# Market Efficiency within the German Stock Market: A Comparative Study of the Relative Efficiencies of the DAX, MDAX, SDAX and ASE Indices

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## ABSTRACT

It can be implied from the efficient market hypothesis that the more transparent a market is, then the more likely that the market will be efficient. This paper is a study of whether the different transparency standards applied to the different indices quoted on the German stock market have any impact on their relative efficiencies. It is found that the differences in transparency standards do have an impact on market efficiency. The case for a higher level of market efficiency in respect to Prime Standard index stocks is reinforced by the additional finding that calendar anomaly effects appear to have only limited statistical significance.

**Key words:** *Market Efficiency, Calendar Anomalies, DAX, Transparency Requirements*
JEL Classifications: C10, C12

## 1. INTRODUCTION

Most of the evidence available indicates that academics trend to support the efficient markets hypothesis (EMH) in some form or other whilst practitioners tend not to (See, for example, Flanegin and Rudd, 2005). This paper attempts to take this debate further by examining the impact on market efficiency of the differences in informational requirements (transparency standards) for stocks listed on the senior and junior stock markets in Germany. Fama (1991) identified that different levels of information flowing into a market will result in different levels of market efficiency. This study applies runs tests and serial correlation tests to identify what proportion of the prices of stocks listed on the different indices follow a random walk. In addition, a related secondary study of market efficiency is undertaken by examining whether or not there are differences between the Prime Standard indices in respect to calendar anomaly effects.

Section 2 of this study introduces the concept of market efficiency and subsequently Section 3 identifies the different information requirements made of companies listing on the different German indices. This is followed in Section 4 by an examination of the methodology and data used. The empirical results are presented and discussed in Section 5 and finally, conclusions are drawn in Section 6.

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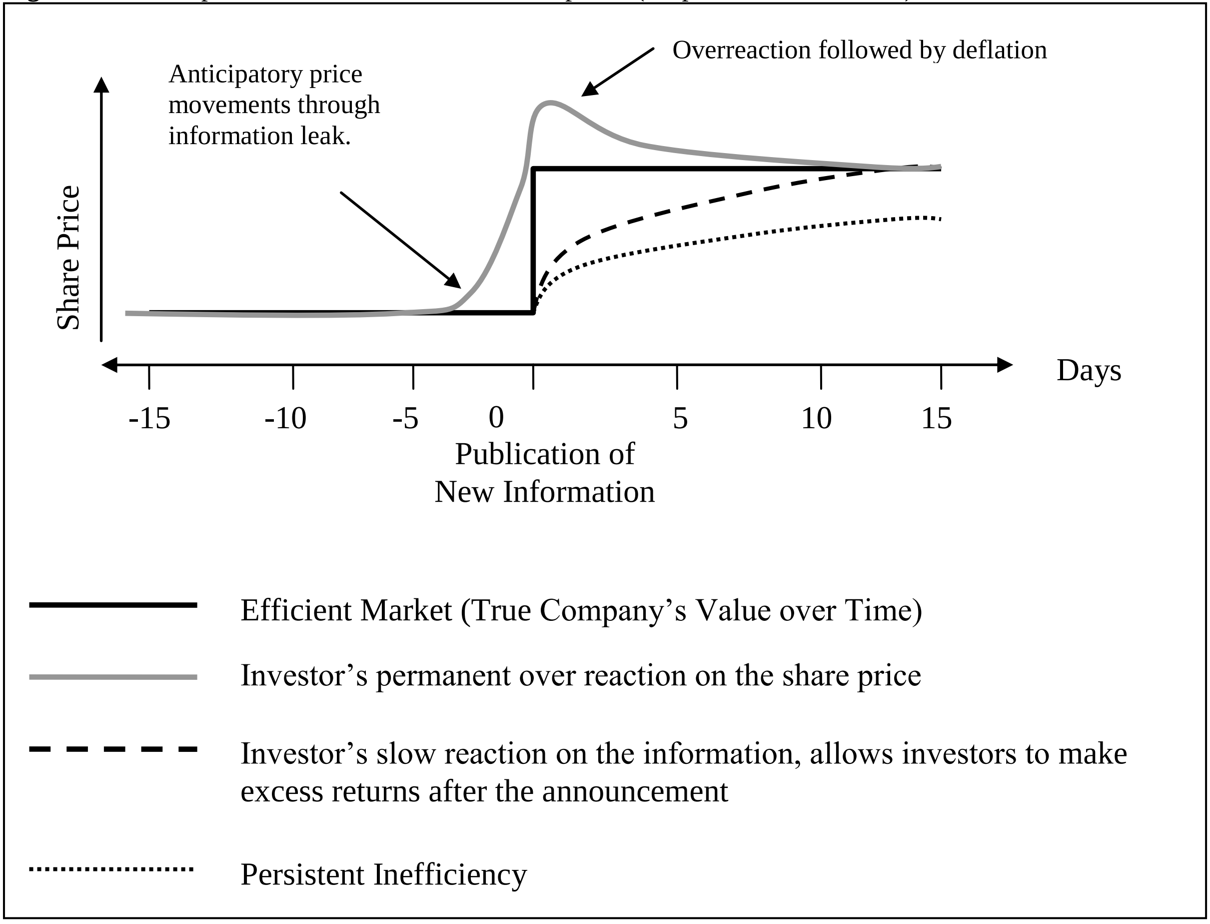
## 2. MARKET EFFICIENCY

Market efficiency implies that future returns are unpredictable from past returns and therefore as new information enters the market, stock prices will follow a random walk. Glen (1998) identified graphically the relationship between the level of market efficiency and the way that new information impacts on market prices. This is shown in Figure 2.1.

