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An Analysis of Skewness and Skewness Persistence in Three Emerging Markets
by

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Abstract

This paper reports an investigation into the extent and persistence of skewness in stock returns in three emerging markets, namely The Czech Republic, Kenya and Poland. Thee study is undertaken using the extended skew normal distribution and an asymmetric version of the generalised error distribution. The motivation for this paper is the hypothesis that skewness is a particular feature of returns in emerging markets; it may lack persistence and may decline in absolute terms as time passes and the market matures. When daily returns are considered, the majority of stocks in all three markets exhibit a significant degree of skewness. The value of the skewness parameter is often different in each of the three estimation periods considered. Little evidence has been found to support the view that skewness is an artifact of emerging or evolving markets. Over the period covered by the study, the number of stocks with a significant degree of skewness has remained more or less the same. For weekly returns, the same conclusions apply to The Czech Republic and to Kenya, but there is far less evidence of skewness in weekly returns on Polish Stocks.

Keywords: Emerging market, generalised error distribution, skew normal distribution, skewness, skewness persistence.

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1. Introduction

The aim of this paper is to investigate the extent and persistence of skewness in stock returns in three emerging markets. This study is undertaken using the extended skew normal distribution, which was originally popularized by Azzalini and his co-workers (see for example Azzalini, 1985, 1986) and an asymmetric version of the generalised error distribution. The markets covered in this study are The Czech Republic, Kenya and Poland.

The motivation for this paper is threefold. First, it is well known that returns are not normally distributed and that, in addition to fat-tails, there is substantial empirical evidence that stock returns can exhibit skewness. Secondly, it may be the case the skewness is a particular feature of returns in emerging markets; reflecting perhaps a degree of inefficiency as well as the effects of rapid growth of the capital markets in such countries. Thirdly, the association of asymmetric returns with growth and development of markets conforms, if true, with the idea that skewness does not persist in the long term: it is essentially a transient phenomenon.

It is generally accepted in the literature that there are two ways of dealing with non-normality of asset returns. The first is to consider the issues that arise from the perspective of portfolio selection and, as a consequence, to make changes to the investor's utility function. This generally involves adding components that reflect the higher moments under consideration into the standard quadratic utility function. The second approach is to employ a suitable model for the probability distribution of asset returns. In this paper the second approach is followed. This is because the aim of the work reported here is to estimate skewness and to study the extent of persistence and not to carry out portfolio selection. The latter may be the subject of a future study.

The structure of this paper is as follows. Section 2 contains a review of the literature. Section 3 describes relevant properties of the two probability distributions and the data that are use in this study. Section 4 describes the study of Poland in some detail. Section 5 outlines the corresponding results for the Czech Republic and for Kenya and provides some aggregated results for all three markets together. Section 6 concludes. Notation is that in common use. In keeping with increasingly common practice only the main results are present in the paper. More detailed results are available as a separate appendix from the corresponding author.

2. Literature Review

There is much consideration of skewness in asset pricing in the literature. By contrast however, there is relatively little consideration of the persistence of skewness. It appears that this is due to a general belief that the third moment of asset returns is transient. Furthermore, it appears to be the case that the lower the frequency of observation the less likely that the return series will exhibit significant skewness. The sensitivity of skewness to sample size, time period of considerai0on and frequency of measurement interval is shown in Fogler and Radcliffe(1974).

Lau & Wingender(1989) show that skewness will tend towards zero as the intervaling period increases for log-returns.

One of the first studies of fitting an asymmetric distribution to stock data was the use of a mixture of normal distributions by Kon(1984). He found that a mixture of three or four normal distributions gave a better fit than the Student distribution for 18 years of daily returns on US stocks. This result is described in Bookstaber and McDonald(1987), using a generalised beta distribution, and Affleck-Graves and McDonald(1989), testing multivariate normality. In these papers, daily and weekly returns are shown to exhibit both skewness and kurtosis, whereas monthly and annual returns show a smaller deviation from normality. Several authors have used the generalised skew student or GST distribution to model returns on financial assets. Examples are studies by McDonald and Newey(1988), McDonald and Nelson(1989), McDonald and Xu(1995), Theodossiou(1998) and Harris et al(2004).

