The Economic and Social Review, Vol. 25, No. 2, January, 1994, pp. 157-177

Some Empirics of the ISEQ Index

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Abstract: This paper looks at the empirical distribution of the official index for the Irish Stock Exchange, ISEQ. Evidence is provided that the data are serially dependant, are characterised by long lags in their determination, show some temporal anomalies, are not normally distributed and are in fact of such a distribution that there is no doubt as to whether or not some of the standard finance theories are applicable in this case. Parameters of the underlying distribution are estimated, indicating a distribution of the stable paretian class.

I INTRODUCTION

This paper looks at the empirical distribution of the ISEQ — The Irish Stock Exchange Official Index. It is primarily driven by a desire to examine the distribution of that index, and in particular to re-address the issue of the existence of anomalies. This paper adds to the methodologies used in the papers of Donnelly (1991) and McKillop and Hutchinson (1987), who have already addressed this issue.

A large number of studies have come to the conclusion that there are persistent anomalies in the distribution of stock market indices internationally. (See Panas, 1990). Such analyses include persistent seasonal anomalies (Thaler, 1987). Some of these have been examined, in recent work on the Irish Stock market, in particular, McKillop and Hutchinson (1987), Coghlan (1988) and Donnelly (1991). All found that the stock exchange exhibited results that are contradictory to the efficient markets hypothesis. This paper finds further evidence that there are persistent anomalies. It finds

*I with to thank Jim Stewart of the School of Business Studies, and the participants in a seminar organised by the Dublin Economic Workshop, in particular Patrick Honohan. Two anonymous referees assisted greatly with the paper.

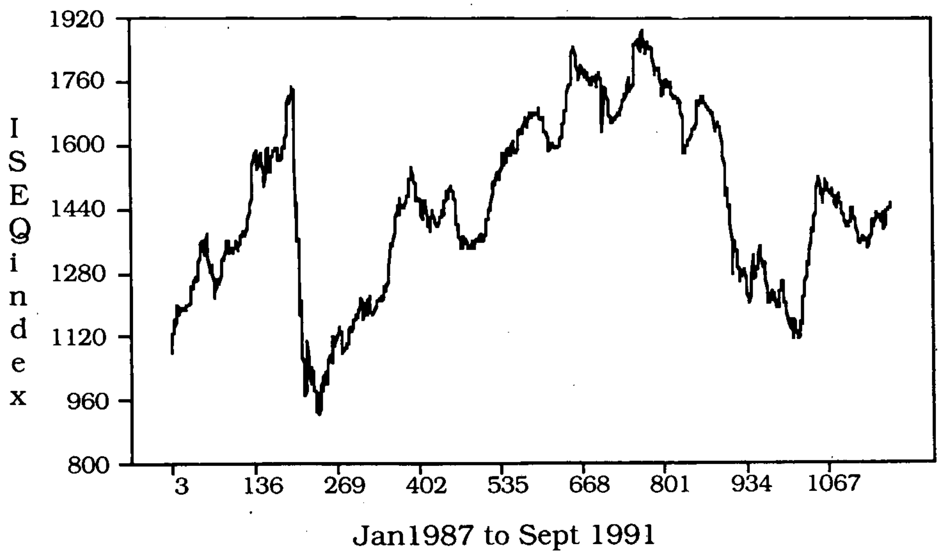
further evidence of the "Day of the Week" and "Month of the Year" effects and also of non normality in the distribution of the ISEQ index.

II DATA AND MODELS

The data used in this study are based on the daily closing values of the ISEQ from January 1987 to September 1991. The ISEQ is the official Irish stock exchange index. It is calculated four times daily. It is a value weighted Laspayeres index, the weights being the capitalised value of the stocks relative to the market, and being changed on a quarterly basis.

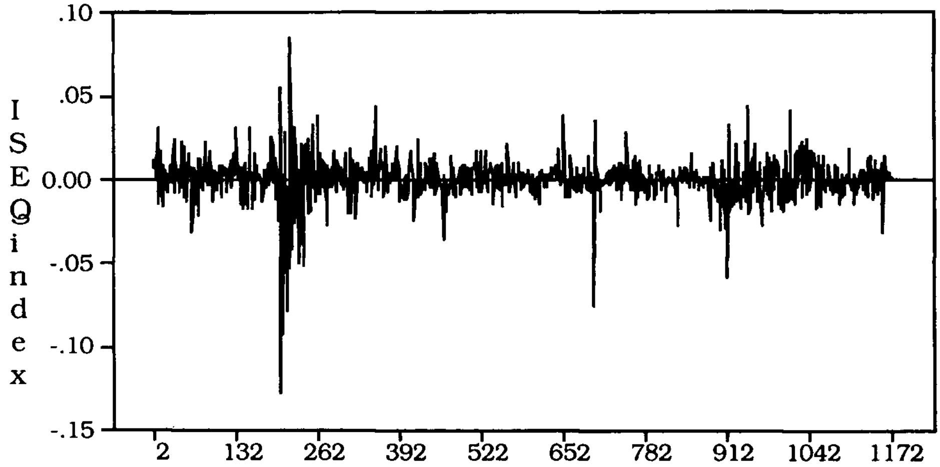
The data are expressed in percentage changes, calculated as $\text{Log}\left(\frac{\text{Pt}}{\text{Pt}-1}\right)$ where Pt denotes the price (the level of the index) in period t.

Weak form efficiency implies that the successive returns, including dividends, should follow a martingale process; that is, the returns should be serially independent, and they should be uncorrelated with past information in the information set. If we examine the basic data, we see the following pattern of distribution for the daily returns, the data that are to be analysed.