**Figure 2.1** The impact on new information on stock prices (adapted from Glen 1998)




If the market is efficient then the impact of the new (previously unknowable) information on price is immediate and price movements over time should be random and not predictable. If however the process of price adjustment to new information follows a regular pattern (for example, as shown in Figure 2.1, resulting from the slow reaction of markets to the new information) then future share prices will be to some extent predictable and the market will not be completely efficient.

Fama (1970) identified different levels of market efficiency. The weak form of the EMH requires that future prices cannot be predicted from historical price data. This does not require the market price to be equal to the true value at every point in time but it does require that errors in the market price are random and unbiased. If the deviations from the true value are random it follows that no investor should be able to identify under or over valued stocks from past price data. This means that price movements should follow a random walk which Malkiel (2003, p. 1) defines as: "(the) idea that if the flow of information is unimpeded and information is immediately reflected in stock prices then tomorrow's price change will reflect only tomorrow's news and will be independent of price changes today". A number of studies have been undertaken of the DAX index suggesting that it does indeed follow a random walk and is therefore weak form efficient. For example, Voit (2001), Franses and Van Dijk (2000).

If a market is efficient and follows a random walk then it should not be possible to find ‘calendar anomalies’ within stock price data (for example, higher returns are made in January). There are, however, a significant number of studies in the literature that suggest calendar anomalies exist. For example, Siegel (2002) and Cornett et al. (1995). These types of anomalies are inconsistent with efficient markets as investors should not be able to find patterns in future stock prices with the help of historical data (Fawson et al., 1995). Although the studies cited above suggest that there is evidence of the DAX following a random walk, there are also a number of studies which suggest that calendar anomalies can be found in the German markets. For example, Hansen and Lunde (2003).

This study attempts to identify whether or not the differences in the transparency standards (information requirements) applied to the different indices of the German market have an impact on their relative efficiencies. The methodology applied is to examine how closely stocks within these indices follow a random walk and whether or not the returns to these stocks show evidence of calendar anomalies.

## 3. TRANSPARENCY REQUIREMENTS IN THE GERMAN STOCK MARKET

The German stock market has different transparency standards for access to different elements of its capital market. These are: the Prime Standard, the General Standard and the Entry Standard. The first two fulfill the highest international transparency requirements and are requirements for stocks listed on the DAX, MDAX, TECDAX and SDAX. The Entry Standard provides small to medium sized companies fast and cost efficient access to the capital market. It requires companies to publish significantly less detailed performance-related information than the Prime Standard and it can therefore be argued that trading on this market is likely to be less efficient.

The constituents of the DAX index are the 30 largest German companies in terms of turnover and market capitalization. The MDAX index contains the next 50 largest companies by way of turnover and market capitalization and the SDAX the subsequent 50 largest companies. The All Share Entry (ASE) index constituents are the companies that are traded on the basis of the Entry Standard requirements. These tend to be companies that are relatively new and less well established and tend to be significantly smaller in terms of turnover and market capitalization[1].

## 4. METHODOLOGY AND DATA

### 4.1. Methodology

The primary objective of this paper is to identify any differences in the levels of efficiency of the Prime Standard and Entry Standard indices of the German stock market. The study tests for the presence of random walks within stock prices using both runs tests and serial correlation tests (with a single lag). This dual approach is followed to examine for consistency

[1] Further information on German stock market transparency standards and performance indicators is available on the German stock market homepage (http://deutsche-boerse.com).

within the test results. The tests are undertaken on a randomly selected number of stocks from each index[2].

Calendar anomaly effects are also tested for in order to provide additional evidence. These tests use both daily and monthly data. The method applied is to identify any statistically significant differences in the mean returns between the relevant period (day or month) and the remaining periods in the calendar. In addition, further evidence is presented in the form of the returns from simulated trading strategies based on these effects.

### 4.2. Data

The source of the data used in this study is Yahoo Finance[3]. The serial correlation tests, runs tests and day-of-the-week effect tests use daily data on individual company stock prices covering the period 1st January 2005 to 1st January 2007. Month of the year effects are examined over the period 1st January 2001 to 1st January 2007. The number of observations for serial correlation tests, runs tests and day-of-the-week effects tests is 508 for the majority of companies[4]. The names of the individual stocks used for these tests can be found in the Appendix. The analysis of month-of-the-year effects uses 72 monthly observations.

## 5. EMPIRICAL RESULTS

### 5.1. Serial Correlation Tests

The statistical significance of any first order[5] serial correlation identified was estimated using *t*-tests. The values of the estimated *t*-statistics are shown on the *y*-axis in Figure 5.2. Rejection of the null hypothesis at the 5% significance level (given by an approximate value of $t \geq 2$) identifies that a stock price is not following a random walk[6].