Fielitz and Smith(1972) and Fielitz(1976) use asymmetric variants of the stable distribution. Both papers find that there is significant skewness when using these distributions to fit daily returns for stocks traded on the New York Stock Exchange. The authors note that one of the most problematic issues when considering non-normal stable distributions is infinite variance and higher moments. As pointed out in Beedles and Simkowitz(1980), this leads to erratic sample sensitive measures of skewness. Lambert and Lindley(1999) use a stable asymmetric distribution to examine daily returns on Abbey National Stock during the summer of 1991. They find that the distribution provides a significantly superior fit to the normal and symmetric stable distributions. Furthermore, they find that the skewness parameter changes over the period considered from positive to negative. However, it should be noted that with such a short sample the conclusions drawn should be treated with some caution. Badrinath and Chatterjee(1988) and Mills(1995) use the so-called Tukey g x h distribution, which accounts for both skewness and kurtosis. Using this model, the return distribution for the UK FTSE100 is seen to have a heavier left tail and the CRSP market portfolio a heavier right tail. In both cases, the tails are significantly heavier than those exhibited by the corresponding normal distribution.

Using conditional skewness measures, Harvey and Siddique(1997) consider a discount factor which is quadratic in the market return. This gives rise to a relationship between the expected excess return on individual assets and (i) the covariance with the market return and (ii) the conditional coskewness with the market return. Omitting the time subscript for simplicity, this allows the conditional three moment CAPM to be written as:

$$E\left(\tilde{R}_i\right) = \beta_i E\left(\tilde{R}_M\right) + \gamma_i E\left(\tilde{R}_M^2\right).$$

In this notation, the variables $\tilde{R}_{i,m}$ denote respectively the excess return on stock i and the market index. The parameters β_i and γ_i are functions of the variance, skewness, covariance and co-skewness of the market and asset as appropriate. The results suggest that there is a premium for systematic skewness and that co-skewness with the market can explain a part of the cross-sectional variation of asset returns. An associated paper (Harvey and Siddique, 1999) considers the autoregressive conditional skewness, which is an extension to the GARCH framework. Using the GARCHS framework they demonstrate, as earlier studies have found, that the dynamics of the various moments are linked to the frequency and aggregation of the return series.

A number of authors have considered the persistence of skewness over time and dependence on the frequency of the data. In a notable paper, Singleton and Wingender(1986) consider the persistence of skewness using monthly returns data for the period 1961-80. They find that positively skewed assets are as likely to exhibit negative skewness in the next period as positive and vice versa. Using Spearman's rank order correlation test, the relationship between current and future skewness was found to be weak and statistically insignificant. Furthermore, they found that when assets are combined in portfolios skewness is generally reduced. However, Lau et el(1989) argue that the estimates used a random variables and that it is possible for the sample values to show evidence of change even when the population values remain constant.

Beedles(1979) considers the impact of the definition of return and the sample period on the skewness measures on monthly data over the period 1927-1976. He finds that the estimates of skewness are persistently significant. However, he also reports that they are not necessarily stationary; that is they are not constant in time. Muralidhar(1993) and De Fusco et al(1996) apply bootstrap methods to US stocks. They report that skewness does not persist. However, the lack persistence of skewness does not mean that it is impossible to exploit the third moment for portfolio selection. Adcock(2005), Chunhachinda et al(1997) and Sun and Yan(2003) report comprehensive studies in which skewness is incorporated in portfolio selection.

In a study of emerging markets, Bekaert et al(1998) draw attention to the hypothesis that skewness and kurtosis may be time varying. An explanation for such temporal variation is that these forms of non-normality are artifacts of the process of emergence. An implication of this hypothesis, if correct, is that incidence of significant values of these moments will decrease as time progresses.

To summarise: several models for the probability distribution of returns have been used by various authors to estimate skewness; there is evidence that estimated skewness is not constant; and there are good reason *a priori* to hypothesise that skewness may diminish in magnitude as a market develops.

3. Models and Data

In this paper two models are used to describe the probability distribution of returns. The first is the extended version of the skew normal distribution. The second is an asymmetric version of the generalised error distribution. Relevant properties of each of these distributions are described in this section. As the aim of the work reported in this paper is to investigate skewness of individual stocks, univariate distributions are used. The first model is used both because of its tractability and because of a growing body of evidence that suggests that it can provide useful empirical insights. The second model is better established in the literature. It is more flexible in its parameterization, even though this comes with a loss of tractability.

The skew normal distribution was first reported by Del Helguero(1908), and subsequently by Roberts(1966) and O'Hagan and Leonard(1976). Its properties have been comprehensively described in papers by Azzalini and his co-workers, see for example Azzalini(1985, 1986). There is an up to date summary in Genton(2004). The standard form of skew normal distribution is obtained by considering the distribution of a random variable R say, which is defined as:

$$R = U + \lambda V$$

The first variable U has a normal distribution with mean μ and variance σ^2. The second variable V is distributed independently of U and has a standard normal distribution that is truncated below at zero. The skewness parameter λ may take any real value. This model is generally attractive for applications in finance because it has a tractable multivariate representation. Harvey et al(2002) apply the multivariate model to returns on US stocks. Adcock and Shutes(2001), who were the first to use the distribution in finance, propose a generalisation of the model. The variables R and U are as defined as above. The variable V has a normal distribution with mean τ and variance 1 truncated below at zero. This modification generates a richer family of probability distributions and, in particular, gives more flexibility in modelling skewness and kurtosis. Following Shutes(2005), this is referred to as the extended skew normal distribution.

