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THE IMPACT OF TRADING VOLUME ON STOCK RETURN DISTRIBUTIONS: An empirical analysis

TOM BERGLUND*

Research Institute of the Finnish Economy, SF-00120 Helsinki

and

EVA LILJEBLOM*

Swedish School of Economics and Business Administration, SF-00100 Helsinki

This paper studies the relationship between the trading volume on the stock exchange and the properties of corresponding stock returns. The properties to be analyzed are: the dispersion of the returns, i.e. the volatility of the stock prices, the degree of leptokurtosis in the returns, and finally, the serial correlation in returns. The comparison of a low turnover with a high turnover period for the Helsinki Stock Exchange reveals that for the high turnover period the leptokurtosis of the return distributions is lower, as expected. Contrary to expectations stock price volatility is higher. Finally, on serial correlation the results are mixed, which can be explained by a non-linear pattern of serial correlation during the high turnover period. The results imply that considerable caution is warranted in empirical research which covers substantial shifts in the level of trading activity on the exchange.

1. Introduction

The recent development in the trading volume on the Helsinki Stock Exchange gives a new interesting opportunity to investigate what impact trading volume will have on price formation. While the annual turnover in 1980 was 1 185 mil. measured in constant 1988 FIM[1], it had increased to 37 452 mil. FIM in 1988. This increase is partly explained by the increase in relative prices for shares. However, if the quantity of shares traded in 1980 is indexed as 100, the volume in 1988 was still 734[2]. This enormous increase in a relatively short time enables us to focus on the effects of the increase in turnover without having too many exogenous changes affecting the results.

The main hypotheses studied in this paper concerns the effect of the increased transac-

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[1] *The cost living index has been used to transform the 1980-year FIM to 1988-year FIM.*

[2] *Deflating the turnover in current FIM with the UNITAS-market index.*

tions volume on stock returns and return distributions. The impact of an increase in trading volume on several aspects of the return distributions have been discussed in the literature. In this paper we will focus on the following aspects: volatility, excess kurtosis or fat-tailedness of the distribution, and finally serial correlation in the returns.

In the next section we will review the literature to show why the following hypotheses seem plausible: An increase in trading volume will cause 1. volatility to drop, 2. excess kurtosis to drop, and 3. positive serial correlation in returns to decrease. The paper then continues with a description of the data. Next, the results for each of our three hypotheses are given in separate sections. A summary concludes the paper.

2. *Background*

A number of studies have indicated that volatility will increase when there is less trading. These studies include Cohen, Maier, Schwartz, and Withcomb (1978), Garbade and Silber (1979), Tauchen and Pitts (1983), and Pagano (1989). According to the models in these papers the reduction in the variance of the returns is mainly a consequence of the increased number of traders which usually accompany an increase in trading volume. The larger number of traders will imply that idiosyncratic demand shifts for individual traders will cancel out to a larger extent[3]. According to Cohen, Maier, Schwartz, and Withcomb (1978) this applies mainly to non-specialist markets. On markets with designated market makers idiosyncratic shifts tend to be smoothed out by the specialists.

Empirical support for a negative relationship between volatility and trading volume is found in an earlier study by Cohen, Ness, Okuda, Schwartz and Withcomb (1976). The study compares the New York Stock Exchange, the American Stock Exchange, the Tokio Stock Exchange and the stock exchange in Rio de Janeiro. The comparison is based on the 50 stocks with the highest capitalization for each exchange[4]. The prices are from the first quarter of 1972. The ranking of the exchanges in terms of their turnover turns out to be exactly the opposite to the ranking in terms of average volatility of the stocks in the sample. Furthermore, the logarithm of the variance of the returns for individual stocks turned out to be significantly correlated with the turnover for these stocks. A similar negative correlation is found by Pagano (1985) on data covering August 1976 through September 1984 for the Milan stock Exchange.

In addition to the second moment we will also be interested in what happens to the fourth moment, i.e. to the excess kurtosis, as the trading volume increases. According to an early paper by Clark (1973) one reason for fat-tailed return distributions can be found in the fact that transactions are unevenly distributed over time. For days with a large number of transactions, according to Clark (1973), we should observe a higher closing price to closing price variance than for days with a small number of transactions, even if the variance of the returns between adjacent transactions is the same[5].

This argument can easily be extended to show that returns on stocks that are more thinly traded ought to be more fat-tailed than returns of frequently traded stocks. The reason is that the relative fluctuations in trading frequency will be higher for a stock subject to infrequent trading. The law of large numbers can be invoked to show that the relative day-to-day fluctuations in trading frequency will drop as the average number of transactions in the stock increase.

There are at least two other reasons based on the reaction of stock prices to new information for the degree of kurtosis to be lower for more freqently traded stocks than for less frequently traded ones. The first explanation is based on investors reaction to news once it is generated and the second is based on the generation of news.

The first explanation is based on the assumption that transactions made by specula-

[3] As pointed out by Tauchen and Pitts (1983) this phenomenon should be separated from the opposite relationship between price changes and trading volume in the short run which has been observed in a large number of studies. A survey of these studies is given in Karpoff (1987). The short-run relationship builds on a reverse causation, i.e. from price changes to volume

[4] In the case of Rio on the 28 stocks with the highest capitalization.

[5] For a proof see Clark (1973).

tors constitute one of the factors which make new information show up in prices. If the stock is thinly traded, speculators will obtain a smaller expected profit on a piece of new information than if it is frequently traded, the reason being that the stock price will be more sensitive to the generated excess demand in the case of the thinly traded stock. Since speculators are driven by expected profits the piece of news has to be more significant for a thinly traded stock to generate a reaction from speculators. Thus, only the most important pieces of new information will filter into the price of the stock for an infrequently traded stock, whereas even less important pieces of new information will filter into the stock price for a frequently traded one.

The second explanation stems from the fact that trading frequency and firm size are correlated. Smaller firms' stocks are usually less frequently traded. Since a larger firm has more extensive operations, the larger firm will be subject to a large number of events which may have some impact on the best cash flow estimate for the firm. On the other hand, a firm with more limited operations will experience fewer events, but these events will be relatively more important due to indivisibilities and a lower degree of internal diversification[6].