Figure 5.2 identifies that the hypothesis of no serial correlation is rejected for relatively few of the Prime Standard index stocks (around 10%) but for a relatively large proportion of the Entry Standard index company stocks (47%). This is indicative of the Prime Standard markets being more efficient than the Entry Standard market.

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[2] 10 stocks are used from the DAX index, 14 stocks from the SDAX and 15 stocks from each of the MDAX and ASE indices. These represent one third of the constituents of the DAX, 28% of the SDAX, 30% of the MDAX and 20% of the ASE.

[3] (http://uk.finance.yahoo.com).

[4] There were fewer observations available for HII Hanseatische Immobilien Invest AG, NanoFocus AG and ZertifikateJournal AG.

[5] Serial correlation tests with up to a lag of 5 were produced. As the first lag produced the strongest evidence of correlation by a substantial margin only these results are reported.

[6] Serial correlation is estimated as follows:

$$\alpha_k = \frac{\sum_{t=k+1}^{n} (Y_t - \bar{Y}) \cdot (Y_{t-k} - \bar{Y})}{\sum_{t=1}^{n} (Y_t - \bar{Y})^2}$$

where $Y_t$=current rate of return, $\bar{Y}$ = mean rate of return, $k$= number of lags. (Source: White, 1961)
The associated *t*-statistics are estimated by:

$$t_I = \frac{\alpha_k \cdot \sqrt{n-2}}{\sqrt{\mathbf{1} - \alpha_k^2}}$$

Within the Prime Standard there are significant differences. As identified in Figure 5.2, all of the DAX stocks follow a random walk whilst the respective figure for the MDAX is 7% and for the SDAX 21%. These can be contrasted with the 47% of Entry Standard stocks that do not follow a random walk. These results suggest the conclusion that the more senior the market and the more widely traded the stock then the more efficient the market will be.

**Figure 5.2** Significance of serial correlation tests on individual stocks

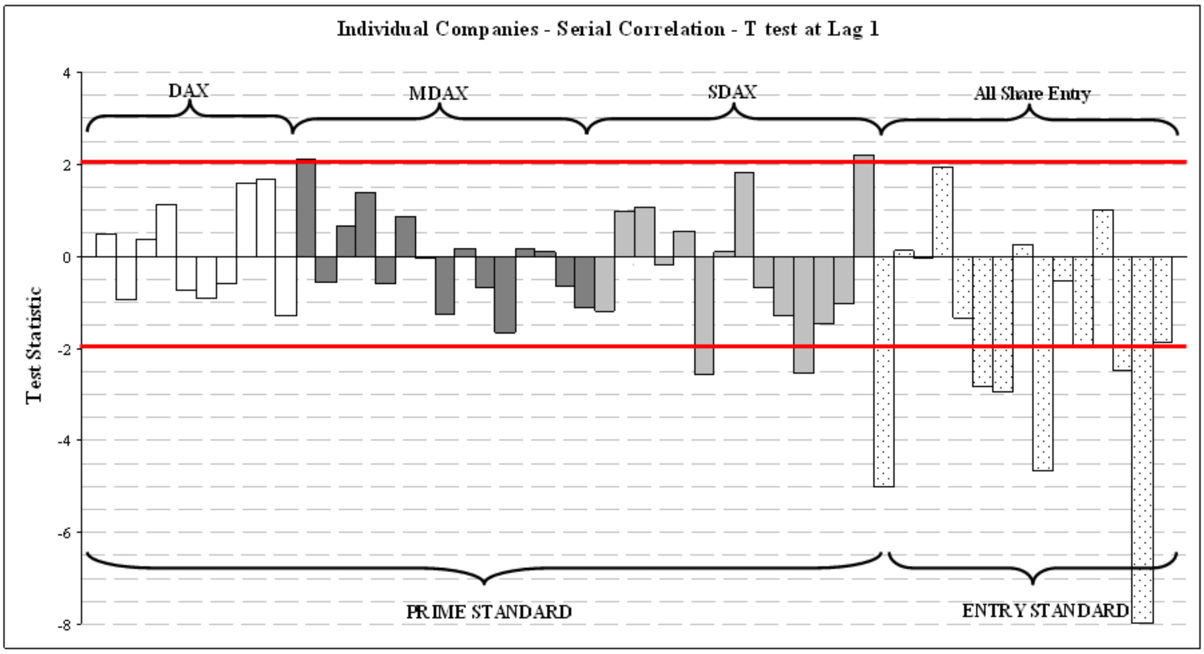
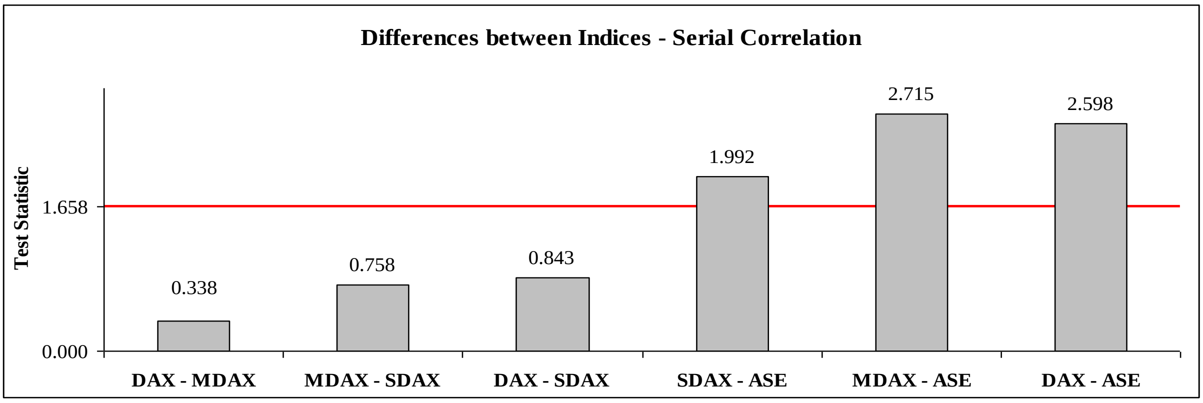