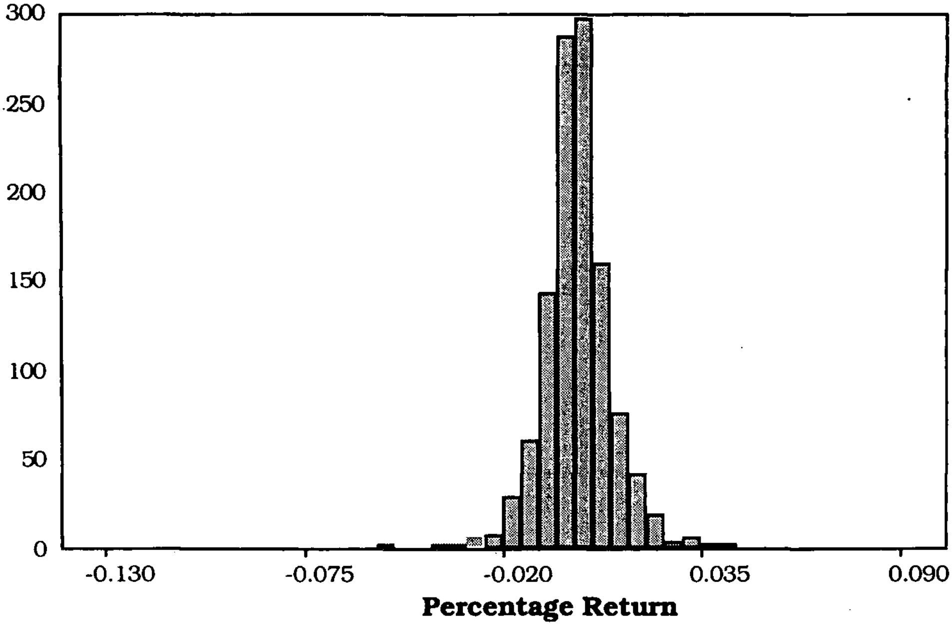


Graph 1: *The ISEQ Index over the Sample Period*

Clearly, the time period under analysis is, in many respects, atypical. There was a great deal of volatility in the ISEQ, which can be attributed to the initial stages of the Gulf conflict, relaxation of exchange controls, increasing economic confidence, the crash of 1987, and a number of other unusual happenings. The graphs below show respectively the daily percentage changes and the frequency distribution derived therefrom.



Graph 2: *Per Cent Changes in the Index, January 1987-September 1991 (Daily Basis)*



Graph 3: *Frequency Distribution of Daily Changes in ISEQ Index, January 1987-September 1991*

The objective of the paper is to more fully investigate these data in an attempt to investigate the distribution of the ISEQ.

III TESTS OF SERIAL INDEPENDENCE

Should we find stock data exhibiting serial dependence, we would be in a position of having found evidence contrary to the efficient markets hypothesis. The hypothesis, in its weakest form, would imply that there should not be persistence in the returns data. If there were persistent patterns, we would be in a position to obtain supernormal profits. The arbitrage principle, which states that no such opportunities should persist, would also be violated.

Studies of the New York, London, Frankfurt, Paris, Stockholm, Kuwaiti, Swiss, Milan, Hong Kong, Kuala Lumpur and Amsterdam Stock Exchanges show mixed evidence (see Panas 1990). In a study of 36 countries, Cooper (1982) found that only the UK and US showed evidence of serial independence. Both McKillop-Hutchinson and Donnelly, op. cit., have found some evidence that the Irish Stock Exchange is not efficient in the weak sense.

3.1 Autocorrelation Tests

Consider the autocorrelations of the data, which are formally defined as

$$\rho_k = \frac{\sum_{t=1}^{n-k}\left(x_t - \bar{x}\right)\left(x_{t-k} - \bar{x}\right)}{\sum_{t=1}^{n}\left(x_t - \bar{x}\right)^2}.$$

In a series that is intrinsically random, while the individual deviations from the mean of a lag would be non zero, on average they would be zero. Thus, on average, the squares of these deviations would also be zero.

The standard error of these autocorrelations[1] as defined by Bartlett in Kendall and Stewart (1961) is given as

$$\frac{1+\left(2\sum_{i=1}^{m}\rho_i\right)}{2}.$$

A table in the Appendix shows the coefficients. In the daily returns' series, 75 per cent of the first 20 autocorrelations are positive. This indicates that there is a systematic positive bias in the degree of serial correlation.

Might this be a reflection of the bull market during the period? As Bernstein and Bernstein (1988) state, about a selection of the Dow Jones stocks:

> Sheer price momentum had been the only functioning model for selected stocks: The stocks that moved were the stocks that were moving. Valuation parameters ... had been left far behind in the dusk.

1. For white noise, this reduces to $\frac{1}{\sqrt{n}}$. The series in question is not, however, white noise and so the more general formula is used. This was kindly pointed out by a referee.

3.2 Taylor's Price Trend Test

Taylor (1986) provides a test for the presence of a price trend in the series. This is given as

$$T^* = 0.4274\sqrt{n}\sum_{t=1}^{30} 0.92\rho_\tau$$

where ρ_τ is the τ_{th} autocorrelation coefficient.

This is claimed to have high power in testing for the trend-no trend hypotheses. Rejection of the null of no trend in the series is indicated if this test statistic T* is greater than 1.65. For the daily returns' series, T* = 8.7666, considerably higher than the 1.65 limit. Thus, there would seem to be a price trend present in the data. The strength of this serial dependence is also intriguing. For the daily data, the returns are strongly positively dependent up to lag 11.

Why this degree of persistence should be is unclear. Further details of the autocorrelations can be found in the Appendix. Interestingly, in Cooper (1982) the Irish market showed the highest absolute autocorrelation coefficient at .4, and had by far the highest degree of serial dependence. Inspection of the autocorrelation coefficients indicates a degree of cyclicality. This is not consistent with the price trend evidence, as that is calculated over a window of 30 observations. Why this persistent cyclicality should exist is a matter for further investigation.