Thus, there are several reasons to expect that a higher trading volume will be accompanied by a lower degree of kurtosis in return distributions. Empirical comparisons of return distributions for different countries give further support for the hypothesis that return distributions for stocks listed on smaller exchanges tend to be more leptokurtic than return distributions for stocks listed on large exchanges[7].

The last aspect of the returns that we will focus on relates to weak-form informational efficiency. On a stock market which is informationally efficient in the weak form sense stock returns should not exhibit any temporal dependence. Past returns should be worthless in forecasting future returns. In practice, frictions in the trading process will cause the price behaviour to deviate from informational efficiency. Thus, serial correlation which tends to be negative for thin securities and positive for frequently traded securities has been observed in daily returns, as noted by Cohen, Hawawini, Maier, Schwartz and Withcomb (1980) on the basis of an extensive survey of the literature in the area. Furthermore, Cohen, Hawawini, Maier, Schwartz and Withcomb (1980) state that:

> Positive serial correlation would result from specialist intervention to provide price continuity, from »clairvoyant» specialist absorption of the »random» component in current demand [see Goldman-Beja (1979)], from specialist/dealer inventory rebalancing, and from the breaking up of large orders. In addition, delays in updating limit orders on the book can lead to positive serial correlation as those traders who respond quickly enough to new information have an opportunity to hit orders that have not yet been revised.

A closer look at these explanations indicates that an increase in trading volume accompanied by a larger number of intermediaries active on the exchange ought to produce a lower degree of positive serial correlation in returns. The strongest impetus for a lower degree of serial correlation comes from the increased competition between intermediaries brought about by the higher potential profits in intermediation in response to the increase in demand for the services of intermediaries. The increase in competition is especially expected to shorten the delays in updating limit orders. The larger trading frequency, as such, will increase the penalty for delays in updating limit orders in the form of a larger number of trades at unfavourable prices. Furthermore, the increase in trading frequency will probably result in a reduction of the need to break up large orders over several days[8]. The comparison between the Nordic stock exchanges reported in Berglund, Wahlroos, and Örnmark (1983) lends some empirical support for the hypothesis that a higher trading frequency on the exchange will imply a lower degree of serial correlation in stock returns.

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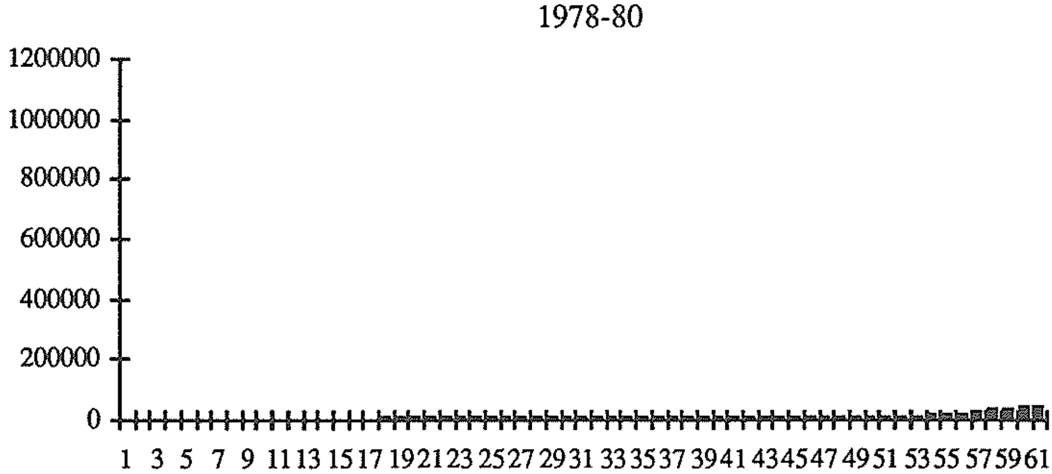
[6] *This argument can be found in Cohen, Maier, Schwartz, and Withcomb (1978), p. 161 in a slightly different context.*

[7] *See Berglund, Wahlroos and Örnmark (1983).*

[8] *This is true if the increase in turnover reflects an increase in the number of transactors, rather than an increase in the size of the portfolio of each transactor.*



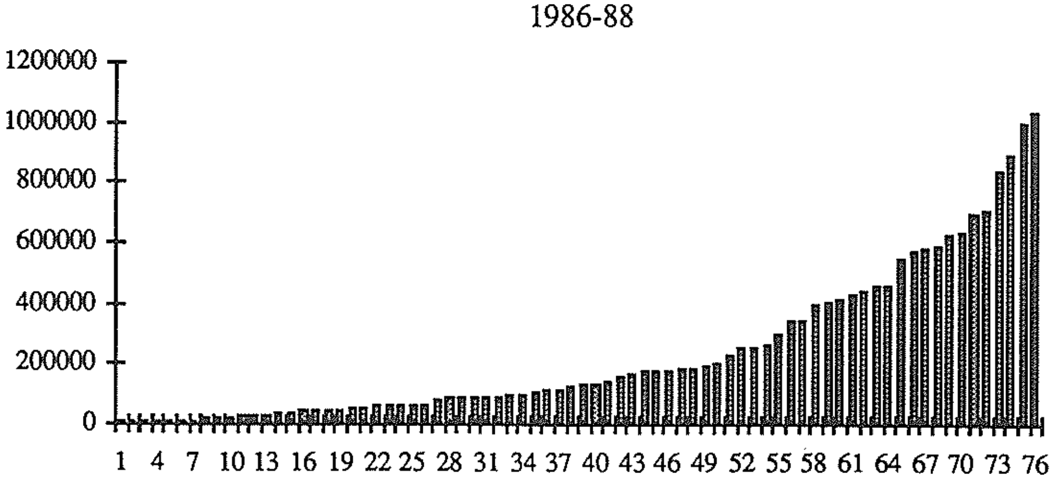


Figure 1. The average annual turnover in 1988-year FIM of individual stocks in the two sample periods. The stocks are ranked in order of increasing turnover. Stocks that have not been listed throughout the period have been omitted. The vertical scale is the same to facilitate comparison.