The probability distribution of univariate extended skew normal distribution, henceforth ESN distribution, has a density function given by:

$$f(r) = n(r, \mu + \lambda\tau, \sigma^2 + \lambda^2)\frac{\Phi[\upsilon]}{\Phi[\tau]}; \qquad (1.)$$

where:

$$\upsilon = \frac{\tau + \frac{\lambda}{\sigma^2}(r - \mu)}{\sqrt{1 + \frac{\lambda^2}{\sigma^2}}}; \qquad (2.)$$

and where $\Phi(x)$ is the standard normal distribution function evaluated at x. The notation $n(x, \omega, \eta^2)$ denotes the probability density function, evaluated at x, of a normal distribution with mean ω and variance η^2. Moments of all orders exist.

When $\lambda = 0$ the model reverts to the normal distribution $N(\mu,\sigma^2)$ regardless of the value of τ.

The second model used in this paper is the asymmetric version of the generalised error distribution, henceforth GED. The probability distribution has a density function given by:

$$f(r) \begin{cases} = \dfrac{K}{2^{1+\frac{1}{\omega_1}}\sigma_1\Gamma(\omega_1)} e^{-\frac{|r-\mu|^{\omega_1}}{2\sigma_1^{\omega_1}}}, r < 0 \\ ; \\ = \dfrac{K}{2^{1+\frac{1}{\omega_2}}\sigma_2\Gamma(\omega_2)} e^{-\frac{|r-\mu|^{\omega_2}}{2\sigma_2^{\omega_2}}}, r \geq 0 \end{cases} \quad (3.)$$

where K is the normalizing constant. Variation of any of the parameters $\omega_{1,2}$ and $\sigma_{1,2}$ generates different types of skewness. Three cases are considered, as follows:

GED–1 in which $\omega_1 = \omega_2$ and $\sigma_1 = \sigma_2$. This version of the model imposes symmetry but allows for non-normality because ω is a parameter to be estimated rather than being set equal to 2 in which case the GED is identical to the normal.

GED–2 in which the $\omega_1 = \omega_2$ but $\sigma_{1,2}$ are unrestricted. This forces departures from normality to be described solely by asymmetry in the values of the scaling parameter σ.

GED-3 in which all parameters are unrestricted.

This model is similar in spirit to the generalised skew student or GST distribution, which has been applied to returns on financial assets by several authors, including for example McDonald and Newey(1988), McDonald and Nelson(1989), McDonald and Xu(1995), Theodossiou(1998) and Harris et al(2004). The GED distribution arises as a special case of the GST as the parameter, which is analogous to degrees of freedom, tends to infinity. The GED model is used in this paper because of the focus on skewness. For further details of this distribution, see Nelson(1991).

In both the ESN and GED models, the parameter μ is not in general equal to the mean of the distribution. Accordingly, the models are referred to as location parameter models. In the empirical study described in section 4, the location parameter model is estimated for all securities including the market index. If μ is replaced by a scalar quantity of the form (and in the usual notation) $\mathbf{x}^T\boldsymbol{\beta}$ then each distribution may be used to estimate linear regression models in which the error term has either an ESN or GED distribution. In this paper, in addition to the location parameter model, two forms of the market model are estimated. The first takes the form:

$$\tilde{R}_i = \alpha_i + \beta_i \tilde{R}_m + \varepsilon_i ; \qquad (4.)$$

where the variables $\tilde{R}_{i,m}$ denote respectively the excess return on stock i and the market index; that is total return minus the risk free return. The unobserved residual term ε_i follows either of the distributions defined at equations (1.) and (3.) with location parameter set equal to zero. The form of market model with an intercept is preferred because there is no reason a priori to assume that the market in index is mean variance efficient portfolio. In this case, exclusion of the intercept would result in a specification error.

The motivation for estimating the model at (4.) is the hypothesis that skewness in stock returns is accounted for solely by the skewness of the market and that the residual return ε_i is normally or at least symmetrically distributed. This hypothesis conflicts with the findings reported by Singleton and Wingender(1986) namely that individual stocks may exhibit skewness, but that this is diversified away in the market index. However, the hypothesis is supported by theoretical considerations of the skew normal distribution itself. When returns on all stocks follow the multivariate form of the extended skew normal distribution as defined in Adcock and Shutes(2001), the regression model defined at (4.) represents the conditional distribution of $\tilde{R}_i$ given $\tilde{R}_m$. The properties of this distribution are described in detail in Adcock(2004). In particular, it may be shown that the residuals ε_I may continue to exhibit skewness even though the return on the market index does not, that is returns on the market index are normally distributed.