3.3 Portmanteau Q Tests

We should note however that, even if there were to be strict white noise underlying the price returns, there would, by chance, be some coefficients that were significantly different from zero. To further investigate this, the Box-Ljung Portmanteau Q statistic is calculated. This is defined as

$$Q(k) = n(n+2)\sum_{m=1}^{k} \frac{1}{n-m}\rho^2 m,$$

where k = the number of auto-correlations calculated.

The statistic is therefore a test of the *equality* of the autocorrelations. Recall that we would assume that there would not be significant deviations from zero in a random series. Under the null that $\rho_i = \rho_j = 0$ for all i, j, the statistic is distributed as a χ^2 with k degrees of freedom. As the test statistic gets large, that indicates that the null is less likely to be accepted as if the null were true, then the individual summations would be small. Table 1 gives the Q statistics for the series.

Table 1: *Portmanteau Q Statistic for Two Series*

$\chi^2(300)$	=	56.91214	Not significant
$\chi^2(100)$	=	129.5494	Significant at 1%
$\chi^2(25)$	=	114.9427	Significant at 1%

The null being tested is that the autocorrelations are independent and identically distributed with zero mean.

At 25 lags, we cannot accept the null hypothesis of independence with zero mean. At 100 lags, or 10 per cent of the series length, the null is rejected at a significance level of 10 per cent for the daily series. At 300 lags for the daily series, equivalent to 25 per cent of the series length, there is non rejection of the null. Thus, there is evidence of extreme persistence in the data.

3.4 Cumulated Periodogram Tests

There is yet another form of test that may indicate the existence or not of an autoregressive process. That is to calculate the Durbin statistic, a cumulated periodogram that is distributed as a Kolmogorov-Smirov Statistic. The test is based on the cumulated periodogram which is given as the ratio of two autocorrelation functions.

$$\psi_j = \frac{\sum_{h=1}^{j} \rho_h}{\sum_{h=1}^{k} \rho_h} \quad j = 1 \text{ to } k$$

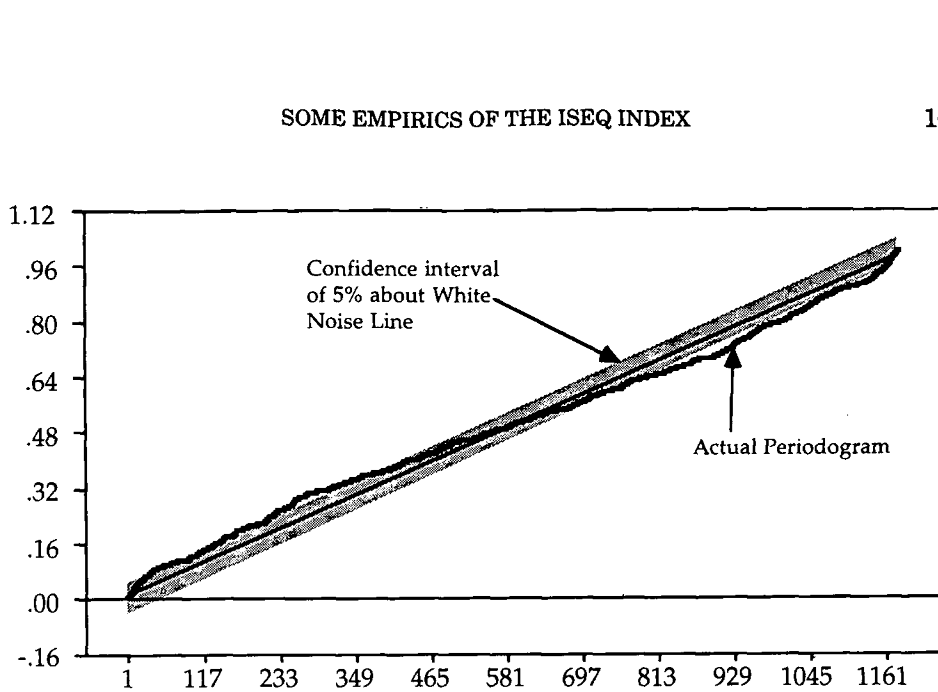
and the test statistic is given as the maximum gap between the cumulated periodogram and the theoretical distribution function for white noise, a straight line.

$$D_n = \max. \left| \psi_j - \frac{j-1}{k-1} \right|.$$

Table 2 and Graph 4 show the results of the test.

Table 2: *Cumulated Periodogram Test for Serial Independence*

Daily	Max.Gap = 0.0689	Entry 903	Critical Value = $\frac{1.358}{(\sqrt{n})}$ = 0.0396



Graph 4: *Cumulated Periodogram v White Noise for Daily Data*

We can clearly see that the test indicates that the null hypothesis cannot be accepted at 5 per cent confidence. Therefore, we would have to conclude that there exists further evidence that the data are not serially independent.

3.5 Unit Root Based Tests

An interesting statistical area that has come into prominence recently is the idea of cointegration. This tests whether or not series have a long-term stable relationship. Two series may each be I(1), that is to say they have unit roots in that $\chi_{t+1} = \alpha + \beta\chi_t + \varepsilon$ where $\beta = 1$ i.e., they are random walks, but their difference may be I(0), a stable, mean reverting series.[2] A test for the presence of a unit root is then a test of the statistical independence of a series in a sense. Two tests, both with the same limiting distribution and thus the same critical values are used most frequently to test for the presence of unit roots. These are the Dickey-Fuller test and the Phillips-Perron tests.[3] The results are shown below.

The null hypothesis is that there is a unit root in the series, at the appropriate number of lags. Presence of such a root would imply that the series is characterised by a random walk. The issue of whether or not there is a trend present may also be addressed.