3. *The data*

The empirical analysis will be based on a comparison of stock returns generated during two distinct periods on the Helsinki Stock Exchange (henceforth the HeSE), the first — the low turnover period — being 1978 – 80, and the second — the high turnover period — being 1986 – 88. Table 1 gives a crude comparison of the 2 periods based on the average annual turnover for all stocks during the two periods.

Even in deflated form the increase is by a coefficient of 30. However, as a measure of average trading volume for individual stocks the average reported in Table 1 may be misleading if the number of listed stocks differ substantially between the periods. The number of listed companies in 1978 – 1980 was 49 to 50. In the later period the number was rapidly increasing from 51 at the end of 1985

Table 1. Average annual turnover on the Helsinki Stock Exchange during the two sample periods. The adjustment for inflation is based on the cost-of-living index and the conversion to USD:s on the average exchange rate during the year.

	in mil. FIM	in mil. 1988-year FIM	in mil. USD
1978–80	528	968	137
1986–88	28222	29199	6392

to 69 at the end of 1988[9]. Since this increase is minor compared to the increase in turnover, we would expect that the turnover for individual stocks was substantially higher in the latter period. Figure 1 confirms this conjecture.

The increase in turnover which is highlighted in Figure 1 was accompanied by an increase in the number of brokerage firms from 11 at the end of 1980 to 26 at the end of 1988. At the same time the two largest brokerage firms' shares of the annual turnover fell from above 50 % to approximately 30 %.[10]

The returns on which the analysis in the paper is based are computed as:

$$(1) \quad r_t = \ln \left(\frac{P_t + d_t}{P_{t-1}}\right),$$

where ln is the natural logarithm, P_t is the average of the lowest and highest trading price on day t, adjusted for splits, stock dividends and rights issues, and d_t the dividend at day t, taken to be 0 if the stock does not happen to go ex-dividend on that day. Days in which no trading in the stock has occured are omitted. Thus the number of observations may differ from one stock to another. However, to be included in the sample the stock had to be listed during the whole three-year period, and furthermore it had to be subject to trade during more than 80 % of all trading days in that period. Thus, we were left with 28 stocks in the first, low-turnover period and 56 stocks in the high-turnover period. Table 2 summarizes the information on the trading frequency in our two samples.

A general problem in the test design used in the present paper is that although the two periods are relatively close to each other in time, there are many other changes than the increase in turnover that may have affected the return distributions between the two periods. Among these factors one of the most important is that international investors discov-

Table 2. Characteristics of the low-volume (1978–80) and the high-volume (1986–88) samples[11] used in this study. The total number of trading days on the HeSE was 714 in the previous period and 748 in the latter[12]. The third column reports the average over the sample for the number of days with at least one transaction recorded for the stock. The last column reports the same number as a percentage of the total number of trading days on the exchange in the sample period.

Period	# of stocks in sample	Average # of days trading	Average rel.tr.freq.
78–80	28	668.0	93.55 %
86–88	56	705.2	94.28 %

[9] The number of listed issues on the exchange is substantially larger especially during the latter period due to the fact that the same company may have shares which are restricted vs. unrestricted (since '84) regarding foreign ownership and shares which differ with respect to voting power, listed separately on the exchange.

[10] The trading procedure remained the same on the HeSE throughout both periods although considerable strain on the system was occasionally experienced during the latter period. Each day, the trading started with a calling out, an auction in which all stocks were »called» out one by one. The purpose of this calling out was to find the right price interval. Trades were allowed after the calling out exclusively in the so-called bid-ask spread established in the double auction.

[11] The actual number of firms in the sample is smaller than the number of stocks since there are firms that have several issues listed on the exchange. Leaving only one issue per firm — the most frequently traded one — would have reduced the 78–80 sample to 23 stocks, with an average relative trading frequency of 94.1 %, and the 86–88 sample to 38 stocks, with an average relative trading frequency of 94.3 %.

[12] The surprisingly large difference between the number of trading days between the periods is explained by the fact that the exchange was closed on Mondays during the summer in the previous period.

ered the Finnish stock market in the beginning of the eighties. Foreign investments in Finnish stocks on a larger scale began to appear in 1982 and 1983. In the beginning of 1984 the HeSE started to list stocks which were unrestricted from foreign ownership separately from stocks that were restricted. In 1988 the law was modified changing the upper limit of foreign ownership in Finnish companies from 20 % of the equity to 40 %, while the upper limit on the voting power was kept at 20 %. In spite of their undisputable importance the effects of these changes as opposed to the effect of the increase in turnover will not be subject to analysis in this paper[13].

4. *Impact on volatility*

The main reason to expect a decrease in volatility in response to an increase in volume[14] is the fact that the increase in volume usually is accompanied by an increase in the number of traders. The price effects from idiosyncratic demand shifts tend to cancel out to a larger extent when there is a larger number of traders. Thus, we would expect a lower standard deviation in returns for individual stocks in the 1986 – 88 than in the 1978 – 80 period.

However, there is one serious problem which will hamper the comparison of the two periods. That problem is related to the crash in October 1987. The stock market volatility on the HeSE, as on other exchanges around the world, reached a record-level during that week. It is clearly inappropriate to treat this increase in volatility as a consequence of the higher trading volume on the HeSE. In the following we attempt to assess the impact of the October crash by reporting the results excluding the week that started on October 19th along with the results for the second period as a whole. Still, the »nervousness» created by the October crash probably had some effect on the volatility after the crash week as well.

As pointed out by Pagano (1985) we would expect an increase in trading volume to affect only the non-systematic volatility. In a CAPM world with a constant risk-free rate (r_f) the return on the i:th stock during period t (r_{it}) will depend on three separate random disturbances, i.e.

$$(2) \quad r_{it} = r_f + B_i\,((r_{mt} - \bar{r}_m) + (\bar{r}_m - r_f)) + \delta_{it} + \varepsilon_{it}$$

where the first random term is the difference between the realized market return, r_{mt}, and its expected value: $\bar{r}_m$. In the return for the individual stock this distrubance will be dampened or amplified by that stock's beta β_i, the second random term δ_{it} is due to new information which exclusively concerns company i, and which is interpreted in the same way by all individuals, and the third random term ε_{it} consists of the aggregate effect of the idiosyncratic demand shifts for all individual investors. The terms δ_{it}, and ε_{it} together constitute the non-systematic part of volatility. An increase in the number of traders will affect the volatility of the return exclusively through ε.