The second model draws on the work of Harvey and Siddique(1997) and includes a quadratic term:

$$\tilde{R}_i = \alpha_i + \beta_i \tilde{R}_m + \gamma_i \tilde{R}_m^2 + \varepsilon_i ; \qquad (5.)$$

The motivation for this model is that the term in $\tilde{R}_m^2$ may account for skewness in returns. In this case, in the context of the models specified above, this would leave estimated residuals, which either have a normal or a GED-1 distribution.

The parameters of all models are estimated using the method of maximum likelihood. Each model is compared to corresponding normal distribution using a likelihood ratio test. In general, it is appropriate to regard the likelihood ratio test as a general test of one model against another. In the case of the extended skew normal distribution, it is equivalent to a test of the skewness parameter λ. This is because when $\lambda = 0$ all terms involving τ vanish from the likelihood function.

The data used in this study consists of daily and weekly prices of the constituent stocks in the main index in each of the three countries covered in the study. The names of the indexes, the number of constituent stocks used in the study and the date on which data was downloaded are summarised in table 1. All data came from Datastream and all prices are in local currency. They were converted to returns in the usual way by taking logarithms. For the analysis of daily returns for The Czech Republic and Poland the risk free rate was taken to be a suitable overnight rate. For the weekly analyses for the same markets, a weekly rate was used. For the analysis of Kenya, appropriate daily and weekly values of the same risk free rate were used.

For the analysis based on daily data, 500 observations (that is approximately two years) were used. To facilitate the investigation of skewness persistence, every model was estimated using three consecutive but non-overlapping blocks each of 500 days duration. For the analysis of weekly returns three consecutive but non-overlapping blocks each of 100 observations were used, thus also giving estimation windows of about two year's duration. Stocks which did not have valid returns data for 1500 (equivalently 300 weeks) days were excluded from the analysis. In the case of the Czech market, it was also necessary to exclude some other stocks for which price changes are infrequent. The number of stocks which were available for analysis in each market is listed in table 1. The omission of stocks which did not have the requisite number of useful observations available means that the finding of this study are restricted those securities stocks which have been constituents of their respective indices for at least six years. The issue of an appropriate model that will deal with thin trading is also a topic for future work.

Table 1 about here

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4. Empirical Study of Poland

This section of the paper reports the results of the study of skewness in Polish stocks returns. As noted in the introduction, this is done in some detail. The main corresponding findings for The Czech Republic and Kenya are reported briefly in the next section.

Table 2 shows a summary of the results of fitting the location parameter model to daily returns in each of the three 500 day estimation windows. The summary is based on an analysis of the p-values for the likelihood ratio tests computed for each model. The table shows three panels, corresponding to the three estimation windows used.

Table 2 about here

The table suggests that the symmetric generalised error distribution (GED-1) does not offer any improvement in fit compared to the normal distribution even though its parameterisation allows it to capture non-normality. This is because in all three estimation periods the majority of stocks have a p-value which is greater than 10%. For the two later periods, the GED-1 model only gives a p-value of better than 1% for one stock. The skewed versions of the generalised error distribution (GED-2,3) offer a significant improvement in fit, that is a p-value of 5% or better, in about 50% of cases in the first two periods but offer little or no improvements in period 3. In all periods, the fit of the three models based on the GED distribution is inferior to that of the extended skew normal. The rest of the analysis reported in this paper is therefore based on the extended skew normal distribution.

Table 3 shows a summary of the standardized sample values of skewness and of the estimates produced by the extended skew normal distribution. Individual stocks are listed in alphabetical order of name as defined by Datastream. For convenience, the index is listed last. Each estimation period is covered separately. The three estimation periods, which cover 1999-2001, 2001-2003 and 2003-2005 are referred to in subsequent tables as A, B and C respectively.

The standardized sample statistics are computed in the usual way and expressed as a Z statistic defined as:

$$Z = \sqrt{\frac{T}{6}}\,\frac{\dfrac{\sum_{t=1}^{T}\left(R_t - \overline{R}\right)^3}{T-1}}{S^3}$$

where S is the corresponding sample volatility. Each probability shown in table 3 is computed as a tail value, that is for a given value $z \geq 0$ it is $P[Z \geq z]$ and for $z < 0$ it is $P[Z < z]$. As the table shows, the sample characteristics of skewness of daily returns on the stocks in the WIG20 index is varied. There are several stocks which exhibit skewness throughout all three estimation periods. There are those for which skewness exhibits changes, which can be of both sign and magnitude. The index itself exhibits a significant degree of skewness in only one out of the three periods.