**Figure 5.2a** Statistical significance of between-index differences in the serial correlation tests




Further tests were undertaken to test for the statistical significance of the differences between the numbers of individual stocks in each index following a random walk[7]. The results of these tests, presented in Figure 5.2a, suggest that the degree to which the Entry Standard ASE is less efficient than the other indices is statistically significant[8].

[7] The test statistics for Figure 5.2a were calculated as follows:
$$T_I = \frac{\bar{R}_i - \bar{R}_k}{\sqrt{\frac{s_i^2}{n_i} + \frac{s_k^2}{n_k}}}$$

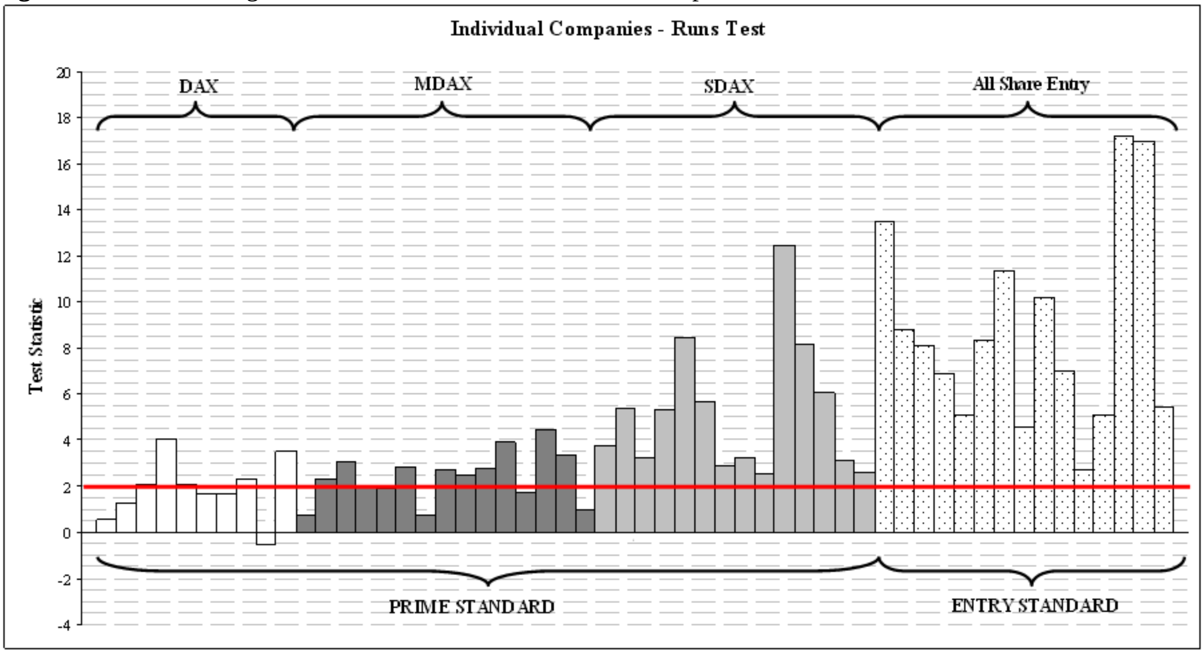
where $\bar{R}$ is mean percentage of stocks following a random walk for each index.

[8] At the 5% level, where $t \geq 1.658$. A 1-tail test is used to test whether the efficiency of the senior market is significantly higher statistically than that of the junior market.

## 5.2. Runs Tests

The runs test examines whether there is a statistically significant difference between the actual and 'expected' numbers[9] of runs of a specific length. Figure 5.3 identifies that for most of the individual companies analyzed, the actual number of runs to be higher than the 'expected' number. There are also clear differences between Entry Standard and Prime Standard companies. The tests undertaken[10] indicate that the hypothesis of stock prices following a random walk can be rejected at the 5% level ($z \geq 1.96$) for all of the Entry Standard and SDAX companies.