As in Pagano (1985) we will try to eliminate changes in the volatility which are due to changes in the market using a modified market model:

$$(3) \quad r_{it} = \alpha_i + \frac{\beta_i\,(r^*_{mt} + \rho_{-1}\, r^*_{mt-1} + \rho_{-1}\, r^*_{mt+1})}{(1 + 2\rho_{-1})} + v_{it},$$

where:
α_i = the market model constant, β_i = the OLS beta coefficient for stock i, ρ_{-1} = the first order serial correlation coefficient for the market return, v_{it} = the idiosyncratic return component of stock i, and r^*_{mt} = the market return in excess of its long-run mean. The modification to the standard market model is in essence the Scholes-Williams (1977) correction for non-synchronous trading.

The fact that returns on individual stocks on the HeSE[15] are subject to significant first order serial correlation will also affect the calculated daily volatility. As shown by Cohen Hawawini, Maier, Schwartz and Withcomb (1983) positive serial correlation implies that the computed standard deviation will be a

[13] *For an analysis of the pricing of restricted as opposed to unrestricted shares on the HeSE see Hietala (1989). A discussion of the impact on volatility along with some empirical results is found in Berglund and Liljeblom (1990).*

[14] *See Cohen, Maier, Schwartz, and Withcomb (1978), Garbade and Silber (1979), Tauchen and Pitts (1983), and Pagano (1989a).*

[15] *See e.g. Berglund, Wahlroos and Örnmark (1983).*

Table 3. Means and standard deviations multiplied by 1000 and corresponding cross-sectional dispersions (standard deviations of average) for log-price differences during the two periods[16]. The residual standard deviation denotes the deviation of v_i in expression (3). The CHMSW adj. standard deviation is computed separately for each stock using formula (4).

		# of stocks	Mean	St.dev.	Res.st.dev.	CHMSW. adj.
1978–80	Average	28	0.80	11.07	9.32	14.68
	st.dev.		0.08	0.61	0.54	0.75
1986–88	Average	56	1.40	20.70	17.11	21.33
	st.dev.		0.12	0.73	0.70	0.69
1986–88 Excl. crash week	Average	56	1.56	19.61	17.02	21.24
	st.dev.		0.12	0.74	0.70	0.69

Table 4. The results of a Wilcoxon-Mann-Whitney test for the equality of volatility in the two samples. (Critical value at the 1 % significance level for Z is 2.33.)

Volatility	incl.crash	excl.crash	market adjusted returns	CHMSW adj.
U:	59	107	116	232
E(U)	784	784	784	784
Std(U)	105.39	105.39	105.39	105.39
Z-val, for U – E(U)[17]	–6.87	–6.42	–6.33	–5.23

downward biased estimate of the true variance. They prove that an unbiased estimate of the true variance is provided by:

$$(4) \quad s^2_{adj.} = s^2 (1 + 2\sum_{i=1}^{n} \rho_{-i}),$$

where s^2 is the sample variance, ρ_{-i} is the serial correlation coefficient of order i, and n is the number of relevant coefficients. Based on our results on the autocorrelation structure of the returns that are reported below, as well as on the results on beta estimation reported in Berglund, Liljeblom, and Löflund (1989), we decided to keep n as low as 2.

[16] *The corresponding basic figures for the one stock/company sample are:*

		# of stocks	*Mean*	*St.dev.*	*CHMSW. adj.*
1978–80	*Average*	*23*	*0.78*	*10.71*	*14.13*
	st.dev.		*0.09*	*0.69*	*0.83*
1986–88	*Average*	*38*	*1.52*	*19.61*	*20.49*
	st.dev.		*0.16*	*0.84*	*0.77*

[17] *Follows the standardized normal distribution under the null-hypothesis of equivalence between the samples.*

The different volatility measures during the two periods are compared in Table 3.

The table clearly reveals that the change in volatility does not correspond to our expectations. Instead of a decrease we seem to observe a significant increase in volatility when we move from the 78–80 to the 86–88 period. This is the case even if we leave the crash-week out or adjust for market fluctuations using expression (3). The CHMSW-adjustment according to expression (4) brings the standard deviations most closely in line. Whereas the standard deviation on an average is approximately 45 % lower in the other cases the difference is reduced to somewhat above 30 % when the CHMSW (1983)-adjustment is used. This fact indicates that the serial correlation in returns was significantly stronger during the previous period.

As a further interesting detail we may note that only the unadjusted volatility seems to be affected by the omission of the crash week. For separate reasons the difference disappears in the adjusted returns. The fact that the difference in the case of market adjusted returns is negligible is explained by highly correlated fluctuations for individual stocks during the crash week. Removing the effect of the market removes the excess volatility for individual stocks. On the other hand, the fact that the omission of the crash week has a scant effect on the CHMSW-adjusted standard deviations is explained by a drastic change from positive to negative serial correlation in returns during the crash week. When the crash week is omitted the drop in volatility is counterbalanced by an increase in average serial correlation, an increase which makes the CHMSW correction more powerful. We will return to this subject below.

Since measured standard deviations are strongly affected by outliers, we used a nonparametric method to check for the robustness of the results. For this purpose a nonparametric test, the Wilcoxon-Mann-Whitney test, was used to compare the standard deviations is the two samples.

All four Z statistics are considerably higher in absolute value than critical values at any conventional significance levels. The results in Table 4 in general point in the same direction as those in Table 3. The change in the autocorrelation pattern is the most important single factor to exaggerate the true change in volatility when moving from the 1978 – 80 to the 1986 – 88 period. However, we still have to conclude that the volatility of the returns for individual stocks in the latter period was significantly higher than in the low-turnover period.