Table3 about here

Table 3 shows that the results from using the ESN model are comparable in general terms with the use of the standardized sample values. However, there are differences. The most notable are (a) that the ESN model appears to increase the level of significance of stocks for which the magnitude of estimated skewness is high but conversely (b) it appears to reduce it for those stocks the magnitude of estimated skewness is low. Daily returns on the market index exhibit a significant degree of skewness only in period B. This lends some support to the finding of Singleton and Wingender(1986), namely that individual stocks may exhibit skewness, but that this may be diversified away in a suitable portfolio.

Table 4 shows two three by three contingency tables. In this table, the values of the estimated skewness parameter in the ESN model shown in table 3 are categorised as being positive or negative if the tail probability is less than or equal to 5%. Otherwise they are categorized as neutral. The contingency tables in the two panels in table 4 are formed by comparing the values at the ends of (i) periods A and B and (ii) periods B and C respectively. The rows of panel (i) [(ii)] represent the situation at the end of period A [B] and the columns of panel (i) [ii] represent the situation at the end of period B [C].

Table 4 about here

The data in both panels suggests that there is a considerable a degree of dynamic change in estimated skewness. That is: skewness is not persistent and in general it changes from period to period. For example, at the end of period A 53% of stocks exhibited positive skewness. At the end of period B, 62% of these continued to show positive skewness, 25% were neutral and 13% showed negative skewness. As noted in the literature review, the efficient markets hypothesis implies that skewness is transient. This may be interpreted in two ways. First, the skewness of individual stocks may change from period to period. Secondly, if skewness is a feature of an emerging or evolving market, it may die away altogether. Although this study has covered a short period in calendar time and a small number of stocks, the table confirms the first aspect of persistence. There is evidence that skewness changes from period to period. However, there is also some evidence to support the hypothesis that skewness is a transient phenomenon *per se*. At the end of period A, 80% of stocks exhibited a significant degree of skewness. At the end of period C, the corresponding percentage was 67.

The small size of the sample precludes use of standard tests of significance. However, it may be noted that the standard Chi-test test of association fails to achieve significance. It may also be noted that the rank correlations between the ordering of the estimated skewness parameters in successive periods is low, never larger than 35%. Similar contingency tables were computed using the standardized sample skewness measures shown in table 3. A bootstrap simulation was also conducted using the daily returns data. The details of these analyses are omitted. In brief, they both confirm the implications of table 4; namely that skewness changes from period to period and that there is some evidence of a decline in the number of stocks with significantly skewed returns.

Two similar analyses were carried out using the linear and quadratic market models defined at equations (5) and (6.) respectively. The findings are generally similar to those reported above. The ESN model provides a superior fit when compared with the GED or normal distributions. The evidence from the corresponding contingency tables supports the finding that the estimated skewness of stocks changes from period to period. However, the analysis of estimated skewness from both versions of market model does not support the view that the overall incidence of a significant skewness is diminishing. For both versions of the market model, the number of stocks which exhibited a significant degree of skewness was the same at the ends of both periods A and C. Details of these results are available as a separate appendix on request.

The analyses were repeated for weekly data using three periods each of 100 weeks. The findings are summarised in the two contingency tables in table 5.

Table 5 about here

As the table shows, the majority of stocks do not exhibit skewness when weekly returns are considered. That is, in the majority of cases neither the GED nor the ESN models offer a significant in fit when compared to the normal distribution. For the minority of stocks whose weekly returns do exhibit skewness, it is clear that the phenomenon is not persistent. For example in panel (i) of table 5, all stocks with significant skewness at the end of period A had neutral skewness at the end of period B. There is some evidence to suggest that the number of stocks that exhibits skewness has increased. At the end of period A, 20% of stocks had significant skewness. At then end of period C, this percentage had increased to 27. However, this evidence is based on a small number of stocks and should therefore be interpreted with caution.

5. The Czech Republic Kenya and All Three Markets

The same analysis reported in section 4 was also carried out The Czech Republic and Kenya. Details of these results are also available as a separate appendix on request. The main findings are as follows

For the location parameter model for daily returns both countries, all three versions of the GED distribution and the ESN distributions offer a significant improvement in fit over the normal distribution in all three estimation periods. Formal comparison of the GED models with the ESN is beyond the scope of this paper, but the fact that all three are superior to the normal is taken as evidence that skewness in returns is a well-established feature of daily returns. However, as noted in section 3, this may be a consequence of infrequent trading. In contrast to the results for Poland, according to the ESN model the market indices for both countries generally exhibit a significant degree of skewness. The only exception is period A for The Czech Republic. The commentary that follows and the entries in table 6 are based on estimates of skewness from the ESN distribution.