**Figure 5.3** Statistical significance of runs tests on individual companies




These results suggest clear differences between the market efficiencies of companies in the senior Prime Standard indices and those in the junior Entry Standard (ASE) index. The percentage of companies in each index where the random walk hypothesis is rejected was 50% for the DAX, 67% for the MDAX and 100% for both SDAX and ASE.

The relatively high efficiency found in the DAX index and the relatively low levels of efficiency found in the ASE and the SDAX indices are similar to the findings of the serial correlation tests.

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[9] The number of expected consecutive (positive and negative) runs in stock prices if stock prices follow a random walk.

[10] The test statistics for the runs test are estimated as follows (Source: Wald and Wolfowitz, 1940):

$$Z_I = \frac{R_I - E(R)}{\sigma_R}$$

where: number of runs = $R$, standard deviation= $\sigma_R$

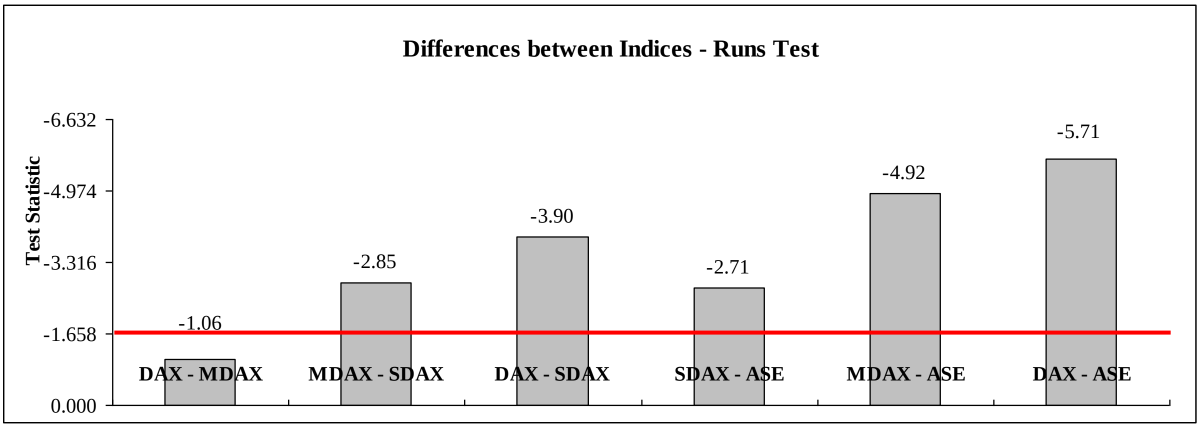
$$E(R) = \frac{2 \cdot N_1 \cdot N_2}{N} + 1$$

where: number of positive changes=$N_1$, number of negative changes=$N_2$

$$\sigma_R = \sqrt{\frac{2 \cdot N_1 \cdot N_2 \cdot (2 \cdot N_1 \cdot N_2 - N)}{N^2 \cdot (N-1)}}$$

Figure 5.3a examines the statistical significance[11] of the differences between the numbers of individual stocks in each index following a random walk[12]. These suggest that the degree to which the Entry Standard ASE and the SDAX index are less efficient than the other two indices is statistically significant.

**Figure 5.3a** Significance of between-index differences for runs tests




## 5.3. Implications of the Serial Correlation Tests and Runs Tests Findings

The serial correlation results suggest higher levels of market efficiency than the results indicated by the equivalent runs tests. Both sets of tests however, show that the Prime Standard indices, with their higher transparency standards, are substantially more efficient than the Entry Standard index[13]. Both sets of tests also suggest that within the Prime Standard, the senior DAX index is substantially more efficient than the small capitalization SDAX index.

In addition to the runs tests and the serial correlation tests, Augmented Dickey-Fuller (ADF) test were undertaken to identify unit roots (random walks) within the data. Although these tests are not strictly comparable[14], their results reinforce the above findings as they indicated that whilst stocks in the Prime Standard followed a random walk, a significant proportion of the ASE stocks do not.

The results from this study are comparable to differences found in the Chinese stock market[15] between ‘A’ and ‘B’ shares by Shiguang (2004). Serial correlation tests in this study found 12% of stocks in the A-Shares index did not follow a random walk (this compares with an average of 14% in this study for Prime Standard stocks). For Chinese B-Shares the rejection rate rose to 45% (compared to 47% in this study for the German Entry Standard stocks). Runs tests undertaken by the same author also produced results comparable with this study. These indicated about 35% of A-Shares did not follow a random walk (compared with 50% of DAX shares in this study). For Chinese B-Shares the rejection rate increased to 75% (compared to 100% for the German Entry Standard shares in this study).

[11] A 1-tail test is undertaken, as with Figure 5.3a.
[12] See foodnote 7 above for formula.
[13] It should be noted that, in addition to transparency effects, differences in efficiency levels between indices could also, in part, be due to different trading frequency in the junior markets.
[14] The statistical power of the standard ADF test is relatively weak given that unlike the runs and serial correlation tests, the null hypothesis is for the existence of a unit root (i.e. random walk). The null is only rejected in the standard test if there is less than 5% chance of this outcome being true.
[15] Based on a composite study of the Shanghai and Shenzhen markets.