Referring to Table 3 we note that the average return was also considerably higher during the 1986 – 88 than during the 1978 – 80 period. To the extent that the higher volatility also is present in the market return the higher return may perhaps be interpreted as a higher risk premium due to the higher volatility. Another tentative explanation in which the causality is reversed is that the higher average return during the latter period gave less scope for the short selling restriction to dampen the fluctuations than during the previous period.

The considerably higher return in the 1986 – 88 than in the 1978 – 80 period coincides with a difference in economic activity in Finland. This fact may affect the observed difference in volatility between the two periods. On data for the U.S. Schwert (1989) found a significant relationship between the phase of the business cycle and the volatility of stock prices. According to Schwert's results the volatility tends to be higher in recessions than in expansions! This is, according to Schwert (1989), explained by the fact that the average leverage of firms tend to be higher during recessions.

The 1978 – 80 period in Finland marked the end of a recession, while the 1986 – 88 period was a period with a high level of economic activity. The average leverage during the first period was consequently higher than during the latter period. Thus, rather than being an explanation for our observed difference in volatility, Schwert's (1989) results point in the same direction as our original hypothesis.

5. *Impact on kurtosis*

A smaller kurtosis in return distributions is expected when the high-volume period is compared with the low volume period. This expectation is based in part on relative fluctuations in trading frequency, in part on the relationship between the trading volume and potential speculative profits, and finally in part on the average size of listed firms:

1. In Clark (1973) it is assumed that during days when trading is more frequent prices will fluctuate more than during days with less frequent trading. Since relative fluctuations in trading frequency will be higher for an infrequently traded stock than for a frequently traded one, return distributions ought to be more leptokurtic for infrequently traded stocks[18].

2. A small trading volume requires more significant news to create potential profit opportunities. Consequently, in response to a less significant news item no one may have the incentive to react, in the case of a thinly traded share, and the price may remain constant. Furthermore, several less important news items may occasionally accumulate to create a larger delayed reaction. Thus a thinly traded stock may exhibit a few large price reactions where a frequently traded stock would

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[18] *If the arrival of orders were independent of each other, the standard deviation of the number of orders per day would increase only in proportion to the square root of the expected number.*

Table 5. Average skewness and excess kurtosis and corresponding cross-sectional dispersions (standard deviations) for the averages computed on log-price differences during the two periods using formulas (5) and (6)[20]. The market adjusted return is defined as v_i in expression (3).

		Skewness		Excess kurtosis	
		unadj. returns	market adj. ret.	unadj. returns	market adj. ret.
78 – 80	Average	1.968	1.781	45.42	38.25
	st.dev.	0.740	0.668	13.38	11.94
86 – 88 incl. crash	Average	– 0.385	0.260	16.23	11.72
	st.dev.	0.168	0.159	2.20	1.78
86 – 88 excl. crash	Average	0.138	0.271	10.31	11.74
	st.dev.	0.132	0.160	1.35	1.78

exhibit a large number of small changes.

3. A large firm has more extensive operations and is consequently subject to more frequent changes than a small firm. On the other hand each change is probably less important for the large firm as whole than the change is for the small firm. Thus, a small firm is likely to produce less frequent but more dramatic news items than a large firm, which translates into a more leptokurtic return distribution for the small firm.

Finnish firms in the latter half of the eighties were clearly different from what they were at the end of the seventies. The most important change occurred in the degree of internationalisation. Operations in other countries contributed to a much larger part of the cash flow of listed firms in the latter period. Thus, rational cash flow estimates of the firms listed on the HeSE were to a larger extent affected by news items from other countries during the 1986 – 88 period than during the 1978 – 80 period. On the other hand, during the 1986 – 88 period the average piece of relevant news probably had a smaller effect on the value of the firm than during the 1978 – 80 period.

In Table 5 the excess kurtosis for the two periods are compared. To check for asymetries in the return distributions the skewness measure is reported as well.[19]

Table 6. The results of a Wilcoxon-Mann-Whitney test for equality of kurtosis in the two samples for unadjusted returns. (Critical values for Z are: 2.33 at the 1 % level and 1.64 at the 5 % level.)

	1978 – 80 vs. 1986 – 88 incl. crash	1978 – 80 vs. 1986 – 88 excl. crash
U:	900	1059
E(U)	784	784
Std(U)	105.39	105.39
Z-val. for E – U(E)	1.11	2.61

The effect of the crash is clearly seen in Table 5. When the crash is included the average skewness for unadjusted returns is negative. When we exclude the crash week, skewness turns positive and excess kurtosis falls by more than a third. However, when market-adjusted returns are used, the effect of excluding the crash week is negligible.

The results in Table 5 indeed indicate that kurtosis was lower during the latter period. This conclusion is somewhat impeded by the

[19] *The skewness and the excess kurtosis measures are computed as follows:*

$$\text{skewness} = \frac{\Sigma (r_i - \bar{r})^3}{\sqrt{(n-1)^3}\, \sigma_r^3}, \text{ and}$$

$$\text{excess kurtosis} = \frac{\Sigma (r_i - \bar{r})^4}{(n-1)^2\, \sigma_r^4} - 3,$$

where r_i is the change in the log price, $\bar{r}$ is the average r_i, σ_r is the standard deviation of r, and n is the number of observations.

[20] *The corresponding figures for the unadjusted returns in the one stock/company sample were:*

		Skewness unadj.returns	Excess kurtosis unadj.returns
1978 – 80	*Average*	*1.968*	*45.42*
	st.dev.	*0.740*	*13.38*
1986 – 88 incl. crash	*Average*	*– 0.385*	*16.23*
	st.dev.	*0.168*	*2.20*

fact that the cross-sectional dispersion in the kurtosis measures for the first period is so high. To further compare the kurtosis in the two samples the Wilcoxon-Mann-Whitney test was used. The results are reported in Table 6:

The results in Table 6 reveal that although equality of kurtosis in the two periods cannot be rejected when the crash week is included, leaving the crash week out allows us to reject the null-hypothesis at the 1 % significance level. Since it would be absurd to attribute the crash to the increase in trading volume on the HeSE, it seems that the higher trading volume indeed contributed to a drop in the leptokurtosis in stock returns between our two sample periods.

