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Abstract

We examine the relation between trading volume and skewness in 6 international stock markets - Britain, France, Germany, Italy, Japan and the United States - using daily data from February 1978 to December 2001. We construct both single equation and VAR models of the relation between the first three moments of market returns and trading volumes. Our results show hitherto unrecognised channels of influence, and are supportive of the investor heterogeneity approach to explaining return asymmetries.

Key Words: International stock markets, Skewness, Volume, VAR.

JEL Classification Codes: C14, F31, G12, G15

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1. Introduction

There is increasing recognition in theoretical and empirical finance that the returns to individual stocks as well as to aggregate stock markets might well exhibit asymmetric behaviour. Two main explanations have been advanced for this. *Representative investor theories* explain asymmetries either by leverage effects, whereby a drop in prices leads to volatility in subsequent returns because of increased operating and financial leverage (Black (1976) and Christie (1982)), by volatility feedback mechanisms whereby volatility raises the risk premium and reduces the impact of good news relative to bad news (French, Schwert and Stambaugh (1987) and Campbell and Hentschel (1992)), and by stochastic bubble models in which the asymmetry is caused by the bursting of the bubble (Blanchard and Watson (1982)). The alternative explanation is to be found in *investor heterogeneity theories*, whereby investors differ in their opinions concerning the fundamental values of stocks (Clark (1973), Epps and Epps (1976), Holthausen and Verrecchia (1990), Harris and Raviv (1993), and Shalen (1993)). This heterogeneity in beliefs is recognised in the microstructure literature to drive the relation between trading volumes and volatility (Tauchen and Pitts (1983)), and it has spawned a substantial literature on the relation between trading volume and the second moment of price changes (see Karpoff (1987) for a review).

Although many studies have investigated the nature, extent and persistence of asymmetries in stock markets, little attention has been paid to the relation between trading volume and the third moment of price changes, that is, to skewness. The exceptions are Chen, Hong and Stein (2001), Hong and Stein (2003), Hueng and Brooks (2003) and Charoenrook and Daouk (2004). Chen, Hong and Stein (2001) examine whether differences of opinion about the future value of stock returns, which cause trading volumes to rise, induce greater skewness in returns. Using firm-level data for the United States from July 1962 to December 1998, they estimate cross section models in which the skewness from 6-monthly non-overlapping observations is regressed on lagged returns and lagged detrended volumes. Consistent with the investor heterogeneity theory, they show how stocks that have experienced higher than average returns and volumes tend to be associated with future negative skewness. When they examine market data, however, they are forced to use overlapping time series, and the relation between volume and skewness disappears. Building on the work of Chen, Hong and Stein (2001), Hueng and Brooks (2003) use a similar dataset to use an asymmetric generalised t-distribution to obtain conditional estimates of the sample skewness. This allows them to estimate their models on non-overlapping daily time series data. They find that although lagged returns and volumes are significant determinants of future skewness, the coefficients are rarely negative. They also find that if the prior return or the current conditional skewness is positive, the effect of prior turnover on skewness can be negative. More recently, Charoenrook and Daouk (2004) use daily market data for 57 countries from January 1973 to December 2002 to estimate both individual country time series models and pooled cross-section time series models of the relation between lagged returns and skewness, between lagged volatility and skewness, and between lagged trading volumes and skewness. They report that lagged positive returns lead to future negative skewness and that lagged negative returns lead to future positive skewness, and they find weak evidence that lagged trend-adjusted volumes lead to more negative skewness. Overall, these studies provide evidence in favour of the investor heterogeneity theory, but they also suggest that the volume–skewness relation might be more complex than is implicitly assumed in the literature to date, involving a possibly wider set of variables and more sophisticated dynamics.

In this paper, we examine the relation between trading volume and skewness in 6 international stock markets (Britain, France, Germany, Italy, Japan and the United States) using daily data from February 1978 to December 2001. We construct single equation models and a vector autoregressive (VAR) model of the relation between the first three moments of market returns and trading volumes. We use unconditional measures of the second and third moments of returns and volumes, and we estimate our models on 287 monthly observations using the general-to-specific estimation strategy together with Newey-West standard errors to correct for any autocorrelation and heteroscedasticity. Our approach constitutes a generalisation of previous specifications because it allows us to examine the full set of possible interactions between the first three moments of trading volumes and market returns. We examine the nature of the volume-volatility relation when allowance is made for possible interaction amongst the third moments. We also examine the existence of indirect mechanisms through which volumes influence skewness by first influencing returns and/or volatility. Finally, we examine the evidence of feedback mechanisms through which market returns, volatility and skewness in turn influence subsequent trading volumes.

Our findings confirm the CHS result that there seems to be no role for trading volume in explaining the skewness of market returns in the United States. We also confirm CHS's finding that lagged returns are significant determinants of skewness in the United States, but contrary to CHS, we find that lagged volatility does significantly explain market skewness. In looking at the other major international stock markets, we confirm a role for trading volumes in explaining the skewness of market returns, and we find significant feedback from returns to trading volumes in 5 of our 6 markets. Overall, our results support the investor heterogeneity approach to explaining return asymmetries, and suggest that more generally specified models are necessary to capture the richness of the volume–skewness relation in equity markets.

The remainder of our paper is organised as follows. In section 2 we provide the background to our study and describe the data that we use in our empirical analysis. Section 3 contains a description of our model specifications and presents our results. The final section summarises the main arguments of our paper and draws together our conclusions.

2. Background and Description of the Data

It is well understood that the empirical distributions of daily equity market returns have higher peaks and fatter tails than the standard normal distribution (see Mandelbrot (1963), Fama (1965) for early work on this issue). With regard to the third moment of equity market returns, however, there is less agreement about the nature, extent and implications of skewness. Using updated data from Fama (1965), Simkowitz and Beedles (1980) found evidence that the returns on individual securities are positively skewed. Subsequent work by Singleton and Wingender (1986), Aggarwal, Rao and Hiraki (1989), Alles and Kling (1994), Peiró (1994, 1999, 2002), Aggarwal and Schatzberg (1997), Cont (2001) and Jondeau and Rockinger (2003) have all found varying degrees of skewness in national and international equity markets.