Table 6 about here

Table 6 shows the contingency tables for the estimated skewness parameters for daily returns from the location parameter model for The Czech Republic and Kenya. Both panels of both parts of the table confirm that there is substantial dynamics in the estimated skewness of Czech and Kenyan stocks. In Kenya, every stock in the study has an estimated skewness that is significantly different from zero in all three estimation periods. There is no evidence that the incidence of skewness is declining in the Czech Republic. At the end of period A, 73% of stocks exhibited a significant degree of skewness. At the end of period C, the corresponding figure was 93%. There are similar findings for daily returns for both markets and for both versions of the market model.

Table 7 about here

For weekly returns, the findings are different from those for comparable data for Poland. Indeed the findings for both The Czech Republic and for Kenya are similar to those for the corresponding daily returns. All three versions of the GED distribution and the ESN distributions offer a significant improvement in fit over the normal distribution in all three estimation periods. According to the ESN model the weekly returns on both market indices generally exhibit a significant degree of skewness. Table 7 shows the contingency tables for the estimated skewness parameters for weekly returns from the location parameter model for The Czech Republic and Kenya. Both panels of both parts of the table confirm that there is substantial dynamics in the estimated skewness of Czech and Kenyan stocks. Overall, there are stocks in both markets, which do not exhibit skewness. For the Czech republic there is no evidence that the incidence of skewness in weekly returns is diminishing. In Kenya, however, there is some evidence to support the contention that skewness in weekly returns is becoming less of a factor, although it is still significant for over 70% of the stocks considered. There are similar findings for both versions of the market model.

Table 8 shows two contingency tables. These have been formed by aggregating the corresponding tables for the location parameter models for daily returns for all three countries covered in the study.

Table 8 about here

This table confirms the extent of the dynamics of skewness but also suggests that in aggregate terms the percentages of daily return which exhibit significant skewness has remained broadly constant over the study period.

6. Conclusions

The main conclusions of this study are as follows. When daily returns are considered, the majority of stocks in all three markets included in the study exhibit a significant degree of skewness. The value of the skewness parameter is often different in each of the three estimation periods. This therefore supports the view expressed in the literature that skewness does not persist. To the contrary, it changes. However, little evidence has been found to support the view that skewness is an artifact of emerging or evolving markets. Over the period covered by the study, the number of stocks with a significant degree of skewness has remained more or less the same in The Czech Republic and Kenya. There evidence that the number of significantly skewed stocks is declining in Poland is equivocal.

For Weekly returns, the conclusions above also apply to The Czech Republic and to Kenya. By contrast, there is far less evidence of skewness in weekly returns on Polish Stocks.

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Table 1 – Summary of Stock Data Used in the Study

Country	Name of Index	Date of download	No. of stocks used in the study
Czech Republic	Datastream index	3rd May 2005	15
Kenya	Nairobi SE index	4th April 2005	18
Poland	WIG20 Index	4th April 2005	15

Table 2 – Comparative Analysis of Probabilities from the Likelihood Ratio Tests of the 4 models

Analysis of model probabilities

Model	<1%	1-5%	5-10%	>10%
Panel (i) period to 4th June 2001				
GED – 1	3	2	2	8
GED – 2	5	2	3	5
GED – 3	4	2	1	8
ESN	10	2	0	3
Panel (ii) period to 5th May 2003				
GED – 1	1	2	1	11
GED – 2	5	1	2	7
GED – 3	6	1	0	8
ESN	10	2	1	2
Panel (iii) period to 5th April 2005				
GED – 1	1	2	0	12
GED – 2	2	0	3	10
GED – 3	2	0	1	12
ESN	7	3	0	5

The table shows a summary of the results of fitting the location parameter model to daily returns in each of the three 500 day estimation windows. The summary is based on an analysis of the p-values for the likelihood ratio tests computed for each model. The table shows three panels, corresponding to the three estimation windows used. The abbreviations GED-1,2,3 and ESN refer to the three probability distributions defined in section 3 of the paper.

Table 3 - Summary of Sample Skewness and Corresponding Tail Probabilities for Daily Returns on Polish Stocks

The table entries are rounded to two decimal places.