6. *Impact on serial correlation in returns*

According to Cohen, Hawawini, Maier, Schwartz and Withcomb (1980) we would expect positive serial correlation in returns because of specialist/dealer inventory rebalancing, the breaking up of large orders, and delays in updating limit orders on the books. All these reasons are probably more prominent for thinly traded than for frequently traded stocks.

There is one additional institutional phenomenon which has contributed to serial correlation in stock returns on the HeSE: Trading in each stock started with a »calling out», a double auction, during which only a part of the trades for the day were executed. The rest of the trades were defered to the so-called »aftermarket». In the aftermarket trades were allowed only in the closed interval limited by the highest bid and the lowest ask quoted at the end of the calling out. A price pressure in the aftermarket which would have driven the price out of the allowed range would have halted that day's trading. Furthermore, it would have produced a price change in the same direction on the following day, or in other words, serially correlated returns for these particular days.

We would expect a higher trading frequency to amplify the problems produced by this trading rule. A higher trading frequency is likely to increase the density of limit orders and thus to narrow the closing spread established in the calling out. The smaller spread would increase the probability that the true underlying price would move out of the established range in the aftermarket. The severity of this problem could have increased in the latter period in response to a relatively larger increase in trading volume on the aftermarket. The limited time reserved for each stock during the calling out[21] implied that a large part of the increase in volume spilled over into the aftermarket.

There is also another reason to suspect more positively biased serial correlation estimates in the 1986 – 88 than in the 1978 – 80 period. The reason is that the average between the lowest and the highest observed trading price is used to compute our returns. As noted by Working (1960) the use of prices which are aggregated over time will produce serial correlation in returns although the returns based on the original price series would be serially uncorrelated. On the other hand we may argue that the above described restrictions imposed by the exchange may have dampened this effect. Since the price movements in the aftermarket were strictly limited the average normally remained close to the last trading price.[22]

Table 7 reports pairwise and partial serial correlation coefficients for the two periods, for the latter period both including and excluding the crash. Since only transactions prices have been used to compute the returns some of the returns cover several days which implies a potential problem with heteroscedasticity. To correct for this problem the observations are transformed by dividing through with $\sqrt{t}$, where t is the number of trading days covered by the return[23].

The general pattern of serial correlation cor-

[21] No strict limits have been enforced for each stock, but since all listed stocks were to be called out each day the average time spent on each stock was limited. This limitation became more severe as the number of listed stocks increased, e.g. as consequence of the separate listing of unrestricted and restricted shares.

[22] Berglund (1986) p. 64 reports that the average first order serial correlation drops from .40 to .34 when it is computed on opening prices instead of on the difference between the highest and the lowest price in 1982 – 83 for the 13 most frequently traded stocks on the HeSE.

[23] This procedure assumes that the observed returns over several days are generated as if they were accumulated daily returns each being normally distributed with the same variance.

Table 7. Average serial correlation coefficients and their cross-sectional standard deviations computed from the 28 stock sample for the first period and the 56 stock sample for the latter period. The T-ratio denotes the average coefficient divided by the standard deviation of this average. Since the observations for different stocks cannot be regarded as independent, the critical values from the standardized t-distribution do not apply[24].

		Serial correlation coefficients of order				
		1	2	3	4	5
1978–80	Average	0.295	0.110	0.001	−0.045	−0.039
	T-ratio	13.01	7.03	0.10	−4.84	−2.67
1986–88 incl. crash	Average	0.066	−0.015	−0.013	−0.023	−0.012
	T-ratio	4.56	−1.90	−1.94	−3.73	−1.99
1986–88 excl. crash	Average	0.106	0.013	−0.025	−0.037	−0.016
	T-ratio	6.25	1.55	−3.39	−6.12	−2.31
1986–88 incl. crash market adj.	Average	0.054	−0.007	−0.030	−0.032	−0.018
	T-ratio	3.79	−0.88	−4.18	−5.58	−2.61

		Partial serial correlation coefficients of order				
		1	2	3	4	5
1978–80	Average	0.295	0.008	−0.040	−0.044	−0.010
	T-ratio	13.01	0.57	−4.29	−5.82	−0.81
1986–88 incl. crash	Average	0.066	−0.031	−0.009	−0.027	−0.009
	T-ratio	4.56	−4.07	−1.36	−4.47	−1.69
1986–88 excl. crash	Average	0.106	−0.015	−0.026	−0.035	−0.007
	T-ratio	6.25	−1.96	−3.75	−6.24	−1.06

responds to what has been reported in previous research on HeSE-returns, see e.g. Berglund, Wahlroos and Örnmark (1983). The first order serial correlation coefficients are clearly positive while the third and fourth order coefficients tend to be predominantly negative, at least in the case of partial correlation. When the two periods are compared, it turns out that, as expected, the serial correlation dropped substantially between the periods. This is true even when the crash week in October is left out in the second period. As can be seen in the graph in the appendix the October crash produced a remarkable negative serial correlation in market returns. That this is reflected in individual stock returns is seen in the average first order serial correlation coefficients in Table 7. The first order serial correlation is much lower when the crash week is included than when it is excluded.

In the section on kurtosis it was clearly shown that the return distributions during our two sample periods were more leptokurtic than a normal distribution. This was the case for the latter period even if the crash-week was left out. The observed leptokurtoris implies that the computed serial correlation coefficients may reflect the pattern in a few large returns rather than a general tendency in the data. To control for this, following Fama (1965), it is common to use non-parametric Wald-Wolfowitz runs tests to investigate whether the return series contains too few and consequently too long runs of positive, negative, or zero returns.

The basic statistics concering the runs of different kinds of returns are reported in Table 8. Panel A reports frequencies, that is the average of negative, zero, and positive returns, whereas panel B contains the observed and expected number of »runs», i.e. sequences of returns of the same sign. More precisely, panel B reports the aggregate frequencies of all runs as well as separately the number of negative, zero, and positive runs.