The traditional test for the skewness of returns on a financial asset, *i*, is based on the coefficient of sample skewness given in equation (1).

$$SK^i = \frac{\sum_{t=1}^{N}\left(R_t^i\right)/N}{\left(\sigma^i\right)^3} \qquad (1)$$

Here, R^i_t is asset *i's* excess return at time t, σ^i is the sample standard deviation, and N is the number of observations in the series. Under the assumption of normality, the asymptotic distribution of SK^i is given by

$$SK^i \rightarrow N(0,6/N) \qquad (2)$$

Using this test to see whether the degree of skewness is statistically significant warranting rejection of the assumption of normality gives potentially misleading results. This is because the sample distribution of the skewness statistic in (1) is itself based on the assumption that the underlying returns distribution is normal. In recognition of this problem, Peiró (1999) used non-parametric tests to examine the extent to which skewness can be found to be statistically significant in 9 international stock market indices. Using daily data from January 1980 to September 1993, he finds limited evidence of statistically significant skewness. Recent work by Kearney and Lynch (2004) updates and extends the analysis of Peiró (1999, 2002). These authors use a range of binomial and distribution free tests to show that although there is limited evidence of statistically significant skewness in the tails of the distributions of 6 international stock market indicess, there is evidence of asymmetries closer to the mean. Furthermore, the asymmetries that exist closer to the mean are more likely to involve more positive rather than more negative excess returns than is observed in the tails of the distributions.

Following the methodology of CHS, we employ two alternative measures of skewness, namely, SKW^i and DU^i. These are described in equations (3) and (4) below.

$$SKW_t^i = -\frac{N(N-1)^{3/2}\sum_{i=1}^{n} R_t^{i\,3}}{(N-1)(N-2)(\sum_{i=1}^{n} R_t^{i\,2})^{3/2}} \tag{3}$$

$$DU_t^i = \log\left[\frac{(N_u - 1)\sum_{i=1}^{n} Rdown_t^{i\,2}}{(N_d - 1)\sum_{i=1}^{n} Rup_t^{i\,2})^{3/2}}\right] \tag{4}$$

Equation (3) is a derivative of the standard coefficient of skewness presented in (1). It is derived by calculating the negative of the third moment of daily returns, divided by the cubed standard deviation of daily returns. This scaling by the cubed standard deviation is common to equation (1), and it has the desirable effect of standardising the measure of skewness for differences in variance across different markets. The minus sign is also conventional in causing an increase in SKW^i to depict more negative skewness. Equation (4) provides an alternative description of the degree of skewness. The DU^i stands for 'down-to-up-volatility'. It is calculated by dividing the sample into excess returns that are less than the mean return, $Rdown^i$, and excess returns that are greater than the mean, Rup^i. The standard deviation of each of these sub-samples is calculated separately, and then the log is taken of its ratio. A higher value of this also corresponds to a more left-skewed distribution of returns.

Description of the Data

We use daily returns for 6 international stock markets over the period from 28 February 1978 to 29 December 2001, obtained from *Datastream International Ltd.* The specific market indices used are the *Financial Times All Share Index* (Britain), the *DS Total Market Index* (France), the *FAZ* (Germany), the *COMIT* (Italy), the *Nikkei 225 Index* (Japan) and the *NYSE Composite Index* (the United States). Volume is the total number of shares traded each day. To construct the two measures of asymmetry described by SKW^i and DU^i, and to extract the maximum statistical power available to us, we use daily data to calculate the means, standard deviations and skewness for each individual month, giving a total of 287 observations. We then use these means and standard deviations to calculate the ratios of the up to down days for our DU^i statistic as well as deriving the skewness statistic SKW^i which we constrain to be negative.[1]

Summary statistics are presented in Table 1. The Table presents basic statistics on the raw returns, the standard deviations of returns, their skewness as measured by equation (1), and on the two alternative measures of skewness described in equations (3) and (4). The means of the raw returns are broadly similar, ranging from a high of 0.073 for Italy to a low of 0.025 for Japan. The variances range from 0.102 for Italy to a low of 0.034 for the United States. The skewness statistic is negatively signed for all markets, and the values in parentheses are the standard errors of the coefficients of skewness under the hypothesis of normality. The summary statistics for the *SKW* variable show that the mean is positively signed for 2 of the 6 markets, Britain and Germany, with the remaining markets having a negative sign. This is consistent with Kearney and Lynch (2004) who show that positive skewness in intervals of the distribution close to the means can frequently dominate negative skewness in the tails. Figure 1 plots the monthly returns in each of the markets, and Figure 2 plots the monthly standard deviations. It is apparent that there are 3 periods of relatively high volatility, associated the early 1980s, the stock market crash of 1987, and the Asian crisis of 1997-98. Figure 3 depicts the skewness statistics computed monthly from the daily returns.

3. Model Specifications and Results

There is a substantial literature on the relation between trading volume and the second moment of price changes (see Karpoff (1987) for a review). In the pre-ARCH studies (see, *inter alia*, Epps and Epps (1976) and Tauchen and Pitts (1983)), unconditional price volatility was typically measured by squared price changes, and this was hypothesised to relate positively to trading volume for two main reasons. In the course of his explanation of leptokurtic price changes, Clark (1973) argued that it emerges because of randomness in the number of intra-day transactions, while Epps and Epps (1976) argued that the intra-day price changes reflect the average of changes in traders' reservation prices. An increase in the extent to which traders disagree is

[1] We are indebted to Jeremy Stein for helpful comments on the use of this convention.

associated with a larger absolute price change. The positive volatility-volume relation arises because the volume of trading is positively related to the degree of dispersion in traders' reservation prices. Tauchen and Pitts (1983) extended the model of Epps and Epps (1976) by specifying two components of informational events: those common to all traders and those specific to individual traders. Their model predicts that price volatility is influenced by both common informational events and by the average of trader-specific informational events. Since volume is determined by trader-specific informational events, the positive relation between volume and price volatility emerges once again. Subsequent models of the volume - volatility relation have similar implications. Jang and Ro (1989) argued that greater belief changes among investors induces larger price changes, but for volume to be affected there needs to be an increase in the dispersion of changes in investor belief. Holthausen and Verrechia (1990) showed that market 'informedness' is positively related to both the variance of price changes and to trading volume. Wang (1993, 1994) argued that information asymmetry between informed and uninformed investors explains the volume - volatility relation, because as this asymmetry increases, uninformed investors are less willing to trade and they correspondingly reduce the price they are willing to pay. Harris and Raviv (1993), Shalen (1993) and Hutson and Kearney (2001) also present models of speculative trading in which volume is positively related to the dispersion in investor opinion.