## 5.4. Tests for Calendar Anomaly Effects

If stock prices follow a random walk then investors should not be able to make money by exploiting calendar anomalies. However there is significant empirical evidence to suggest that profit opportunities from such anomalies do exist. This section of the paper reports the results of tests for day-of-the-week and month-of-the-year anomalies in the German market. The methodology used is to examine whether or not the mean returns made on one specific day of the week (or month) are statistically significantly different from the returns made on the other days in the week (months in the year). Data limitations with ASE stocks[16] meant that these tests are undertaken for Prime Standard Indices only.

### *5.4.1. Day-of-the-week-effects*

The data shows there to be clear between-index differences in the mean daily returns. For example, Mondays produce higher returns for the DAX, whereas Fridays produce higher returns for the MDAX and SDAX. Tuesdays, generally appear to produce the lowest returns for all indices. It is identified that for stocks listed on the DAX, day-of-the-week effects were statistically significant at the 5% level for only 2% of observations (a single company in the sample on a single day). For the more junior indices of the Prime Standard this proportion is slightly higher. The effects were found to be significant for 4% of observations from the MDAX and 10% of observations from the SDAX. Details of the significance levels for the individual stocks used in the sample are shown in Figure 5.4[17].

The results found in this study are comparable with those of Shiguang (2004) who also found clear, but statistically insignificant, daily differences in China. Like the German market, Chinese markets were found to produce their lowest returns on a Tuesday, and like the MDAX and SDAX, the highest returns were found on a Friday.

Although the results from this study suggest that day-of-the-week effects are generally not statistically significant, simulated trading tests show that in some cases a trading strategy based of this approach can outperform a buy-and-hold strategy[18]. Excluding transactions costs, the returns on 20% of DAX stocks using a day-of-the-week strategy outperformed a buy-and-hold strategy. The figures for the MDAX and SDAX were 53% and 57% respectively[19].

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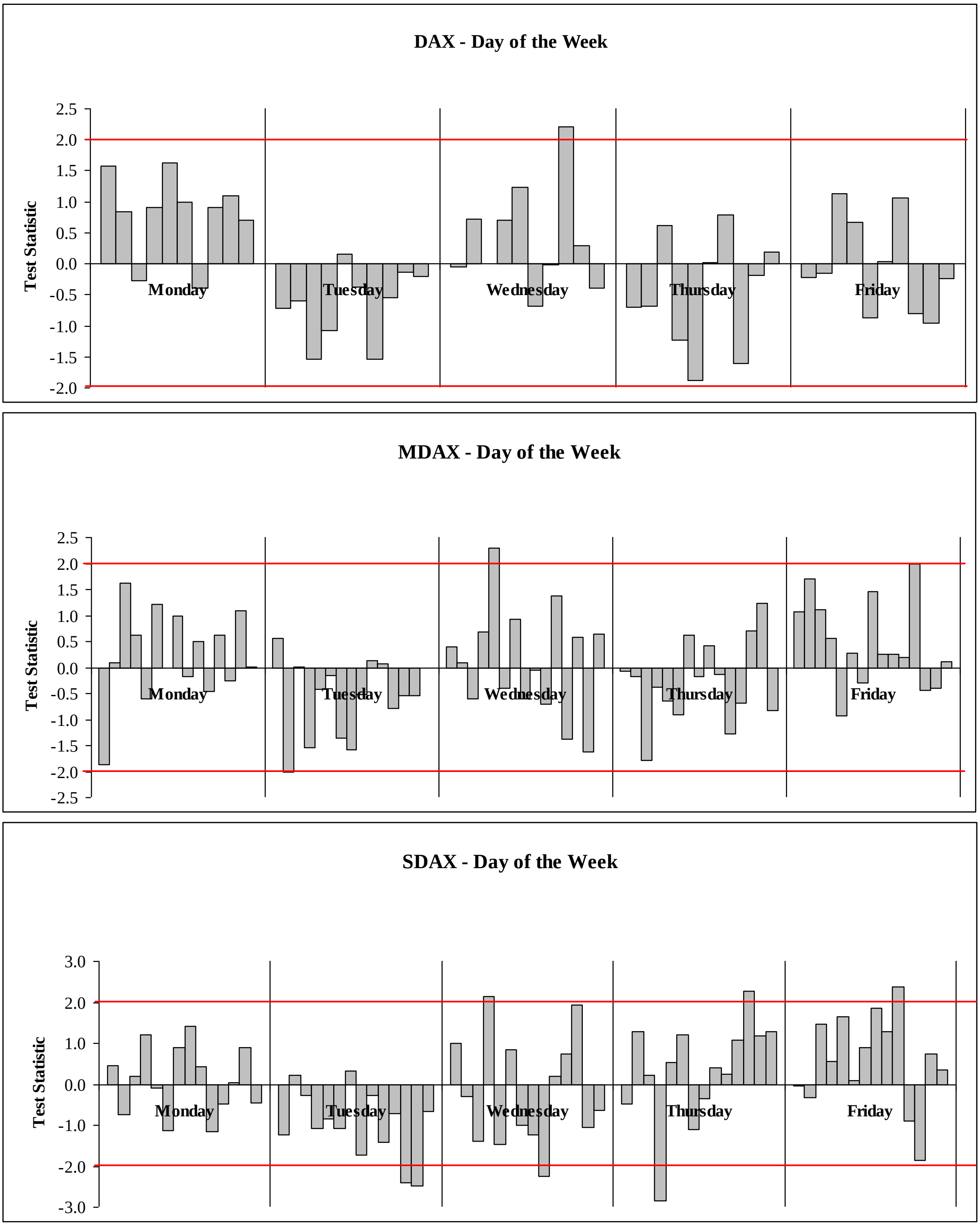
[16] A number of the stocks in the ASE sample were not listed on the market over the full 6 year period.