Surprisingly enough the drop in serial corre-

[24] *If no other common factors than the market would affect the returns for individual stocks, market adjusted returns would consitute an exception.*

Table 8. The average frequencies of total, negative, zero, and positive returns and the cross-sectional dispersion around this average measured by the standard deviation (Panel A), and (Panel B): the average frequencies of total (observed and expected under randomness), negative, zero, and positive runs, and the standard deviation around the average, plus the deviation from the expected value, absolute as well as relative.

Panel A		no. returns	no. neg. returns	no. zero returns	no. pos. returns
	Average	667.0	315.9	229.0	122.1
1978–80	st.dev.	37.8	66.8	60.2	93.6
	Average	705.2	331.0	275.2	99.0
1986–88	st.dev.	43.5	36.7	30.2	21.8

Panel B		Obs. no. runs	Exp. no. runs	Δ from exp.	Obs. no. −runs	Δ from exp.	Obs. no. 0-runs	Δ from exp.	Obs. no. + runs	Δ from exp.
1978–80	Average	349.8	395.2	−45.4	130	−17	76	−10	144	−18
	st.dev.	47.0	36.6	−11.48%		−11.82%		−12.00%		−10.89%
1986–88	Average	368.54	427.2	−58.7	147	−21	73	−12	149	−26
	st.dev.	27.16	22.9	−13.73%		−12.36%		−13.66%		−15.08%

lation present in Table 7 is not reflected in the results reported in Table 8. The deviation from what we would expect under randomness is in fact somewhat larger in the latter period especially in the case of plus runs. However, the overall deviation from what we would expect under randomness is quite evenly distributed over the three different categories of returns.

Statistics for the standardized deviation from the expected number are reported in Table 9. Under the null hypothesis of randomness the K value for each stock follows the standardized normal distribution.

The average K value reported in Table 9 exceeds the critical value on all commonly applied significance levels. Contrary to what we observed for the serial correlation coefficients the latter period seems more inefficient than the first. Assuming that the returns for the different stocks were independent[25] and that the standard deviation for the K-values are the same for the two samples, the difference between the average K:s can be subjected to a T^2 test. The T^2 statistic for the difference between the average K:s turned out to be 2.68 which can be compared with 2.75, which is the critical value for the F-distribution for 1, and 120 degrees of freedom (1, and 82 in this case) on a 10 % significance-level. Thus, the difference in the observed K:s between the two periods is not significant. This still leaves us with a puzzle: Why do we observe a significant drop in the average first order serial correlation while there is an increase in the average length of return runs in our sample?

The fact that the first order serial coefficient increased substantially when the crash week was left out in Table 7 indicates that the serial correlation pattern may be nonlinear. Whereas the serial correlation for small returns is positive, it may generally be negative for large changes, as it was during the

Table 9. The average standaridized deviation from the expected number of runs, and the number of negative deviations and their percentage of the total number (28 for the first period and 56 for the second) of stocks in the sample.

Deviation (standardized)		K	No. K<0
78–80	Average	−3.74	
	st.dev.	3.06	25
	st.dev. of mean	0.58	89.29%
	T-ratio	−6.47	
86–88	Average	−4.70	
	st.dev.	2.15	56
	st.dev. of mean	0.29	100.00%
	T-ratio	−16.33	

[25] *Individual stock returns are clearly not independent since all the stocks are affected by the market.*

crash week. To further test this hypothesis returns larger than .05[26] were separated from the rest of the sample. The correlation between these large returns and the preceding as well as the succeeding return was then computed. As a control the serial correlation coefficient based on small returns ($\Delta|\ln p| < 0.5$) was computed. The results are reported in Table 10.

Table 10 does not support the hypothesis of a general nonlinearity in the serial correlation pattern for both periods. Instead, Table 10 indicates that a change has occurred between the two periods. In the first period there is a surprisingly high correspondence between the serial correlation for small and large returns. In the latter period the first order serial correlation for the two groups is radically different. Furthermore, the difference observed for the latter period is not exclusively a consequence of the crash as can be seen by comparing the first order serial correlation coefficient for the small returns with the first order serial correlation coefficient obtained when the crash week was excluded. From Table 7 we find that the value was 0.106, which is at the 5 % level, one-sided test, significantly smaller than the value 0.147 reported for the small returns in Table 10. Thus, the exclusion of all large returns eliminates negative serial correlation beyond the negative serial correlation observed during the crash week.

The strongest negative serial correlation is found between the large negative and succeeding returns. The same pairs of observations have in many cases contributed to the significant correlation between large positive and their preceding returns. Thus it seems that what appears to be a short-run overreaction may generally have been present in price drops during this period.

The results in Table 10 explain the contradicting results found in the serial correlation as opposed to the runs tests during the 1986–88 period. The general serial correlation pattern that emerges is that long runs of small returns have been interrupted by some huge price oscillations. The small returns dominate in the runs tests, since all returns with the same sign carry the same weight,

Table 10. Serial correlation coefficients for large and small returns. T-ratios are reported in parenthesis. Stocks with less than five observations satisfying the criterion were dropped from the sample. The total number of stocks included are reported in italics. For the 1978–80 period results for positive and negative returns are not reported separately due to the small number of returns falling into each category.

	Period: 1978–80		
	ρ_{-1}		ρ_{+1}
$\lvert\Delta\ln P\rvert \le .05$		0.318 (18.05) *28*	
$\lvert\Delta\ln P\rvert \ge .05$	0.336 (2.83) *8*		0.359 (2.23) *8*
	Period: 1986–88		
	ρ_{-1}		ρ_{+1}
$\lvert\Delta\ln P\rvert \le .05$		0.147 (9.13) *56*	
$\lvert\Delta\ln P\rvert \ge .05$	−0.042 (−1.19) *56*		−0.229 (−6.97) *56*
$\Delta\ln P \ge +.05$	−0.251 (−5.76) *46*		−0.040 (−0.77) *46*
$\Delta\ln P < -.05$	0.171 (3.30) *45*		−0.468 (−8.76) *45*

whereas large returns dominate the serial correlation tests since a large return carries a much larger weight in the serial correlation coefficient.