To examine the relation between trading volume and skewness in international stock markets, we first estimate the following model.

$$\begin{aligned} SK_t^i = {} & \alpha_0^i + \sum_{j=1}^{6} \alpha_j^i SK_{t-j}^i + \sum_{j=0}^{6} \beta_j^i \sigma_{t-j}^i + \sum_{j=0}^{6} \delta_j^i R_{t-j}^i \\ & + \sum_{j=0}^{6} \varepsilon_j^i V_{t-j}^i + \sum_{j=0}^{6} \phi_j^i SDV_j^i + \sum_{j=0}^{6} \varphi_j^i SKV_j^i \\ & + \sum_{k=1}^{11} SD^k + \xi_t^i \end{aligned} \tag{5}$$

This examines the extent to which the evolution of stock market return skewness in country i, SK^i, varies in relation to five basic determinants. In addition to lagged skewness, the model includes terms for the contemporaneous and lagged second moment of returns as measured by the unconditional standard deviations, σ^i, the contemporaneous and lagged excess returns, R^i, the contemporaneous and lagged trading volumes, V^i, the standard deviation of trading volumes, SDV^i, and the skewness of trading volumes, SKV^i. The model also contains a set of monthly seasonal dummy variables, SD^k, to capture any seasonal variation in the skewness of market returns.

This model is similar to that estimated by CHS on market returns for the United States. In particular, the inclusion of lagged skewness variables together with volatility and excess return variables and the volume variable is common to CHS, and the estimation is conducted using Newey-West t-statistics that correct for any heteroscedasticity and autocorrelation. There are some important differences, however. First, unlike the CHS model that incorporates one lag of all right hand side variables and 5 lags of market returns, our model is estimated using the general-to-specific dynamic estimation strategy. This involves the initial specification of a general model with up to 6 lags on each variable, and it is sequentially tested and restricted until the parsimonious model is derived. Second, unlike CHS, we use unconditional standard deviations, σ^i, in order to avoid the generated regressors problem that yields inefficient estimates, introduces bias into a number of their diagnostic test statistics, and provides potentially invalid inferences (see *inter alia*, Pagan (1984, 1986), McAleer and McKenzie (1991) and Oxley and McAleer (1993)). Third, we do not use detrended volume data, and finally, in addition to the level of market volume, we also include the standard deviation and skewness of market volumes.

The results from estimating equation (5) for each country in our sample are presented in Table 2. This uses the DU^i measure of skewness. The results obtained using the SKW^i measure are qualitatively similar, although with less tendency for trading volumes to impact upon stock market skewness[2]. Looking first at the equation diagnostics in Panel B, the R^2 statistics are of a commensurate level with expectations for this type of modelling, averaging .29 across the 6 countries and ranging from a

[2] For brevity, the results presented here focus exclusively on the DU^i measure, and the results using the SKW^i, which are very similar, are available on request from the authors.

high of .49 for Japan to a low of .05 for the United States. The means of the dependent variables, *MDV*, are mostly negative, but are positive in 2 countries (Britain and Germany). This replicates our findings in Table 1. The standard errors of the estimates, *SEE,* and the sums of squared residuals, *SSR* are as expected relative to the R^2 statistics. The Box-Pierce *Q* statistics indicate that first or higher order autocorrelation is not a problem in any of the models except for the United States. Recall, however, all our test statistics are adjusted for the presence of both autocorrelation and heteroscedasticity.

The constant terms are all negative with the exception of the United States which is essentially zero, but only Germany and Italy is statistically significant at the 5 percent level. The lagged dependent terms, α^i_j, are significantly negative at the 5 percent level in 2 of the 6 countries (Germany and Italy), and they do not feature in the other markets. The lagged standard deviation terms, β^i_j, are statistically significant in all countries except Japan. They are positively signed in 4 of the 5 countries in which they are statistically significant, with an average net coefficient of 0.059 which varies little across countries. Interestingly, the United States is the exception in this regard with a negative and statistically significant aggregate effect equal to –0.014. This contrasts with CHS who did not find any significant effect of variations in market standard deviations on market skewness in any of their market models. We believe this result stems from their use of simple dynamics and inappropriately including the conditional standard deviation in their models. The lagged market return terms, δ^i_j, are negatively signed and strongly statistically significant in all countries except the United States, with an average aggregate value of –0.300. This finding also contrasts with CHS who found that their lagged return terms were all positively signed, although many were statistically insignificant.

Looking next at the effects of variations in the behaviour of trading volumes on market skewness, we first consider the trading volume level terms, ε^i_j. The level of trading volume is statistically insignificant in 3 markets, Britain, France and the United States. This concurs with CHS who included a single lag of their turnover variable in all their market models for the United States, and although it was always positively signed, it was not statistically significant in any of them. Our volume terms are statistically significant in 3 countries; Germany, Italy and Japan. Overall, our evidence suggests that a more sophisticated modelling exercise might be needed to uncover the nature of the relation between market skewness and trading volumes, because where significant effects are found, there tend to be dynamics in the relation whereby they change sign over time in a manner that leads to a small overall effect. This can potentially explain why CHS did not find significant effects of trading volume in any of their market models. In a first attempt to examine whether this might be the case, we re-estimated all our models described here, allowing up to 12 lags on the volume terms. Interestingly, this exercise resulted in the level of trading volumes being statistically significant and positively signed – although with small coefficients - in all markets except for the United States. This provides strong evidence that lagged trading volumes are directly associated with subsequent negative skewness in these market – which is consistent with the results reported by Chen Hong and Stein (2001) and Charoenrook and Daouk (2004).

Turning now to the second moment of the volume variable, the effects are provided by the parameter ϕ_j^i. The standard deviation of trading volumes is statistically significant in all countries except Japan, and it is positively signed in 4 of these countries (the exception being Italy). This suggests that previous researchers have missed an important variable in forecasting market skewness, and it is interesting to speculate on the extent to which this result will carry over to our more general VAR model. Finally, given that we are examining the relation between market return skewness and trading volume, it is interesting to consider whether the skewness of the latter impacts on the former. The parameter φ_j^i provides the answer to this. The evidence is weak, however, being statistically significant in only 2 countries (France and Italy) and signed differently in each.