	Period to 4th June 2001		Period to 5th May 2003		Period to 4th April 2005	
Stock	Skewness	Probability	Skewness	Probability	Skewness	Probability
Panel (i)	**Sample statistics**					
AGORA	1.06	14.45	5.92	0.00	1.13	12.88
BANK-BPH	-3.33	0.04	-0.17	43.18	-2.26	1.20
BRE-BANK	1.57	5.84	-6.91	0.00	3.29	0.05
COMPUTERLAND-POLAND	4.75	0.00	4.97	0.00	3.81	0.01
DEBICA	3.24	0.06	4.62	0.00	-0.95	17.15
KETY	-3.85	0.01	-4.48	0.00	-2.45	0.71
KGHM	5.60	0.00	-1.20	11.45	-1.12	13.17
ORBIS	2.07	1.94	2.59	0.48	1.77	3.82
PEKAO	3.12	0.09	0.16	43.67	3.27	0.05
PROKOM-SOFTWARE	3.50	0.02	1.99	2.32	0.60	27.56
SOFTBANK	-0.27	39.19	-9.11	0.00	4.12	0.00
STALEXPORT	-7.48	0.00	11.13	0.00	1.10	13.67
SWIECIE	-45.37	0.00	-1.25	10.63	-0.88	18.99
TELEKOMUNIKACJA-POLSKA	1.40	8.13	3.05	0.12	1.49	6.83
POLWG20	-1.27	10.22	4.07	0.00	1.22	11.21
Panel (ii)	**Based on extended skew normal distribution**					
AGORA	0.08	0.74	0.05	0.00	0.04	2.50
BANK-BPH	-0.07	0.01	-0.01	83.57	-0.02	3.02
BRE-BANK	0.04	4.13	-0.07	0.00	0.05	0.01
COMPUTERLAND-POLAND	0.11	0.00	0.04	0.00	0.03	0.01
DEBICA	0.03	0.21	0.03	0.00	-0.03	0.66
KETY	-0.07	0.00	-0.02	0.00	-0.02	1.05
KGHM	0.08	0.00	-0.04	5.30	-0.02	23.52
ORBIS	0.03	2.36	0.03	1.07	0.02	10.02
PEKAO	0.09	0.02	0.01	73.89	0.05	0.09
PROKOM-SOFTWARE	0.12	0.00	0.04	2.48	0.02	40.63
SOFTBANK	-0.02	67.99	-0.16	0.00	0.06	0.00
STALEXPORT	-0.14	0.00	0.24	0.00	0.24	0.00
SWIECIE	-0.22	0.00	-0.06	0.00	-0.04	0.89
TELEKOMUNIKACJA-POLSKA	0.03	24.71	0.04	0.62	0.02	24.31
POLWG20	-0.02	12.97	0.03	0.01	0.01	22.65

Stock names are as used by Datastream. In panel (i) skewness is the standardized sample value, expressed as a Z statistic. The percentage probability shown is computed as a tail probability, ie for $z \geq 0$ it is $P[Z \geq z]$ and for $z < 0$ it is $P[Z < z]$ and is rounded to two decimal places. In panel (ii) the values of skewness shown are estimates based on the of extended skew normal (ESN) location model. Each of the three periods is 500 days.

Table 4 – Contingency Tables Showing the Dynamics of Sample Skewness for Daily Returns on Polish Stocks

The table entries are relative frequencies expressed as a percentage, rounded to two decimal places. The table entries are based on the location parameter model.

		positive	neutral	Negative	Totals
Panel (i)	Period A versus period B				
	Positive	33.33	13.33	6.67	53.33
	Neutral	13.33	0	6.67	20
	Negative	6.67	6.67	13.33	26.67
	Totals	53.33	20	26.67	100.00
Panel (ii)	Period B versus period C				
	Positive	20	26.67	6.67	53.33
	Neutral	6.67	6.67	6.67	20
	Negative	13.33	0	13.33	26.67
	Totals	40	33.33	26.67	100.00

The frequencies shown in the table are based on the estimated values of skewness shown in panel (ii) of table 3. Skewness is taken to be positive(negative) if the estimated value is positive(negative) and the associated tail probability is less than 5%. Stocks which do not fall in either category are classified as neutral. The row totals represent the situation at the end of periods A and B, the column totals represent the situation at the end of periods B and C.

Table 5 – Contingency Tables Showing the Dynamics of Sample Skewness for Weekly Returns on Polish Stocks

The table entries are relative frequencies expressed as a percentage, rounded to two decimal places. The table entries are based on the location parameter model.

		positive	neutral	Negative	totals
Panel (i)	Period A versus period B				
	positive	0	6.67	0	6.67
	Neutral	13.33	53.33	13.33	80
	negative	0	13.33	0	13.33
	Totals	13.33	73.33	13.33	100.00
Panel (ii)	Period B versus period C				
	positive	6.67	6.67	0	13.33
	Neutral	13.33	53.33	6.67	73.33
	negative	0	13.33	0	13.33
	Totals	20	73.33	6.67	100.00

The frequencies shown in the table are based on the estimated values of skewness for weekly returns. Skewness is taken to be positive(negative) if the estimated value is positive(negative) and the associated tail probability is less than 5%. Stocks which do not fall in either category are classified as neutral. The row totals represent the situation at the end of periods A and B, the column totals represent the situation at the end of periods B and C.