[17] See footnote 7 above for formula, where $R_i$ and $R_k$ represent the mean returns for the individual day of the week and the mean return for the sum of the rests of the days of the week respectively.

[18] For each stock, the buying day is identified as the day during the week that produces the lowest mean return. The selling day is the day in the week that produced the highest mean return. The returns from buying and selling once a week on this basis were compared with the returns from buy the stock at the start of the period of the study and holding it until the end of this period.

[19] On the inclusion of transactions costs (buying costs 1.5% and selling costs 1%) all profits from this trading strategy were eliminated.

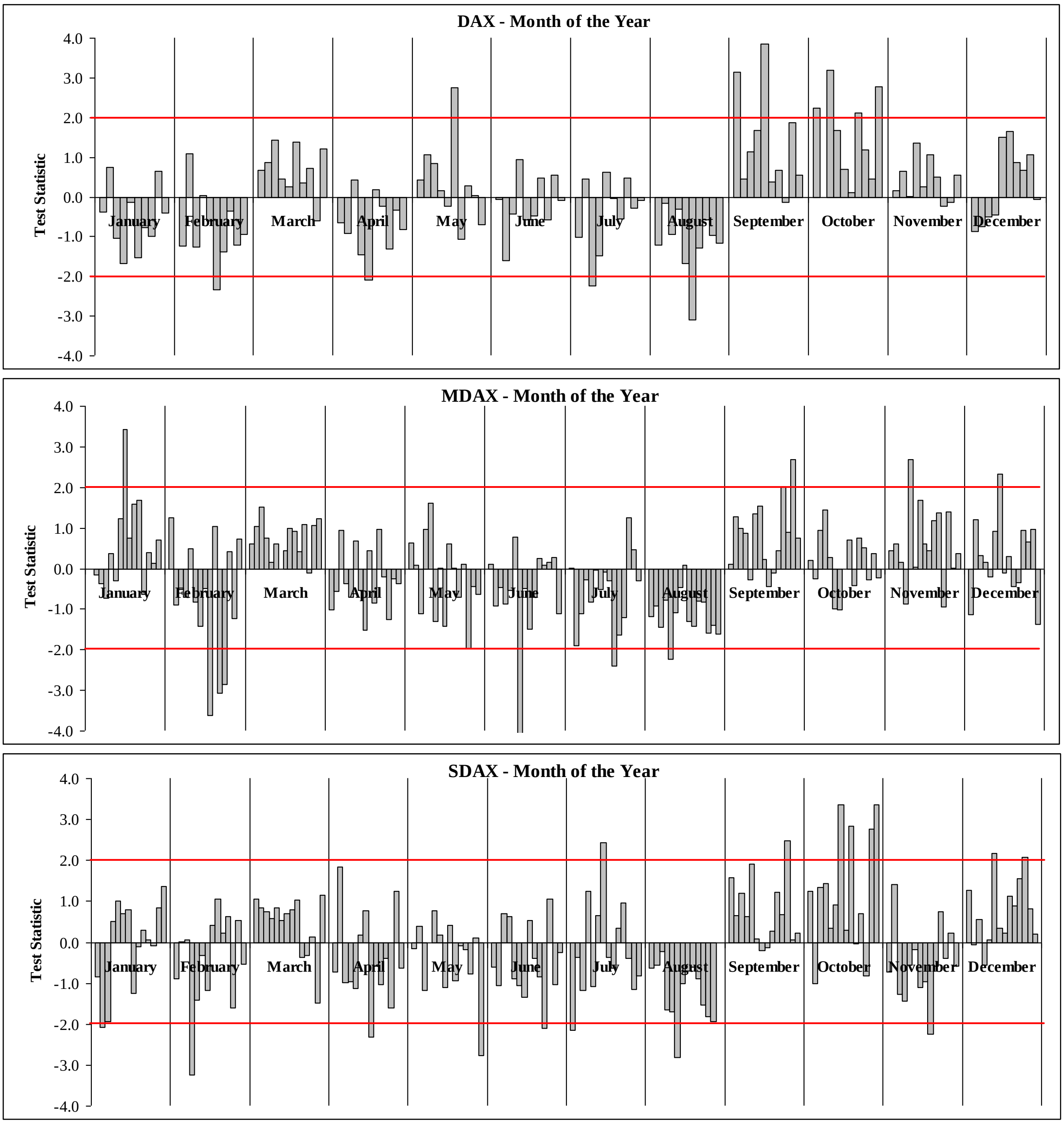
**Figure 5.4** Statistical significance of mean return based day-of-the-week effects (individual stocks)




### *5.4.2. Month-of-the-year-effects*

A number of studies suggest the existence is a positive January effect, whilst others studies suggest the existence negative summer and October effects (Siegel, 2002). The data in this study indicates that, for the DAX at least, most stocks do not exhibit positive mean returns in January. All of the indices suggest that negative returns are made in August and that positive returns are made in September. Results for month-of-the-year effects were statistically significant at the 5% level for between 7%-10% of observations across three indices[20]. Details for the significance levels for the individual stocks used in the sample are shown in Figure 5.5.