From our analysis to this point, it seems that there is mixed evidence for the existence of a positive relation between the level of trading volumes and skewness of stock market returns. There is, however, more evidence of skewness being influenced by the second moment of trading volumes. A shortcoming of this analysis, however, is that it does not allow for the existence of alternative transmission mechanisms whereby the level of trading volumes might impact first on market returns or on the standard deviation of market returns, and that these variables might in turn influence the skewness of market returns. In other words, trading volumes might well influence the skewness of market returns indirectly by first impacting on one or more of the other variables in our models. The evidence we have presented is consistent with at least part of this story insofar as both market returns and their standard deviations significantly affect the skewness of market returns in most of the stock markets studied. Both CHS and Harvey and Siddique (2000) document relationships of this type. Indeed, CHS display considerable concern about this possibility.

> *Recall that the central issue here is whether [trading volume] is really forecasting [skewness] directly, or whether it is instead forecasting [the standard deviation of returns], and showing up in the regression only because [the standard deviation of returns] is correlated with [skewness].*
> [CHS, p362].

In order to shed further light on this issue, CHS argue the advantages of introducing further dynamics, and they subsequently include 2 lags of return standard deviations, dividing them into positive and negative deviations, and they replace the actual standard deviations with predicted values in order to mimic an instrumental variables approach. None of these measures adds to the significance of trading volumes in their return skewness models, and their use of predicted standard deviations again introduces the generated regressors problem.

A more systematic approach to this issue involves the specification of a series of vector autoregressive (VAR) models for each country to examine the nature of the relationships between all variables in the models. The VAR models take the familiar form,

$$A(L)x_t + By_t = u_t \qquad (10)$$

with

$$A(L) = 1 - A_1 L - A_2 L^2 - \ldots\ldots - A_p L^p ,$$

$$E(u_t) = 0, \quad E(u_t u'_t) = \Sigma, \quad E(u_t u'_s) = 0 \text{ , for } t \neq s , \quad E(x_t u_t) = 0 ,$$

$$x_t = (DU_t, \sigma_t, R_t, V_t, SDV_t, DUV_t),$$

and

$$y_t = (Const, SD_t)$$

This is a standard VAR representation in which x is a $(1 \times n)$ vector of variables, A is an $(n \times n)$ matrix of coefficients, u is an $(n \times 1)$ vector of white noise disturbance terms, and L denotes the lag operator (for example, $L^i x_t = x_{t-i}$). The variables appearing in the *x* vector are the *DU* measure of market return skewness, the standard deviation of market returns, σ, the level of market returns, *R*, the level of trading volumes, *V*, the standard deviation of volumes, *SDV*, and the skewness of volumes, *DUV*. The *y* vector contains the constant term, *const*, and the seasonal dummy variables, *SD*. In essence, therefore, this series of VAR models allows us to examine the full range of interaction between the first three moments of both market returns and trading volumes within each country in our study. It therefore incorporates an investigation of the relation between volumes and volatility.

A convenient feature of the VAR represenatation in (10) is that it can be estimated by ordinary least squares, which yields consistent and asymptotically efficient estimates of the A matrix because the right hand side variables are predetermined and are the same in each equation of the model. The first step in estimating the model is to decide upon the appropriate lag length (p). Following Hakkio and Morris (1984), this is accomplished by setting the maximum lag length to 6 and using likelihood ratio tests to examine each restriction against all other possibilities. Table 3 shows the likelihood ratio tests statistics. Restricting the lag length from 6 to 5 lags appears to be valid in 3 of the 6 countries (Italy, Japan and the United States), but invalid in the others. Restricting the lag length from 5 to 4 lags appears to be valid in all countries, but this should be weighed up against the strong finding that 4 lags constitutes an invalid restriction of 6 lags in all countries. On this basis, we set the lag length to 6. Examination of the Ljung-Box Q-statistics provide support for this choice of lag length by failing to detect the existence of residual autocorrelation in the model. It is also consistent with the lag length chosen in the single equation models.

Table 4 presents our VAR results. The overall explanatory power of the models as described by the R^2s is quite good for this kind of modelling, the standard errors of the estimates are respectively small and the Ljung-Box Q statistics all indicate the absence of higher order autocorrelation in the equation residuals. (These are not presented for brevity, but are available on request from the authors). The most interesting aspect of the models concerns the extent of causality between the market return and trading volume variables in the $x_t = (DU_t, \sigma_t, R_t, V_t, SDV_t, DUV_t)$ vectors for each country. This is depicted in the Table by the F-statistics (with their marginal significance levels in brackets) for the joint exclusion of all lags of each variable in each of the equations of the models. Superscripts '*' and '#' over the marginal significance level of the F-statistics indicates the joint significance at the 5 and 10 percent levels respectively of all lags of the relevant variable in the equation under consideration. In discussing these results, we will refer to 'direct' relations as occurring between two variables in the models, and 'indirect' relations will involve transmission effects through one or more additional variables. For example, looking at the results for the United States at the bottom of Table 4, we can see that there is a direct relation between returns and skewness, but there is no direct relation between trading volumes and skewness. This led CHS to conclude that trading volumes do not impact upon return skewness in United States equity markets. In addition to our findings of a direct relation between the standard deviation of volumes and return skewness in our single model estimates reported in Table 2, we can see in Table 4 that the skewness of trading volumes directly determines return levels, which in turn impact upon the skewness of returns.

Similar analysis for the other countries in Table 4 reveals the importance of allowing for the existence of indirect transmission mechanisms in examining the volume-skewness relation in international equity markets. This is summarised in Table 5, which depicts all the significant direct and indirect effects from Table 5. Panel A of the Table lists the main channels of influence from volumes to returns, and Panel B depicts the feedback from returns to volumes. Let us examine Panel A first. For Britain, there is a direct relation between volumes and return skewness, a direct relation between volumes and return standard deviations, and an implied indirect relation between volumes and return skewness through the second moment of returns.

For France, there is a direct relation between the standard deviation of volumes and the skewness of market returns. For Germany, there is a direct relation between the skewness of volumes and the second moment of market returns. For Italy, there is an indirect relation between trading volumes and the skewness of market returns that operates through the skewness of trading volumes. For Japan, there are three indirect relations from trading volumes to the skewness of returns; the first operates through the level of returns, the second operates through the first two moments of market returns, and the third operates from the second moment of trading volumes to the level of returns. Finally, as mentioned above, volumes affect returns through two transmission mechanisms in the United States which have not been so far recognised: from the skewness of trading volumes to the level of returns, and onwards to the skewness of market returns. Summarising these results, trading volumes affect market returns in all countries examined. They influence the skewness of returns in 5 of the 6 countries studied in our sample. The exception is Germany, where volumes influence only on the second moments of market returns.