2. I(n) refers to integration of order n, in that the nth differences of the series are stationary in the statistical sense that they are mean reverting.

3. See Phillips (1987), Phillips and Perron(1988), and Dickey and Fuller (1979).

Table 3: *Unit Root Tests*

Test Statistic	*Trend?*	*# of Lags*	*Daily Returns*
Dickey-Fuller	No Trend Present	0	–996.88
		1	–896.66
		2	–883.46
		3	–760.28
Dickey-Fuller	Trend Present	0	–968.00
		1	–899.03
		2	–887.41
		3	–764.84
Phillips-Perron	No Trend Present	0	–966.87
		1	–962.94
		2	–974.81
		3	–981.51
Phillips-Perron	Trend	0	–968.00
		1	–964.20
		2	–975.92
		3	–982.37

As we can see, given that the 5 per cent value is 2.89 and the 10 per cent one 2.58, there is clear rejection of the hypothesis of a unit root being present. This indicates that there is no evidence of a random walk characterising the series. Accordingly, there is further evidence against the market hypothesis.

3.6 Summary of the Tests

What then is the evidence, from the various tests, regarding the serial independence of the series? The results are summarised below.

Table 4: *A Summary of the Tests*

Test	*Result*
Autocorrelations	Not Independent
Portmanteau Q	Not Independent
Unit Root Tests	Not Characterised by a Random Walk
Cumul. Periodogram	Not Independent

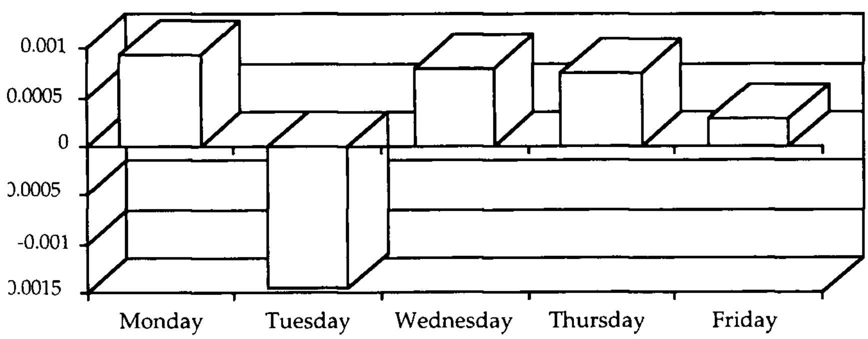
Therefore, we can conclude that, at the very least, there is evidence that the series are not serially independent. There is in fact evidence that there is a price trend in the series and that there is a high degree of serial dependence in the daily returns series.

IV EMPIRICAL ANOMALIES

This part of the study investigates the presence of daily and monthly anomalies that are associated with inefficient markets. Any persistent pattern that is known or knowable to an investor is potentially exploitable. As a consequence, it is evidence against semi-strong market efficiency, which states that trading rules or other publicly available information is useless for making abnormal returns, this information being reflected in the price already.

4.1 Day of the Week Effect

The graph below shows the daily average returns.



Graph 5: *Average Daily Percentage Changes*

To examine the possible day of the week effect, as seen in previous studies, the following regression, $R_i = \sum_{i=1}^{5} D_i$ where D_i is a dummy variable for day i, was run, and the overall significance of the set of explanatory variables checked by means of an F test. This imposes a joint test that all daily returns are equal to zero. The result of the regression F test is $F(4, 1166) = 1.538107$. This is not significant at the 10 per cent level, and so we conclude that there is at least one daily average return different to zero. As Tuesday is the day that has the highest average absolute return, and this return measures significantly different to zero (see Appendix) it was decided to investigate the possible existence of a Tuesday effect.

To further investigate the possibility of a Tuesday effect, it was decided to run the following regression:

$$R_i = \text{Constant} + \text{A Monday} + \text{B Wednesday} + \text{C Thursday} + \text{D Friday}.$$

If a Tuesday effect does exist, then the constant should be the same as the average Tuesday return, and the coefficients on the other daily dummy variables, which now measure the difference between the Tuesday mean return and the return on the individual days, should also be significant.

Table 5: *The Day of the Week Influence on the Data Adjusting for Tuesday Effect*

Variable	*Coefficient*	*T Statistic*	*Significant?*
Constant	–0.001462417	–1.827615	Yes, at 10%
Monday Dummy	0.002409973	2.082435	Yes, at 5%
Wednesday Dummy	0.002264791	2.005549	Yes, at 5%
Thursday Dummy	0.002208701	1.957903	Yes, at 5%
Friday Dummy	0.001741338	1.532264	Yes, at 15%

The constant is the exact same as the Tuesday average return, and the individual coefficients are all significant. There is further evidence of a Tuesday effect in the data. This is contrary to the usual pattern, which finds a significant positive Monday effect. Interestingly enough, there is some evidence that small markets tied to larger have a Tuesday effect (Corhay, 1990).

4.2 The Possible Bias of the Data

This section examines three possible explanations for the data anomalies examined above. First, we look at adjustments of hetroskedasticity. Then the possibilities of autocorrelation having an influence on the data are examined. Finally, the issues of holiday returns are examined.

4.2(i): Adjusting for hetroskedasticity

The utilisation of the regressions above assumes that the variance-covariance matrix is constant across days of the week. Empirically, it is the case that this is not so (see Appendix). Therefore, it was decided to adjust the regression using the Hansen-White procedure for hetroskedastic disturbances. This implemented (see Appendix for details of the results), we see that the marginal significance of the Monday and Tuesday effects are lower here, and the T statistics higher. There is now, at the 15 per cent level of confidence, a measurable Monday effect. Accordingly, it was felt that the possibility of autoregression causing the anomalies, which clearly do exist and are significant, as demonstrated above, should be investigated.

