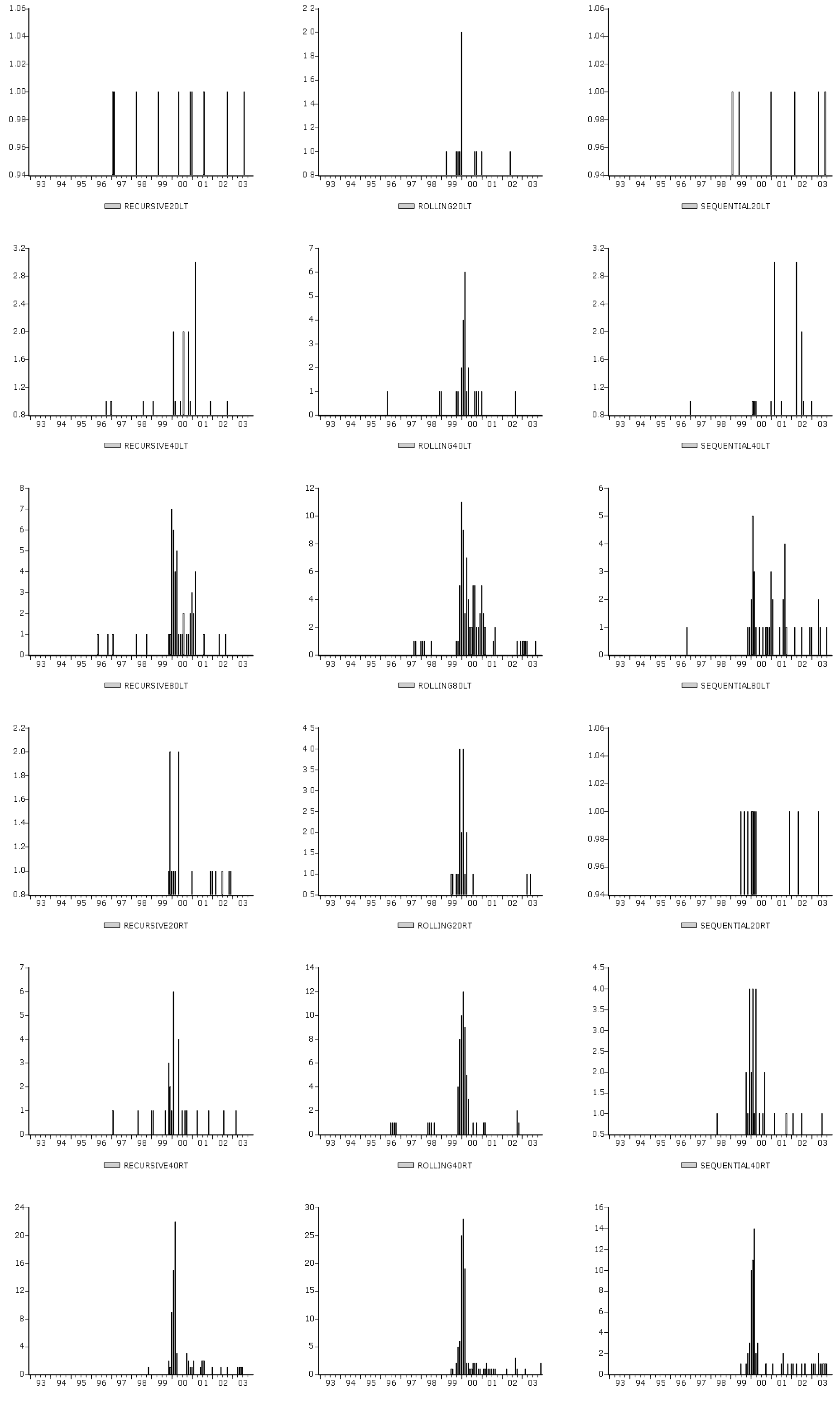

Figure 11. Concentration of break dates. Vertical axis measures number of firms. Horizontal axis measures date 01/93 - 12/03.

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