# Testing the Significance of Calendar Effects

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**Abstract**[3]

When evaluating the significance of calendar effects, such as those associated with Monday and January, it is necessary to control for all possible calendar effects to avoid spurious results. The downside of having to control for a large number of possible calendar effects is that it diminish the power and makes it harder to detect real anomalies.

This paper contributes to the discussion of calendar effects and their significance. We derive a test for calendar specific anomalies, which controls for the full space of possible calendar effects. This test achieves good power properties by exploiting a particular correlation structure, and its main advantage is that it is capable of producing data-mining robust significance.

We apply the test to stock indices from Denmark, France, Germany, Hong Kong, Italy, Japan, Norway, Sweden, UK, and USA. Our findings are that calendar effects are significant in most series, and it is primarily end-of-the-year effects that exhibit the largest anomalies. In recent years it seems that the calendar effects have diminished except in small cap stock indices.

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# 1 Introduction

Calendar effects are anomalies in stock returns that relate to the calendar, such as the day-of-the-week, the month-of-the-year, or holidays, and well-known examples are the Monday effect and the January effect. Small calendar specific anomalies need not violate no-arbitrage conditions, but the reason for their existence, if they are real, is intriguing. Much effort has been devoted to establish the significance of calendar effects, yet the literature have not fully settled on this matter, primarily because the discovery of the calendar effects could be a result of data mining. Even if there are no calendar specific anomalies, an extensive search (mining) over a large number of possible calendar effects is likely to yield something that appears to be an "anomaly" by pure chance.[1] Another observations that points to data mining as a plausible explanation, is that theoretical explanations have only been suggested after the empirical "discovery" of the anomalies.

Since the universe of possible calendar effects is not given from theory (ex-ante), the only way to establish whether a calendar effect is statistically significant, is by controlling for all calendar effects that have been explored. The downside of controlling for data mining, is that it becomes less likely that a true anomaly is found to be significant. How likely a particular test is to detect a real anomaly is defined by its power, and it is therefore crucial to apply a test that is as powerful as possible, when controlling for data mining, in particular in empirical studies that are not motivated by existing theory.

In this paper, we construct a powerful test to evaluate the significance of calendar effects. We apply the test to stock returns from ten countries and find overwhelming evidence that calendar effects are statistically significant, even if one controls for the possibility of data mining. The new test, is a simple $\chi^2$-test that exploits a particular correlation structure of calendar effects. The test achieves good power properties by combining and incorporating the information from all the calendar effects, and this is done without compromising the size of the test. We apply the new test to evaluate the significance of calendar effects to returns on stock indices from ten countries. These countries are: Denmark, France, Germany, Hong Kong, Italy, Japan, Norway, Sweden, Japan, UK, and USA, and we analyze three indices of each country, except for Denmark and Sweden, where we analyze one and two indices, respectively. An analysis of the significance of calendar effects will involve a subjective element, in terms of universe of calendar effects that are under investigation, as different choices can lead to different results. E.g.,

[1] A popular phrase is that "the data has been tortured until it confessed". Merton (1987), Lo and MacKinlay (1990), and Fama (1991) contain good discussions about data mining, and Schwert (2001) gives a recent survey on the subject in relation to anomalies in returns, including the calendar specific anomalies.

the January effect may be significant in a small universe, but insignificant in a large universe. In our analysis, we have included a total of 181 possible calendar effects, and this choice is based on effects that were analyzed in the existing literature. Although it is quite plausible that additional effects have been analyzed, e.g., in unpublished studies, we believe that our choice of universe is rich enough and includes all relevant calendar effects. An extension would, in our opinion, involve farfetched effects that would be hard to justify theoretically, even ex-post.

In our empirical analysis, we find significant calendar effects in most series. The largest anomalies are typically produced by end-of-year effects, but since these effects are mostly insignificant in our analysis of standardized returns, they do not appear to have any economic significance. Most robust significance is found in our analysis of small-cap stock indices, where calendar effects are generally found to be significant, across countries and subsamples. To compliment our results, we also analyze two smaller universes that contain 17 and 5 possible calendar effects, respectively.

An alternative method to control for the universe of possible effects, is a Bonferroni bound test. Since the Bonferroni bound ignores the correlation structure of the objects, which are being compared, and results in a test that is unnecessarily conservative, and our test dominates Bonferroni bound methods in terms of power. Alternatively, one can control for data mining by confronting anomalies found in one data set, with a different data sets. This approach has been suggested by several authors, see, e.g., Schwert (2001). However, this approach cannot entirely remove data mining bias, for two reasons. (1) Even if the two data sets were totally independent, then it is still possible to "mine" the two data sets simultaneously and find calendar effects that appear to be significant in both samples. (2) If the data sets overlap in time, then the data sets are very like to be dependent. The returns on the Dow-Jones index and the S&P 500 index are clearly correlated, and indices from different countries are also correlated to some extend. Therefore, evaluating results found in one equity index, on a different equity index, cannot be viewed as a new independent experiment.

The $\chi^2$ test of calendar effects is related to some recent methods for comparing forecasting models that have been proposed by White (2000) and Hansen (2001b), who builds on results of Diebold and Mariano (1995) and West (1996). These tests exploit indirectly the sample information about the dependence across the forecasting models, which are being compared. This is analog to the $\chi^2$ test, which is based on a particular covariance structure there is across calendar effects.