4.2(ii): Adjusting for autocorrelation

The Appendix shows the autocorrelations. Clearly, there are substantial positive autocorrelations in the index. This is to be expected where there are thinly traded or infrequently traded stocks. For further details, see Cohen, Hawawaini, Maier, Schwartz and Whitcomb (1980). If we adjust the data for the autocorrelation present in the data, as shown in the Appendix, we see the result that the Tuesday (and Monday) effects are washed out of the data.

Table 6: *Hetroskedasticity and Autocorrelation Adjusted Estimates of the Day of the Week Effects*

Variable	*Coefficient*	*T Statistic*	*Significant?*
Monday Dummy	.0009475559	1.056338	Not significant
Tuesday Dummy	–0.001462417	–1.619447	Not significant*
Wednesday Dummy	.0008023744	1.000113	Not significant
Thursday Dummy	.0007462843	.9453233	Not significant
Friday Dummy	.0002789213	.4619337	Not significant

*The marginal significance of the T statistic was 10.5 per cent.

Adjustment for first order autocorrelation can have an impact on the data. It can, in principal, allow the elimination of the anomalies. Testing for the presence or absence of the Tuesday effect while adjusting for hetroskedasticity and autocorrelation shows the following pattern.

Table 7: *Testing for the Tuesday Effect Including Adjustments for Hetroskedasticity and Autocorrelation*

Variable	*Coefficient*	*T Statistic*	*Significant?*
Constant	–0.001462417	–1.619447	Not significant*
Monday Dummy	.002409973	2.148677	Yes, at 5%
Wednesday Dummy	.002264791	2.125151	Yes, at 5%
Thursday Dummy	.002208701	1.846802	Yes, at 10%
Friday Dummy	.001741338	1.623410	Not significant*

*In both cases, the marginal significance levels were 10.5 per cent.

We must conclude that there is a persistent Tuesday effect in the daily stock data which is not attributable to a data artefact.

4.2 (iii): Adjusting for holidays

Disregarding the fact that there are multiday returns on weekends, there are still multiday returns where there are holidays in the week. It would be reasonable to assume that there are measurable effects in these cases, independently of any other adjustments. Thus, by removing the holiday returns, we may see an equalisation of the returns for the days of the week.

Table 8: *The Day of the Week Influence on the Data*
(Estimated over non holiday sample)

Day	*Coefficient*	*T Statistic*	*Significant?*
Constant	–0.001060018	–1.17085	No
Monday Dummy	0.002114312	1.90263	10%
Wednesday Dummy	0.001999940	1.71076	10%
Thursday Dummy	0.001772129	1.45252	No
Friday Dummy	0.00136444	1.22335	No

The data here are adjusted for the known hetroskedasticity and autocorrelation effects. As a result, we can see that, after incorporating these into the estimation procedure, we still have a measured Tuesday effect. The constant is in fact the same as the average return for Tuesday, excluding the holiday effects, but is not significantly different from zero. We also have a difference that is statistically significant as between Tuesday and Monday, and for the difference between Wednesday and Tuesday.

4.3 Month of the Year Effect

Following a similar motivation as the initial Day of the Week effect, a regression using dummy variables for the appropriate months was undertaken. The results, as summarised below, indicate that there are significant effects measured for a number of months.

Table 9: *Month of the Year Effects*

Variable	*Coefficient*	*T Statistic*	*Significant?*
January Dummy	0.003063151	2.568803	Yes, at 1%
February Dummy	0.002508312	2.063051	Yes, at 5%
March Dummy	0.001514341	1.257795	No
April Dummy	–0.0006789362	–.5528589	No
May Dummy	.001531106	1.326117	No
June Dummy	0.002078276	.1709353	No
July Dummy	0.002138884	1.835910	Yes, at 10%
August Dummy	–0.002023904	–1.713364	Yes, at 10%
September Dummy	–0.0002341078	–.1797318	No
October Dummy	–0.003189666	–2.392504	Yes, at 5%
November Dummy	–0.004279951	–3.267128	Yes, at 1%
December Dummy	0.001110356	.7817103	No

The F statistic is, at 9.344089, significant at the 1 per cent level. This confirms the suspicion that there are monthly/seasonal effects in operation. No significant differences arise to these estimates when adjusted for hetroskedasticity or for autocorrelation.

As November had the most significant deviation from zero, it was decided to investigate any evidence of a November effect. Table 10 summarises the results.

Table 10: *Evidence of a November Effect*

Variable	*Coefficient*	*T Statistic*	*Significant?*
Constant	–0.004279951	–3.26713	1%
January Dummy	0.007343102	4.14525	1%
February Dummy	0.006788263	3.79811	1%
March Dummy	0.005794292	3.25664	1%
April Dummy	0.003601015	2.00546	5%
May Dummy	0.005811057	3.32786	1%
June Dummy	0.004487779	2.51096	5%
July Dummy	0.006418835	3.66140	1%
August Dummy	0.002256047	1.27899	No
September Dummy	0.004045843	0.001847355	5%
October Dummy	0.001090285	0.001869094	No
December Dummy	0.005390307	0.001932278	1%

As is obvious, there is a significant set of differences as between most of the months of the year and November. We may therefore take this as evidence of a November effect in the ISEQ.

4.4 Other Moments of the Distribution

So far, we have been concerned with the mean. There are other moments of the distribution that bear investigation. In particular, we can see that the other moments of the distribution, apart from the mean, are significantly different from what one might expect in a standard normal distribution.

We have seen already that there are daily anomalies in the data. There appears to be a Tuesday effect, which may be related to the presence of multiday returns over holiday periods. Similarly, there is a significant degree of skewness and kurtosis present in the datasets under analysis. There is no case where the kurtosis coefficient is close to zero. In cases where the coefficient of kurtosis is negative, that indicates that there is a flatter peak to the distribution than the normal distribution. A positive kurtosis is evidence of a sharper peak. A coefficient greater than 3 indicates Leptokurtosis.