Looking now at Panel B of Table 5, we can see that there is a relation between returns and volumes in all countries considered except Japan. In Britain and France, both the level of returns and the second moment of returns impact upon the second moment of trading volumes, which in turn influence the skewness of trading volumes. In Germany, the second moment of returns impacts on the second moment of trading volumes, while in Italy both the second and third moments of returns impact on the level and skewness of trading volumes. In the United States, there is significant feedback from all three moments of returns to the second moment of trading volumes.

It is also interesting to consider the volume – volatility relation in our models that also include skewness. Panel A of Table 5 shows that volumes lead volatility of returns in 3 markets, and that feedback effects from volatility to volume are significant in 5 of our 6 markets. This suggests that the volume – volatility relation that has been modelled in many previous studies might be enriched by also including the effects that operate through the third moments, and that feedback effects from volatility to volume are an important part of the relation that has thus far been under-researched.

4. Summary and Conclusions

The possibility of asymmetric stock market returns can be explained by representative investor theories (such as the financial leverage effect, volatility feedback mechanisms, and the bursting of speculative bubbles) and by investor heterogeneity theories, according to which investors differ in their opinions concerning the fundamental values of stocks or markets. This heterogeneity in investor beliefs about the likely future path of returns is recognised to drive the relation between trading volumes and volatility. There is a small but emerging literature that extends this analysis to consider the relation between trading volumes and skewness, and to investigate this relation in the international context.

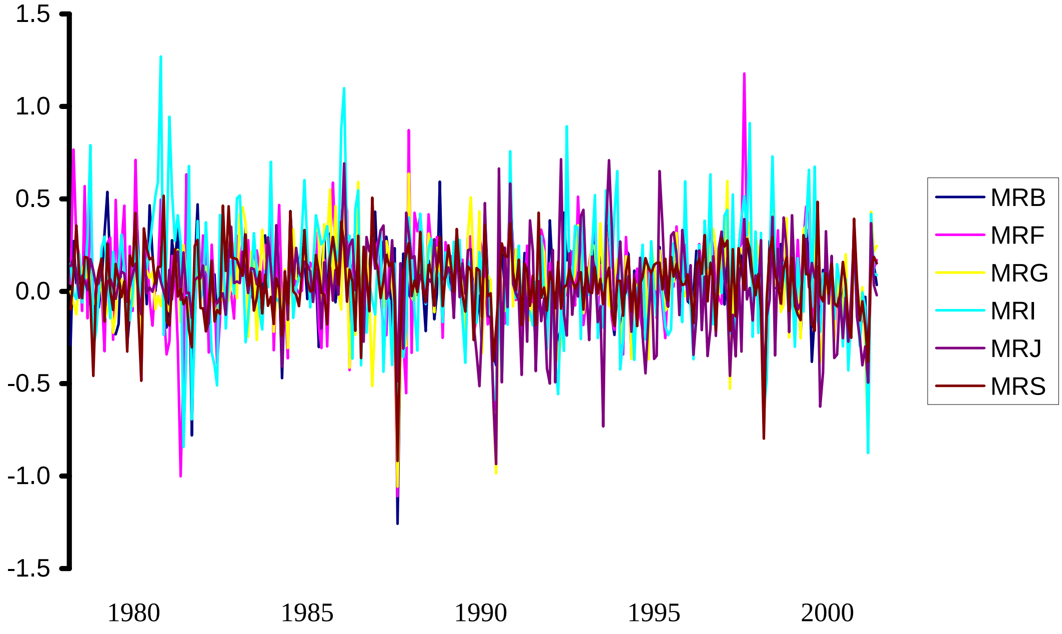
We have examined the relation between trading volume and skewness in international stock markets using daily data from 6 markets (Britain, France, Germany, Italy, Japan and the United States) over the period from February 1978 to December 2001. We constructed both single equation models and a VAR model of the relation between the first three moments of stock market returns and trading volumes. Our results are moderately supportive of the investor heterogeneity approach to explaining return asymmetries. We confirmed the result of CHS that there seems not to be a role for trading volume to explain the skewness of market returns in the United States. We also confirmed the result of CHS that lagged returns are significant in the United States context. Unlike CHS, however, we find that lagged volatility does statistically significantly explain market skewness. In addition, our extension of the CHS model to a set of other major international stock markets confirms a role for trading volumes in explaining the skewness of market returns, and we also find significant feedback from returns to trading volumes in 5 of our 6 countries. More generally, however, our modelling approach that allows a richer set of interactions and feedback mechanisms amongst the first three moments of volumes and returns demonstrates important aspects of the volume – volatility – skewness relation that have been suggested by the recent work of Hueng and Brooks (2003) and Charoenrook and Daouk (2004).

Table 1
Summary Statistics for International Stock Market Returns
February 1978 – December 2001

	Britain	*France*	*Germany*	*Italy*	*Japan*	*US*
Returns						
Mean	0.048	0.059	0.038	0.073	0.025	0.048
Variance	0.045	0.079	0.057	0.102	0.06	0.034
Minimum	-1.258	-1.108	-1.057	-0.875	-0.934	-0.919
Maximum	0.593	1.179	0.635	1.27	0.715	0.517
Skewness	-1.069	-0.293	-0.779	-0.306	-0.402	-0.794
	(.00)	(.04)	(.00)	(.04)	(.01)	(.00)
Kurtosis	5.039	2.014	2.914	1.013	1.188	3.523
	(.00)	(.00)	(.00)	(.00)	(.00)	(.00)
SDs of returns						
Mean	0.798	1.017	0.994	1.175	1.302	0.843
Variance	0.121	0.279	0.309	0.34	0.385	0.254
Minimum	0.299	0.297	0.296	0.302	0.3	0.258
Maximum	3.894	4.967	3.879	4.293	3.422	5.296
Skewness	3.523	3.039	2.098	2.156	0.962	4.441
	(.00)	(.00)	(.00)	(.00)	(.00)	(.00)
Kurtosis	23.668	14.73	6.104	6.864	0.829	30.182
	(.00)	(.00)	(.00)	(.00)	(.07)	(.00)
Skewness of returns						
Mean	-0.086	0.028	-0.065	0.017	0.051	-0.01
Variance	0.364	0.427	0.405	0.506	0.523	0.553
Minimum	-1.846	-2.828	-3.055	-2.761	-2.379	-4.032
Maximum	2.845	4.137	2.287	1.98	2.372	2.328
Kurtosis	1.828	6.171	2.995	1.599	1.022	3.261
	(.00)	(.00)	(.03)	(.00)	(.00)	(.00)
SKEW						
Mean	0.191	-0.142	0.25	-0.213	-0.317	-0.722
Minimum	-28.073	-25.244	-11.189	-12.15	-86.051	-44.518
Maximum	27.202	21.732	30.389	5.533	43.265	13.28
DUV						
Mean	0.003	-0.023	0.009	-0.012	-0.025	-0.015
Minimum	-0.539	-0.978	-0.495	-0.652	-0.692	-0.702
Maximum	0.499	0.488	0.779	0.556	0.461	0.708