For efficiency our results still indicate that the informational efficiency of the market has increased between the periods. This is supported by the following facts:

1. The first order serial correlation for small returns in Table 10 is still considerably below the average for the previous period.

2. In potentially profitable speculation strategies large returns are more important than small returns. If a third of the return on an average carries over to the following day, an expected return of 3 % requires a triggering return of 9 %. Triggering returns below 5 % will produce expected returns that will be

[26] *This value was somewhat arbitrarily selected to correspond to the lower magnitude to changes commonly considered as large.*

Table 11. Serial correlation in squared returns.

		Serial correlation coefficients of order 1	2	3	4	5
1978–80	Average	0.186	0.118	0.081	0.059	0.059
	T-ratio	8.09	7.75	7.95	5.55	4.84
1986–88 incl. crash week	Average	0.274	0.090	0.059	0.036	0.024
	T-ratio	17.77	10.97	7.73	7.27	3.72
1986–88 excl. crash week	Average	0.244	0.111	0.077	0.052	0.032
	T-ratio	16.52	11.11	8.36	7.96	4.65

washed out by transactions costs[27]. The fact that the serial correlation in 1986–88 for large returns was of opposite sign to the serial correlation for small returns, would have made a profitable mechanical trading strategy even more difficult to find ex ante[28].

The fact that large changes tend to be followed by large changes of opposite sign indicate that volatility cannot be considered constant at least during the latter period. Large changes followed by large changes imply that volatility changes and that volatility measures are serially correlated. To investigate whether this is the case the correlogram for squared returns was computed. The results are reported in Table 11.

The results in Table 11 reveal that there is indeed a stronger serial correlation present in volatility during the latter than during the previous period. An interesting fact is that the average serial correlation in squared returns does not drop very radically when the crash week is left out. This means that the higher serial correlation in volatility during the 1986–88 period cannot be attributed to the price gyrations during the crash week.

Although the increase in serial correlation in volatility coincides with the increase in volume, plausible explanations for a causal relationship between these phenomena are lacking. The hypothesis that this increase in serial correlation in volatility is due to a higher degree of dependence on a more volatile international stock market is left for future research.

The fact that the serial correlation in squared returns is quite high during 1986–88, along with the higher volatility during that period, imply that caution is warranted in empirical research on data from the HeSE which include this period. Unless this autoregressive conditional heteroscedasticity is properly handled results on data covering a longer time period may to a much too large extent reflect an unusual period on the exchange.

7. *Conclusions*

The purpose of this paper was to analyse how the enormous increase in trading volume on the HeSE during the first half of the eighties affected the return distributions of stocks listed on the exchange. The characteristics that we focused on were: volatility, excess kurtosis or fat-tailedness, and weak-form informational efficiency in the form of serial correlation in returns.

The analysis was carried out as a comparison of return distribution characteristics of listed stocks on the HeSE in 1986–88 with the distribution characteristics during the low turnover period 1978–80. In real terms the turnover on the HeSE during the latter period was 30 times higher than during the previ-

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[27] *During the 1978–80 period there was a 1 % stamp fee to be shared by the buyer and seller and a 1 % commission, producing a total cost of approximately 3 % for going in and out of a stock. The stamp fee was raised to 1.4 % in 1985. In the beginning of the second year of our high turnover sample, i.e. in 1987, it was again reduced to 1 %. The commission was made negotiable in the 1986–88 period, leading to an average of about .5 % for larger transactions. Thus the total cost was lower during most of the latter period.*

[28] *Note that the negative serial correlation coefficient, relatively high in absolute terms, reported in Table 10 for considerable negative returns is based on a small number of observations and can hardly be considered a very reliable estimate.*

ous period. To make our sample less heterogeneous during each period all stocks that were traded during less than 80 % of all trading days on the HeSE were omitted. This left us with 28 stocks for the first period and 56 for the latter period.

Contrary to our expectations it turned out that stock prices were more volatile during the latter period than during the first. This was the case even after making proper adjustments for changes in return serial correlation, as well as after leaving out the crash week 1987 from the comparison. An increased dispersion was also observed for market model residuals.

Several reasons were given for expecting a lower degree of excess kurtosis during the period with the higher turnover. As expected our results revealed that excess kurtosis was lower during the latter period.

Finally, in the case of weak form efficiency, we initially obtained some contradictory results. Based on the return correlogram it seems that the Finnish stock market was much closer to informational efficiency during the 1986–88 period than during the 1978–80 period. The average first order serial correlation dropped from 0.30 to 0.07. Since the crash in October 1987, as evidenced in the graph in the appendix, produced an element of strong negative serial correlation in individual stock with the huge drop on Tuesday the 20th and a partial recovery the following day, it was expected that leaving out the crash week would produce serial correlation coefficients for the 1986–88 period more in line with those found for the 1978–80 period. As expected, leaving out the crash week increased the average first order serial correlation coefficient, however, not more than from 0.07 to 0.11. Thus, even if the crash week is disregarded, the serial correlation pattern was weaker during 1986–88 than during 1978–80.

The robustness of the results from our serial correlation tests were checked using runs tests. Surprisingly the runs tests indicated that there was a larger negative deviation on an average between the observed number of runs and the expected number of runs during the 1986–88 period than during the 1978–80 period. As an explanation for this phenomenon a nonlinear serial correlation pattern was hypothesized. Correlation coefficients computed separately for large and small returns supported the hypothesis of a nonlinear serial correlation pattern exclusively for the 1986–88 period.

Serial correlation coefficients for squared returns finally indicated a stronger degree of serial correlation in volatility during the latter period. This difference was still present when the crash week was omitted from the 1986–88 period.

Overall, our results indicate the presence of considerable differences in the return distributions for individual stocks between the two periods. This implies that data for the HeSE spanning the end of the seventies and the latter part of the eighties should be used with considerable caution. Results based on the previous period cannot be expected to hold during the latter period. Deeper insights in the reasons for this change will be a considerable challenge for future research. For instance it will be highly interesting to try to disentangle those effects that come from the opening up of the Finnish stock market in the eighties from those that come from an increase in turnover on the exchange.

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Appendix

Differences of the logarithm of a value-weighted all shares index during the two periods.