Donnelly (1991) found evidence that there was a Monday effect, in the sense that the highest mean return occurred on that day. The Tuesday effect is also found by him.

We can see explanations, or at least we can hypothesise about explanations for other effects. Thus, for example, the two main banks, which account for

20 per cent of the weight of the Index, report their results in June/July. There may well be tax effects (bed & breakfasting) in April. Further work on these hypotheses will have to be carried out. These findings on the moments of the distribution are in line with previous researchers, such as Fama (1965), Dryden (1970), and Panas (1990).

4.5 Studentised Range of tests for Normality

One of the statistical problems with utilising the coefficient of skewness and of kurtosis, as an indicator of normality, is that they are sensitive to outliers. As an alternative, the studentised range has been suggested. Fama and Roll (1968) and (1971) show that it has desirable properties against other goodness of fit measures, when the test is of normality versus other stable non-normal alternatives.

The studentised range is given as:

$$\frac{\left[\text{Max.}\{x_i\} - \text{Min.}\{x_i\}\right]}{\left|\frac{1}{n-1}\sum_{i=1}^{n}\left(x_i - \frac{1}{n}\sum_{i=1}^{n} x_i\right)^2\right|}$$

i.e., the range divided by the variance. This test was carried-out for the data in question. A point raised by a referee was the possibility that the non-normality of the data may result from the inclusion of the 1987 crash period in the data.[4] While the apparent Tuesday effect does reduce in the instance of the data being analysed over the 19880-1991 period inspection of the studentised range as shown below indicates that there is still non-normality present.

Table 11: *Studentised Range Normality Tests of the Distribution*

Series	*Obs*	*Studentised Range*	*Critical Values*
			5% 1
Daily changes	1171	1392.81	5.01
Daily changes excluding 1987 data	921	13083.01	5.01

The tables in Pearson and Hartley are calculated only to n=20. However, as $N \to \infty$ we note that the critical value decreases and so the n=20 bound is the upper bound for the achievement of normality. Clearly, as the calculated test

4. The daily/monthly anomaly tests were also carried out on data excluding the 1987 data. In both the month of the year and the daily data there was a reduction in the degree of anomaly present, but there was still a measurable day of the week/month of the year effect present.

statistic greatly exceeds the critical value, there is evidence of non-normality.

Are the returns' series then characterised by a different distribution to the normal?

4.6 Towards a Statistical Distribution of the ISEQ

Mandelbrot (1963) and Fama (1963, 1965) investigated the distribution of the log price changes of the price series, and hypothesised that the stable paretian distribution best fitted the data.

Any stable function has the form in logs of

$$\text{Log}\Phi(t) = i\delta t - \gamma|t|^{\alpha}\left[1 + i\beta\left(\frac{t}{|t|}\right)\omega(t,\alpha)\right]$$

where

$$\omega(t,\alpha) = \tan\frac{\alpha\pi}{2} \text{ if } \alpha = 1, \text{ and } \frac{2\log|t|}{\pi} \text{ if } \alpha \neq 1$$

where t is any real number and $\Phi(t)$ is the Fourier transform of the distribution function F(x). The parameters have the following interpretation that α is the kurtosis parameter, β is the skewness parameter, δ is the location parameter and γ is the dispersion parameter.

The α parameter determines the type of distribution, and is called the characteristic exponent. When $\alpha = 2$ the distribution is normal, when $\alpha = 1$ the distribution is Cauchy. The Mandelbrot-Fama hypothesis is that typically, stock returns have characteristic exponents bounded by 1 and 2, i.e., a stable paretian distribution => $1 \leq \alpha \leq 2$.

Fama and Roll (1971) suggest that the ratio

$$Z_f = \frac{[X_f - X_{1-f}]}{[X_{.72} - X_{28}]} * .827$$

where X_f is the f_{th} estimated fractile of the distribution is an estimate of the characteristic exponent. They suggest that a value of X_f in the range .95 – .97 provides a good estimate of the characteristic exponent. The exponents are calculated to be 1.45 in the case of the daily series. Referring to Table 2 in Fama and Roll (1971) this exponent is associated with an α value of 1.5. Clearly, the exponent is not such as to indicate that the distribution is normal. It does indicate that the distribution is stable. However, as the skewness is such as not to indicate symmetry, as is the case here, then there may well be a problem. One interesting possibility is that the nature of the index itself may impose problems.

Fama and Roll (1971) note that

> Stable Distributions are the only possible limiting distributions for sums of independent identically distributed random variables. (p. 834)

We know that there is some degree of doubt as to the randomness and independence of the index itself, and it may well be that the constituent parts of it, the underlying stocks are themselves neither independent, random, nor identically distributed. These questions are to be addressed in further work. We can note however that Cooper (1982) on examination of Allied Irish Banks, Bank of Ireland and three other shares[5] found that AIB showed significant deviations from the theoretical norm, while Bank of Ireland did not. First, this indicates that in the case of these two extremely important shares, there is a difference in the statistical distribution from which they are drawn, and thus any index that contains them is likely to not show itself as a stable distribution; second, the importance of AIB in the market index, comprising as it does approximately 10 per cent of the market itself. Finally, it is clear from recent work by Hutchinson and McKillop (1988) that there are questions that can be asked regarding the individual shares in the ISEQ. Work by Murray (1992) covering much the same period as this study found that the particular nature of the Irish stock market caused grave difficulties for the estimation of beta in that. This is in line with previous studies.