Table 6 – Contingency Tables Showing the Dynamics of Sample Skewness for Daily Returns on Stocks From the Czech Republic and Kenya

The table entries are relative frequencies expressed as a percentage, rounded to two decimal places. The table entries are based on the location parameter model.

		positive	neutral	Negative	totals
Part I	The Czech Republic				
Panel (i)	Period A versus period B				
	positive	26.67	0	20	46.67
	neutral	13.33	6.67	6.67	26.67
	negative	13.33	6.67	6.67	26.67
	totals	53.33	13.33	33.33	100.00
Panel (ii)	Period B versus period C				
	positive	40	0	13.33	53.33
	neutral	0	0	13.33	13.33
	negative	13.33	6.67	13.33	33.33
	totals	53.33	6.67	40	100.00
Part II	Kenya				
Panel (i)	Period A versus period B				
	positive	16.67	0	22.22	38.89
	neutral	0	0	0	0
	negative	33.33	0	27.78	61.11
	totals	50	0	50	100.00
Panel (ii)	Period B versus period C				
	positive	27.78	0	22.22	50
	neutral	0	0	0	0
	negative	33.33	0	16.67	50
	totals	61.11	0	38.89	100.00

The frequencies shown in the table are based on the estimated values of skewness for daily returns. Skewness is taken to be positive(negative) if the estimated value is positive(negative) and the associated tail probability is less than 5%. Stocks which do not fall in either category are classified as neutral. Row and column totals follow the convention used in tables 4 and 5.

Table 7 – Contingency Tables Showing the Dynamics of Sample Skewness for Weekly Returns on Stocks From the Czech Republic and Kenya

The table entries are relative frequencies expressed as a percentage, rounded to two decimal places. The table entries are based on the location parameter model.

		positive	neutral	Negative	totals
Part I	The Czech Republic				
Panel (i)	Period A versus period B				
	positive	17.39	8.7	0	26.09
	neutral	21.74	8.7	21.74	52.17
	negative	17.39	4.35	0	21.74
	totals	56.52	21.74	21.74	100
Panel (ii)	Period B versus period C				
	positive	30.43	8.7	17.39	56.52
	neutral	4.35	8.7	8.7	21.74
	negative	13.04	4.35	4.35	21.74
	totals	47.83	21.74	30.43	100
Part II	Kenya				
Panel (i)	Period A versus period B				
	positive	11.11	0	5.56	16.67
	neutral	0	11.11	0	11.11
	negative	61.11	0	11.11	72.22
	totals	72.22	11.11	16.67	100
					61.11
Panel (ii)	Period B versus period C				
	positive	33.33	22.22	16.67	72.22
	neutral	5.56	0	5.56	11.11
	negative	11.11	5.56	0	16.67
	totals	50	27.78	22.22	100

The frequencies shown in the table are based on the estimated values of skewness for daily returns. Skewness is taken to be positive(negative) if the estimated value is positive(negative) and the associated tail probability is less than 5%. Stocks which do not fall in either category are classified as neutral. Row and column totals follow the convention used in tables 4 and 5.

Table 8 – Contingency Tables Showing the Aggregate Dynamics of Sample Skewness for Daily Returns on Stocks From All Three Markets

The table entries are relative frequencies expressed as a percentage, rounded to two decimal places. The table entries are based on the location parameter model.

		positive	neutral	negative	totals
Panel (i)	Period A versus period B				
	positive	25.00	4.17	16.67	45.83
	neutral	8.33	2.08	4.17	14.58
	negative	18.75	4.17	16.67	39.58
	Totals	52.08	10.42	37.50	100.00
Panel (ii)	Period B versus period C				
	positive	29.17	8.33	14.58	52.08
	neutral	2.08	2.08	6.25	10.42
	negative	20.83	2.08	14.58	37.50
	Totals	52.08	12.50	35.42	100.00

The frequencies shown in the table are based on the estimated values of skewness for daily returns. Skewness is taken to be positive(negative) if the estimated value is positive(negative) and the associated tail probability is less than 5%. Stocks which do not fall in either category are classified as neutral. Row and column totals follow the convention used in tables 4 and 5.