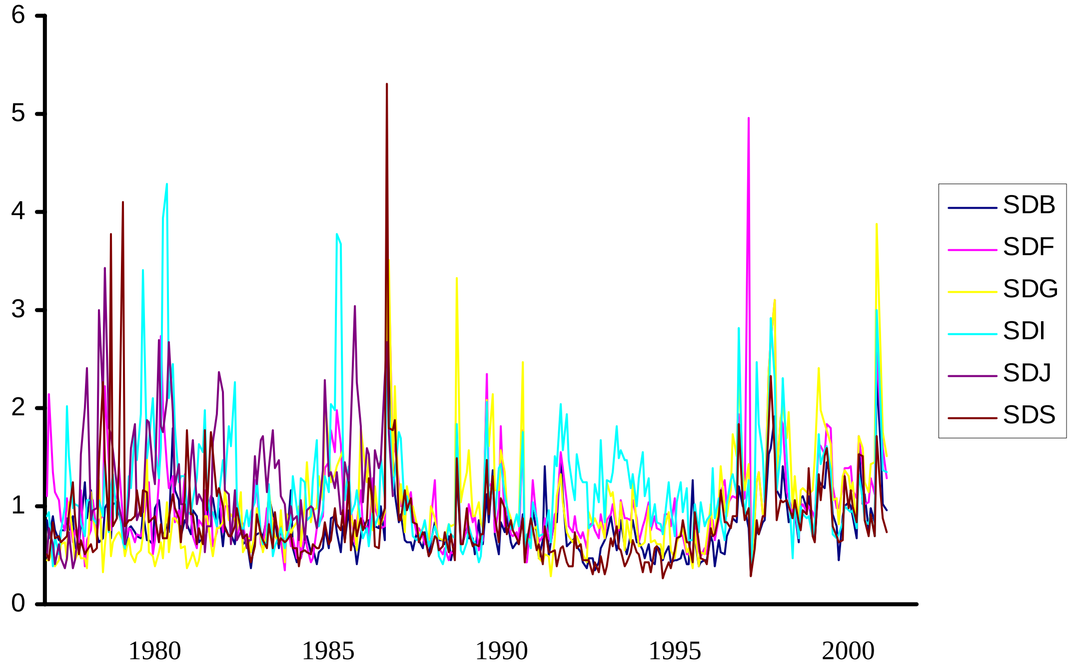
Notes. The variables are as defined in the text. The returns are monthly returns compiled from daily observations. The variables *SKEW* and *DU* are as defined in equations (3) and (4) in the text – and they both measure monthly skewness in market returns, derived from the daily data.

Figure 1
Monthly Returns in 6 International Stock Markets,
February 1978 – December 2001



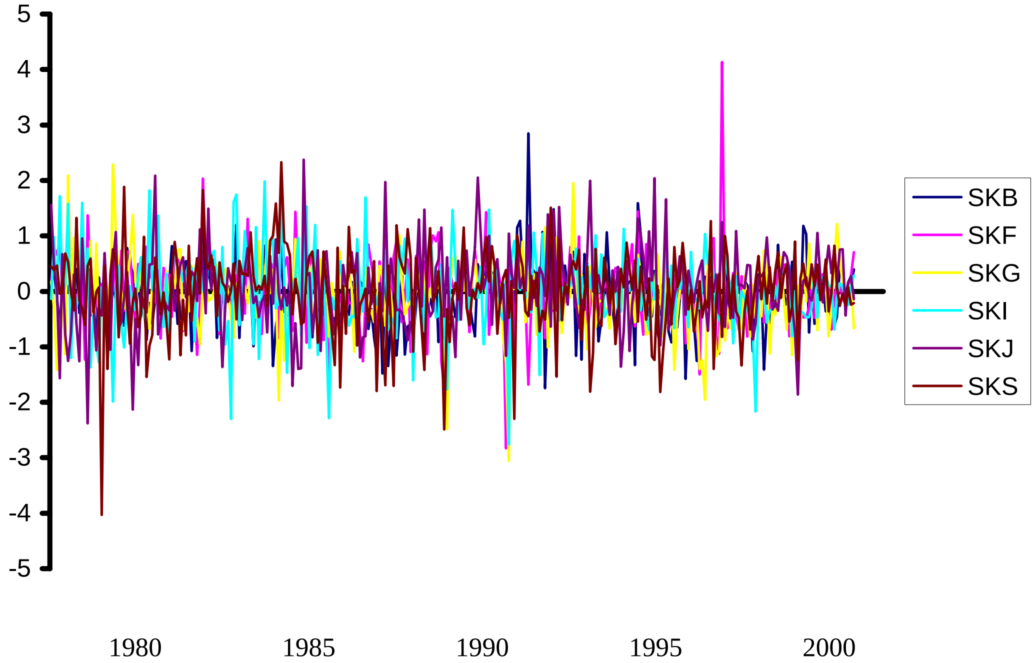
Notes. The source is Datastream International Ltd. All data is sampled daily over the period from 28 February 1978 to 29 December 2001. The returns are then aggregated to a calendar month basis. In the legend, MR stands for monthly return, and the last letter, (B, F, G, I, J and S denotes the country (Britain, France, Germany, Italy, Japan and the United States).

Figure 2
Monthly Standard Deviations of Returns in 6 International Stock Markets, February 1978 – December 2001



Notes. The source is Datastream International Ltd. All data is sampled daily over the period from 28 February 1978 to 29 December 2001. The returns are then aggregated to a calendar month basis. In the legend, SD stands for monthly standard deviation, and the last letter, (B, F, G, I, J and S denotes the country (Britain, France, Germany, Italy, Japan and the United States).