V CONCLUSION

This paper has looked at the distribution and empirical properties of the official index of the Dublin Stock Exchange, the ISEQ index. Three findings have emerged. First, the daily percentage changes of the index do not appear to be characterised by a random walk process. Second, there is evidence to suggest that there is a day-of-the-week/month-of-the-year effect in the data which may be attributable to the holiday pattern. Third, the distribution of the returns, while not normal, has been glimpsed. It appears to be of the stable paretian class of distributions, with a characteristic exponent of 1.5.

5. P.J. Carroll and Company, Irish Distillers and Irish Ropes.

BIBLIOGRAPHY

BERNSTEIN, P., and B. BERNSTEIN, 1988. "Where the Postcrash Studies Went Wrong", *Institutional Investor*, April.

COGHLAN, A., 1988. "Small Firms Versus Large on the Irish Stock Exchange", *Irish Business and Administrative Research*, Vol. 9.

COHEN, K., and G. HAWAWAINI, S. MAIER, R. SCHWARTZ, and D. WHITCOMB, 1980. "Friction in the Trading Process and the Estimation of Systematic Risk", *Journal of Financial Economics*, Vol. 12, pp. 249-257.

COOPER, J., 1982. "World Stock Markets: Some Random Walk Tests", *Applief Economics*, Vol. 14.

CORHAY, A., 1990. "Daily Anomalies in the Brussels Equity Markets", Proceedings of the European Finance Association Annual Meeting, Vol. III.

DICKEY, D., and W. FULLER, 1979. "Distribution of the Estimators for Time Series Regressions with a Unit Root", *Journal of the American Statistical Association*, Vol. 7, No. 366, pp. 427-431.

DONNELLY, R., 1991. "Seasonality in the Irish Stock Market", *Irish Business and Administrative Review*, Vol. 12.

DRYDEN, M., 1970. "A Statistical Study of UK Share Prices", *Scottish Journal of Political Economy*, Vol. 17.

DURBIN, J., 1967. "Test of Serial Independence Based on the Cumulated Periodogram", *Bulletin No. 2 of the International Statistical Institute*.

FAMA, E., 1963. "Mandelbrot and the Stable Paretian Hypothesis", *Journal of Business*, Vol. 36.

FAMA, E., 1965. "The Behavior of Stock Market Prices", *Journal of Business*, Vol. 38, pp. 34-105.

FAMA, E., 1970. "Efficient Capital Markets: A Review of Theoretical and Empirical Work", *Journal of Finance*, Vol. 25, pp. 383-420.

FAMA, E., and R. ROLL, 1968. "Some Properties of Symmetric Stable Distributions", *Journal of the American Statistical Association*, Vol. 63, pp. 817-836.

FAMA, E., and R. ROLL, 1971. "Parameter Estimates for Symmetric Stable Distributions", *Journal of the American Statistical Association*, Vol. 66, pp. 331-338.

HUTCHINSON, R.W., and D. McKILLOP, 1988. "Seasonality and the Small Firm Effect in Ireland", *Irish Business and Administrative Review*, Vol. 10.

KENDALL, M., and M. STEWART, 1961. *The Advanced Theory of Statistics Vol. II*, Griffin.

KENNEALLY, M., and L. GALLAGHER, 1992. "The Irish Unit Fund Industry: Structure and Performance", *The Economic and Social Review*, Vol. 23, No. 4.

McKILLOP, D., and R.W. HUTCHINSON, 1987. "The Relevance of a Beta Book for Ireland", *The Economic and Social Review*, Vol. 18, No. 4.

MANDELBROT, B., 1963. "The Variation of Certain Speculative Prices", *Journal of Business*, Vol. 36, pp. 394-419.

MURRAY, L., 1992. "A Test of the Stability of Beta Values Computed Using Irish Data", Presented to the Irish Accounting and Finance Association Annual Meeting.

PANAS, E., 1990. "The Behaviour of Athens Stock Prices", *Applied Economics*, Vol. 22, pp. 1,715-1,727.

PEARSON, E, AND H. HARTLEY, 1970. *Biometrika Tables for Statisticians*, Cambridge: Cambridge University Press.

PHILLIPS, P., and P. PERRON, 1988. "Testing for a Unit Root in Time Series Regressions", *Biometrika*, Vol. 25, pp. 335-346.

PHILLIPS, P., 1987. "Time Series Regressions with a Unit Root", *Econometrica*, pp. 277-301.

THALER, R., 1987. "Seasonal Movements in Securities Prices II", *Journal of Economic Perspectives*, Fall.

TAYLOR, S., 1986. *Modelling Financial Time Series*, John Wiley and Sons.

APPENDIX

FURTHER DETAILS OF THE DATA

Summary Statistics for Daily and Monthly Returns — Raw Data

	Mean	*Variance*	*Skewness*	*Kurtosis*
MON	0.0009475559	0.000174	–1.00	7.19•
TUE	–.001462417	0.000185	–3.17	25.31•
WED	0.0008023744	0.000151	–2.00	18.22•
THU	0.0007462843	0.000151	0.38	15.91•
FRI	0.0002789213	0.000086	0.22*	3.41•
JAN	0.003063151	0.000139	0.86	1.09
FEB	0.002508312	0.0000077	0.22*	1.03
MAR	0.001514341	0.000087	–0.45*	0.63
APR	–0.000678936	0.000067	–0.49*	1.22
MAY	.001531106	0.000062	1.90	8.84•
JUN	0.002078276	0.000038	0.59	1.49
JUL	0.002138884	0.000065	0.23*	2.03
AUG	–0.002023904	0.000163	–0.23*	3.87•
SEP	–0.0002341078	0.000059	0.74	1.81
OCT	–0.003189666	0.000623	–2.05	7.46•
NOV	–0.004279951	0.000342	0.41*	9.36•
DEC	0.001110356	0.000143	–1.42	4.40•

*Not significantly different from zero at 5 per cent confidence level.
•Leptokurtotic.