**Figure 5.5** Statistical significance of mean return based month-of-the-year effects (individual stocks)




Although only a few of the observations are statistically significant, month-of-the-year effects appear to be discernable in Figure 5.5. The data suggests that the period from April to August produces generally lower returns and that September to December produces generally higher returns. The case for the well documented 'January effect' is however weak as positive returns in this month appear mainly limited to MDAX stocks. These finding can be contrasted with those of Shiguang (2004) who found strongly negative and significant December and

[20] See footnote 7 above for formula, where $R_i$ and $R_k$ represent the mean returns for the individual month of the year and the mean return for the sum of the rest of the months of the year respectively.

January effects and, in marked contrast to Germany, where August was the worst performing month, in China August was the best performing month.

Further simulated trading tests were undertaken to identify whether a trading strategy based on the month-of-the-year effects identified above would outperform a buy-and-hold strategy[21]. Excluding transactions costs, 90% of stocks outperformed buy-and-hold for the DAX. The figures for the MDAX and SDAX were 73% and 80% respectively.

The implications of these findings for market efficiency are mixed. The limited statistical significance of calendar anomaly effects found in this study adds credence to the claim that the Prime Standard indices are relatively efficient. However, the results presented in this study suggest that a case can be made for some element of inefficiency in the market. It may very well be that the old British market adage of ‘sell in May and go away don’t come back until St Leger Day’ also has some credence in the German market.

## 6. CONCLUSION

Using both serial correlation and runs tests this paper has found clear evidence of differences in efficiency levels between Prime Standard and Entry Standard stocks on the German stock market. It has been suggested in this paper that these differences are possibly due to differences in the transparency requirements of these different indices.

Although the serial correlation tests undertaken give a stronger indication than the runs tests that Prime Standard stocks follow a random walk, both suggest that on average the individual stocks found in the DAX are more likely to follow a random walk than the individual stocks found in the MDAX and the SDAX. This indicates that there are probably factors in addition to transparency standard effects that determine the level of efficiency within German markets.

The study found only limited evidence of statistically significant calendar anomaly effects. This adds credence to the findings of the serial correlations and runs tests of high levels of efficiency amongst Prime Standard stocks. However, a caveat needs to be added which calls this finding into question. Simulated trading tests based on a month-of-the-year calendar strategy appear to suggest that in some circumstances trading strategies based on month-of-the-year effects might be profitable.

[21] For each stock, the buying month is identified as the month that produces the lowest mean return. The selling month is the one which produced the highest mean return. The returns from buying and selling once a year on this basis were compared with the returns from buy the stock at the start of the period and holding it until the end of this period. Dividends received are added to the return for the buy and hold strategy. Unlike with day-of-the-week effects, transactions costs are of minor importance.

## APPENDIX

**Table A:** Individual companies used in the study

| DAX companies used | MDAX companies used |
|---|---|
| ALLIANZ N | AAREAL BANK |
| ALTANA | AMB GENERALI HOLDIN |
| Bayer AG | AWD HOLDING |
| DEUTSCHE TELEKOM N | BAYR.HYPO-U.VERBK |
| DT.LUFTHANSA N | BEIERSDORF |
| E.ON AG | IVG IMMOBILIEN |
| THYSSENKRUPP | IWKA |
| TUI N | K+S AG |
| VOLKSWAGEN | KARSTADT QUELLE |
| BASF | KRONES |
| | SUEDZUCKER |
| | TECHEM |
| | VOSSLOH |
| | SGL Carbon AG |
| | Puma AG |

| SDAX companies used | ASE companies used |
|---|---|
| comdirect bank AG | ACTIVA RESOURCES AG |
| CeWe Color Holding AG | Agnico-Eagle Mines Ltd. |
| BALDA | AMITELO AG |
| BAYWA AG VINK.N | Aragon AG |
| Dyckerhoff AG Vz | Artec technologies AG |
| FIELMANN | Ecotel communication ag |
| FUCHS PETROLUB VZ | Elite Model Management Lux. S.A. |
| elexis AG | HII Hanseatische Immobilien Invest AG |
| GFK | HYDROTEC Gesellschaft für Wassertechnik AG |
| TAG TEGERNSEE IMMO | ifa systems AG |
| TAKKT | Mox Telecom AG |
| THIEL LOGISTIK | NanoFocus AG |
| Sixt AG St | trading-house.net AG |
| VIVACON | UNYLON AG |
| | ZertifikateJournal AG |

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