Figure 3
Skewness of Monthly Returns in 6 International Stock Markets, February 1978 – December 2001



Notes. The source is Datastream International Ltd. All data is sampled daily over the period from 28 February 1978 to 29 December 2001. The returns are then aggregated to a calendar month basis. In the legend, SK stands for monthly return skewness, and the last letter, (B, F, G, I, J and S denotes the country (Britain, France, Germany, Italy, Japan and the United States).

Table 2
Trading Volume and Skewness in International Stock Markets

Panel A: Model Estimates

Country	*Constant*	α_j^i	β_j^i	δ_j^i	ε_j^i	ϕ_j^i	φ_j^i
Britain	-0.031 (0.88)		-0.165 (1) (3.61) 0.127 (2) (3.35) 0.090 (4) (2.76)	-0.525 (1) (7.38) 0.190 (6) (3.16)		0.001^{e-1} (6.79)	
France	-0.032 (0.93)		0.058 (1) (2.83)	-0.312 (1) (6.04)		0.01 (2.31) -0.001 (4) (2.98)	***0.117*** (1.96)
Germany	-0.261 (3.56)	-0.156 (2.00)	0.063 (2.62)	-0.322 (5.54) 0.163 (4) (2.99)	-0.01^{e-2} (2.64)	0.215 (3.11) -0.141 (3) (2.03)	
Italy	-0.138 (3.29)	-0.132 (2.01)	0.064 (2.89)	-0.341 (9.15) -0.099 (2) (2.27)	-0.001 (2.13) 0.002 (2) (4.21)	-0.003 (3) (3.29)	-0.151 (2.81) -0.284 (3.65)
Japan	-0.047 (1.46)			-0.270 (5.34)	-0.001 (2.27) 0.002 (6) (3.32)		
United States	0.03^{e-2} (0.01)		0.071 (2) (3.10) -0.085 (4) (3.81)			0.14^{e-3} (12.59)	

Panel B: Model Diagnostics

Country	*R2*	*MDV*	*SEE*	*SSR*	*DW*	*Q*	*NOBS*
Britain	.29	0.007	0.184	5.706	1.82	34.41 (.54)	176
France	.28	-0.012	0.163	3.978	1.88	43.90 (.17)	157
Germany	.28	0.028	0.177	4.664	1.78	22.98 (.95)	157
Italy	.49	-0.001	0.149	3.748	2.03	34.20 (.55)	149
Japan	.34	-0.034	0.155	3.156	2.20	30.87 (.62)	131
United States	.05	-0.008	0.202	7.184	2.10	55.82 (.02)	176

Notes. The estimates in Panel A are of equation (5) in the text which is reproduced below With the *DU* measure of skewness.

$$DU_t^i = \alpha_0^i + \sum_{j=1}^{6}\alpha_j^i DU_{t-j}^i + \sum_{j=0}^{6}\beta_j^i\sigma_{t-j}^i + \sum_{j=0}^{6}\delta_j^i R_{t-j}^i + \sum_{j=0}^{6}\varepsilon_j^i V_{t-j}^i + \sum_{j=0}^{6}\phi_j^i SDV_j^i + \sum_{j=0}^{6}\varphi_j^i DUV_j^i + \sum_{k=1}^{11}\gamma_k SD^k + \xi_t^i$$

The column headings in Panel A refer to the parameters in this equation. The numbers in brackets after the estimated coefficients are lag numbers and the adjusted t-statistics are in brackets below them. MDV, SEE, SSR, DW and Q refer to, respectively, the mean of the dependent variable, the standard error of the estimate, the sum of squared residuals, the Durbin-Watson statistic and the Box-Pierce statistic for higher autocorrelation.

Table 3
Likelihood Ratio Tests of the VAR Lag Length

	Britain	France	Germany	Italy	Japan	United States
Does 5 restrict 6?	.00	.01	.00	.06	.16	.08
Does 4 restrict 5?	.31	.20	.71	.10	.19	.05
Does 4 restrict 6?	.00	.00	.00	.00	.00	.00
Does 3 restrict 4?	.23	.12	.32	.17	.00	.00
Does 3 restrict 5?	.00	.00	.00	.00	.00	.00
Does 3 restrict 6?	.00	.04	.09	.08	.00	.00
Does 2 restrict 3?	.04	.00	.00	.04	.00	.00
Does 2 restrict 4?	.14	.02	.02	.11	.00	.00
Does 2 restrict 5?	.19	.04	.15	.07	.00	.00
Does 2 restrict 6?	.00	.00	.00	.00	.00	.00
Does 1 restrict 2?	.88	.00	.00	.04	.05	.00
Does 1 restrict 3?	.33	.00	.00	.01	.00	.00
Does 1 restrict 4?	.46	.00	.00	.04	.00	.00
Does 1 restrict 5?	.50	.00	.00	.04	.00	.00
Does 1 restrict 6?	.00	.00	.00	.03	.00	.00

Notes. The figures are the marginal significance levels of the likelihood ratio tests of the restricted versus the unrestricted models. Figures less than .05 imply rejection of the restriction at the 95 percent confident limit.