First 100 Autocorrelation Coefficients for Daily Changes

Autocorrelate	*Standard Error*	*T Statistic*	*Significant at 1%?*
0.17500	0.00090	193.42756	Yes
0.06690	0.00091	73.32612	Yes
0.02300	0.00091	25.18438	Yes
0.05040	0.00092	54.92616	Yes
0.12810	0.00095	135.47321	Yes
0.08340	0.00096	87.10785	Yes
0.03960	0.00096	41.24538	Yes
0.08550	0.00097	87.91125	Yes

First 100 Autocorrelation Coefficients for Daily Changes (continued)

0.10070	0.00099	101.73139	Yes
0.13450	0.00102	131.77153	Yes
0.04690	0.00102	45.78038	Yes
–0.00800	0.00102	–7.80819	Yes
–0.03100	0.00103	–30.20842	Yes
0.03930	0.00103	38.19845	Yes
0.03840	0.00103	37.23269	Yes
–0.04800	0.00104	–46.36427	Yes
0.03400	0.00104	32.77895	Yes
–0.03200	0.00104	–30.79893	Yes
–0.01400	0.00104	–13.47020	Yes
0.00860	0.00104	8.27355	Yes
–0.02200	0.00104	–21.14810	Yes
0.06140	0.00105	58.65997	Yes
0.02620	0.00105	25.00284	Yes
–0.03200	0.00105	–30.48703	Yes
–0.05600	0.00105	–53.08189	Yes
0.04960	0.00106	46.82919	Yes
0.00410	0.00106	3.87086	Yes
0.04340	0.00106	40.85057	Yes
–0.01000	0.00106	–9.41106	Yes
–0.03300	0.00106	–31.00234	Yes
–0.01400	0.00106	–13.14838	Yes
–0.01200	0.00107	–11.26744	Yes
0.01960	0.00107	18.39218	Yes
0.05680	0.00107	53.02606	Yes
–0.02700	0.00107	–25.17683	Yes
–0.01000	0.00107	–9.32327	Yes
0.01400	0.00107	13.04851	Yes
–0.00900	0.00107	–8.38725	Yes
–0.03300	0.00107	–30.70013	Yes
–0.04500	0.00108	–41.72978	Yes
–0.06800	0.00109	–62.60065	Yes
0.02800	0.00109	25.74506	Yes
0.00100	0.00109	0.91946	No
–0.04600	0.00109	–42.15554	Yes
–0.04800	0.00110	–43.83060	Yes
–0.04800	0.00110	–43.67393	Yes
–0.01500	0.00110	–13.64334	Yes
–0.03700	0.00110	–33.58228	Yes
–0.03700	0.00110	–33.51128	Yes
0.02260	0.00110	20.45292	Yes
0.00300	0.00110	2.71495	Yes
0.01700	0.00111	15.37787	Yes
–0.05300	0.00111	–47.73596	Yes
–0.06200	0.00112	–55.51435	Yes

First 100 Autocorrelation Coefficients for Daily Changes (continued)

–0.02200	0.00112	–19.68410	Yes
0.00480	0.00112	4.29456	Yes
0.04570	0.00112	40.75795	Yes
–0.04000	0.00112	–35.58776	Yes
–0.05000	0.00113	–44.31664	Yes
–0.01100	0.00113	–9.74788	Yes
–0.01000	0.00113	–8.86037	Yes
–0.00300	0.00113	–2.65807	Yes
0.00170	0.00113	1.50624	No
0.01810	0.00113	16.02905	Yes
0.01730	0.00113	15.31366	Yes
0.02880	0.00113	25.46139	Yes
–0.02300	0.00113	–20.31755	Yes
–0.05200	0.00114	–45.74900	Yes
–0.03300	0.00114	–28.98567	Yes
–0.03500	0.00114	–30.68608	Yes
–0.02100	0.00114	–18.39952	Yes
0.05450	0.00115	47.54018	Yes
0.01410	0.00115	12.29575	Yes
–0.00400	0.00115	–3.48807	Yes
–0.04000	0.00115	–34.79795	Yes
–0.01100	0.00115	–9.56772	Yes
–0.00900	0.00115	–7.82719	Yes
0.00250	0.00115	2.17420	No
–0.00900	0.00115	–7.82618	Yes
–0.05200	0.00115	–45.03738	Yes
–0.05200	0.00116	–44.85825	Yes
–0.03800	0.00116	–32.71156	Yes
0.00670	0.00116	5.76718	Yes
0.01780	0.00116	15.31465	Yes
–0.03300	0.00116	–28.34704	Yes
–0.01000	0.00116	–8.58876	Yes
0.02560	0.00117	21.96613	Yes
0.02000	0.00117	17.15100	Yes
0.02990	0.00117	25.60728	Yes
0.00530	0.00117	4.53890	Yes
–0.03700	0.00117	–31.62342	Yes
–0.01600	0.00117	–13.66989	Yes
0.02650	0.00117	22.61762	Yes
0.00140	0.00117	1.19489	No
0.00680	0.00117	5.80336	Yes
–0.03800	0.00117	–32.36254	Yes
0.01610	0.00117	13.70634	Yes
0.05160	0.00118	43.75927	Yes
0.04510	0.00118	38.13480	Yes
0.00830	0.00118	7.01746	Yes

Hetroskedasticity Adjusted Estimates of the Day of the Week Effects

Variable	*Coefficient*	*T Statistic*	*Significant?*
Monday Dummy	.0009475559	1.448907	Not significant
Tuesday Dummy	–0.001462417	–1.907750	Yes, at 10%
Wednesday Dummy	.0008023744	.9102802	Not significant
Thursday Dummy	.0007462843	.7588401	Not significant
Friday Dummy	.0002789213	.2551153	Not significant