Table 4
VAR Analysis of Trading Volume and Skewness

	DU	***σ***	***R***	***V***	***SDV***	***DUV***
			Britain			
DU^B	1.201 (.31)	3.326 (.00)*	6.014 (.00)*	2.416 (.03)*	0.771 (.59)	0.378 (.89)
σ^B	0.978 (.44)	6.196 (.00)*	2.976 (.01)*	2.278 (.04)*	0.335 (.92)	1.364 (.23)
R^B	0.392 (.88)	0.429 (.86)	0.720 (.63)	0.925 (.48)	0.267 (.95)	0.842 (.54)
V^B	0.442 (.85)	1.094 (.37)	1.354 (.24)	208.682 (.00)*	0.773 (.59)	0.969 (.45)
SDV^B	1.143 (.34)	6.273 (.00)*	4.220 (.00)*	1.351 (.24)	0.593 (.74)	1.365 (.23)
DUV^B	1.020 (.42)	1.731 (.12)	1.041 (.40)	0.474 (.83)	2.757 (.02)*	1.370 (.23)
			France			
DU^F	0.555 (.76)	1.459 (.20)	5.223 (.00)*	0.848 (.54)	1.954 (.08)#	1.554 (.17)
σ^{Φ}	1.365 (.23)	2.908 (.01)*	1.847 (.10)#	2.078 (.06)#	0.806 (.57)	0.501 (.81)
R^F	1.362 (.23)	0.988 (.44)	1.368 (.24)	0.407 (.88)	0.954 (.46)	0.901 (.50)
V^F	0.340 (.91)	1.932 (.08)#	0.726 (.63)	219.365 (.00)*	0.299 (.94)	1.468 (.20)
SDV^F	1.327 (.25)	0.528 (.79)	1.834 (.10)#	0.916 (.49)	13.295 (.00)*	1.293 (.27)
DUV^F	0.404 (.87)	1.063 (.39)	0.786 (.58)	2.010 (.07)#	2.224 (.05)*	0.545 (.77)
			Germany			
DU^G	0.489 (.82)	0.450 (.84)	1.173 (.32)	0.405 (.87)	0.520 (.79)	0.834 (.55)
σ^{Γ}	0.119 (.99)	6.499 (.00)*	1.483 (.19)	0.975 (.45)	1.141 (.34)	2.116 (.06)#
R^G	0.671 (.67)	1.506 (.18)	1.347 (.24)	0.629 (.71)	0.856 (.53)	1.152 (.34)
V^G	0.974 (.45)	0.980 (.44)	0.973 (.45)	116.361 (.00)*	1.842 (.10)#	5.812 (.00)*
SDV^G	0.524 (.79)	1.931 (.08)#	1.484 (.19)	1.857 (.10)#	10.003 (.00)*	9.775 (.00)*
DUV^G	0.451 (.84)	1.156 (.34)	1.585 (.16)	0.943 (.47)	0.977 (.44)	30.207 (.00)*
			Italy			
DU^I	2.117 (.06)#	0.893 (.50)	1.257 (.28)	0.698 (.65)	1.476 (.19)	1.879 (.09)#
σ^I	0.794 (.58)	7.757 (.00)*	0.198 (.98)	0.907 (.49)	0.929 (.48)	1.119 (.36)
R^I	1.476 (.19)	0.750 (.61)	0.623 (.71)	0.844 (.54)	1.005 (.43)	0.939 (.47)
V^I	1.819 (.10)	2.548 (.02)*	0.721 (.63)	84.434 (.00)*	0.837 (.54)	0.831 (.55)
SDV^I	1.727 (.12)	0.342 (.91)	0.636 (.70)	0.351 (.91)	1.135 (.35)	0.934 (.47)
DUV^I	1.425 (.21)	1.058 (.39)	0.950 (.46)	2.405 (.03)*	1.046 (.40)	1.138 (.34)
			Japan			
DU^J	0.626 (.71)	0.251 (.96)	2.112 (.06)#	1.319 (.26)	1.032 (.41)	0.857 (.53)
σ^{ϑ}	1.729 (.13)	3.762 (.00)*	2.002 (.08)#	3.312 (.01)*	1.332 (.25)	1.311 (.26)
R^J	0.840 (.54)	2.852 (.01)*	0.764 (.60)	2.291 (.04)*	2.037 (.07)#	0.845 (.54)
V^J	1.270 (.28)	1.400 (.23)	0.772 (.59)	17.240 (.00)*	2.914 (.01)*	1.141 (.35)
SDV^J	0.371 (.90)	0.345 (.91)	1.404 (.22)	1.543 (.18)	0.815 (.56)	1.163 (.34)
DUV^J	0.533 (.78)	0.727 (.63)	0.364 (.90)	1.377 (.23)	0.743 (.62)	4.303 (.00)*
			United States			
DU^S	1.321 (.25)	1.033 (.40)	3.750 (.00)*	0.526 (.79)	0.173 (.98)	0.535 (.78)
σ^{Σ}	2.389 (.03)*	8.651 (.00)*	1.454 (.19)	0.887 (.51)	0.388 (.89)	0.547 (.77)
R^S	2.279 (.04)*	3.067 (.01)*	1.309 (.25)	1.697 (.12)	0.576 (.75)	1.941 (.08)#
V^S	0.688 (.66)	0.771 (.59)	1.257 (.28)	2386.26 (.00)*	0.093 (.99)	0.375 (.89)
SDV^S	2.392 (.03)*	0.513 (.80)	0.173 (.98)	0.260 (.95)	0.156 (.99)	1.179 (.32)
DUV^S	1.751 (.11)	0.600 (.73)	0.397 (.88)	0.352 (.91)	0.441 (.85)	1.844 (.09)#

Notes. The Table provides the F-statistics for the joint exclusion of all lags of each variable in the VAR models described in equation (6) in the text, along with their marginal significance levels in brackets. Superscipts '*' and '#' denote significance levels at the 5 and 10 percent respectively.

Table 5

Return – Volume Interactions in International Equity Markets

	Panel A: The influence of volumes on returns
Britain	$V \rightarrow DU$; $V \rightarrow \sigma$; $V \rightarrow \sigma \rightarrow DU$.
France	$SDV \rightarrow DU$.
Germany	$DUV \rightarrow \sigma$.
Italy	$V \rightarrow DUV \rightarrow DU$.
Japan	$V \rightarrow R \rightarrow DU$; $V \rightarrow \sigma \rightarrow R \rightarrow DU$; $SDV \rightarrow R \rightarrow DU$.
United States	$DUV \rightarrow R$; $DUV \rightarrow R \rightarrow DU$.
	Panel B: The influence of returns on volumes
Britain	$R \rightarrow SDV \rightarrow DUV$; $\sigma \rightarrow SDV \rightarrow DUV$.
France	$R \rightarrow SDV$; $\sigma \rightarrow V \rightarrow DUV$.
Germany	$\sigma \rightarrow SDV$.
Italy	$DU \rightarrow V \rightarrow DUV$; $\sigma \rightarrow V \rightarrow DUV$.
Japan	None.
United States	$DU \rightarrow SDV$; $\sigma \rightarrow R \rightarrow DU \rightarrow SDV$.

Notes. This Table summarises the results from the VAR model of equation (6) and Table 4. Symbols retain their prior meanings. R, σ and ***DU*** are the returns, standard deviations of returns and skewness of returns. V, SDV and DUV are the volumes, standard deviations of volumes, and skewness of volumes.

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