Several papers have analyzed calendar effects, many references can be found in Dimson (1988), Keim and Ziemba (2000), and Sullivan, Timmermann, and White (2001) (STW).[2] Whereas most papers that

[2] Additional references are: Kato and Schallheim (1985), Lee and Chang (1988), Aggarwal and Rivoli (1989), Calvet

address the issue of data mining apply Bonferroni bound methods or cross country studies to evaluate the significance of calendar effects, STW apply the *reality check* of White (2000) in their analysis. The paper by STW is therefore the paper that is most related to our paper, nevertheless our analysis differs from that of STW in three important ways. (1) The first difference is in terms of what is considered a calendar specific anomaly. Our null hypothesis is that expected returns, or standardized returns, is identical across all calendar dating schemes. This differs from the approach of STW who analyzed whether a particular set of calendar-based trading rules could yield a higher (standardized) return than a buy-and-hold strategy. Their set of trading rules consisted of rules that could take short, neutral, or long positions, according to calendar-based rules. We believe that our approach is better suited for evaluating the significance of calendar effects. To give an example, the *January effect* suggests that expected returns are higher in the month of January than the rest of the year, but this does not imply that one can earn an excess return by taking a long position in January and a short or neutral position the rest of the year. Hence, the message is that one should compare the daily average returns to the daily average return of the particular calendar effect under consideration. (2) The second difference is in terms of how many "objects" that are being compared. We evaluate 181 calendar effects whereas STW evaluated 9,452 trading rules that were based on a set of calendar effects that essentially is identical to ours. This reduction is very beneficial for the analysis because an increase in the dimension reduces the power of significance tests and makes it harder to detect real anomalies. (3) The third difference is the choice of statistical test. The hypothesis that there are no calendar specific anomalies is a two-sided hypothesis of multiple equalities and our test is designed to test this hypothesis. STW applied the reality check of White (2000), which is a test that is designed to test one-sided hypotheses of multiple inequalities. Testing multiple inequalities involves certain complications that are discussed in Hansen (2001b), and if there are non-binding inequalities, the reality check is known to be size distorted and lack power, as pointed out in Hansen (2001a). A poor trading rule can distort the reality check and erodes its power. Interestingly, in Sullivan, Timmermann, and White (2001, Figure 2) it can be seen that the reality check's $p$-value jumps from about .33 to about .52 at a point where the worse performing models are included in the analysis (around model 8,300). This large jump in the $p$-value is likely to be caused by the distortion that poor models have on this test,

and Lefoll (1989), Jaffe and Westerfield (1989), Levis (1989), Barone (1990), Chou and Johnson (1990), Hawawini (1991), Khaksari and Bubnys (1992), Kim, Chung, and Pyun (1992), Kohli and Kohers (1992), Lauterbach and Ungar (1992, 1995), Liano, Marchand, and Huang (1992), Whyte and Picou (1993), Agrawal and Tandon (1994), Kim and Park (1994), Brockman (1995), , Zychowicz, Binbasioglu, and Kazancioglu (1995), Elysiani, Perera, and Puri (1996), Brockman and Michayluk (1997), Tang and Kwok (1997), Husain (1998), Tang (1998), and Dimson and Marsh (1999).

and the correct $p$-value is likely to be smaller than the .554 STW obtain for the full sample.

The rest of this paper is organized as follows. In Section 2, we describes calendar effects and in Section 3, we analyze the statistical properties of the problem and derive the $\chi^2$ test. The data are described in Section 4, and our empirical results that are based on the new test are presented in Section 5. Section 6 contains some concluding remarks. A few proofs are given in the appendix.

## 2 Calendar Effects

This section presents the universe of possible calendar effects that we consider in our analysis. We shall often write "calendar effect" as short for "possible calendar effect". So "calendar effect" need not imply that there is an anomaly associated with the "possible calendar effect".

**Day-of-the-week:** This effect states that expected return, or standardized return, are not the same for all weekdays. This effect was first documented by Osborne (1962), and subsequently analyzed by Cross (1973), French (1980), Gibbons and Hess (1981), Lakonishok and Levi (1980), Smirlock and Starks (1983), Keim and Stambaugh (1983), Rogalski (1984) and Jaffe and Westerfield (1985). In our universe, we include the five day-of-the-week calendar effects: Monday, Tuesday, Wednesday, Thursday, and Friday. The Friday effect considers the return from the preceding trading day's closing price (typically a Thursday) to Friday's closing price, and similarly for the other days. The returns on Mondays are found to be negative in many studies, which is commonly referred to as the weekend-effect.

**Month-of-the-year:** This includes the January effect that was first reported in Wachtel (1942). The January effect is one of the most famous calendar effects, in fact a whole book by Haugen and Lakonishok (1988) is about this effect. In our universe we include the twelve month-of-the-year effects.

**Weekday-of-the-month:** We interact day-of-the-week with month-of-the-year, (Mondays in December, Wednesdays in June, etc.) and this adds $5 \times 12 = 60$ calendar effects to our universe.

**Week-of-the-month:** We follow STW in our definition of week-of-the-month. So *weeks* are constructed such that the first trading of the month defines the first day of the first week. So if the first trading day is a Thursday, then the first week consists of two days (a Thursday and a Friday). The last week-of-the-month is defined similarly, and will often have fewer than five days. Week-of-the-month effects are discussed in Ariel (1987), Lakonishok and Smidt (1988), and Wang, Li, and Erickson (1997). This adds $5 + 5 \times 12 = 65$ effects to our universe.

**Semi-month:** Our definition of semi-months follows that of Lakonishok and Smidt (1988).[3] The trading days are partitioned into two sets. The first set consists of trading days for which the date is 15 or less, and the other set contains dates that are 16 or higher. By interacting these two semi-month-of-the-year with month-of-the-year we get another 24 semi-months, which adds a total of $2 + 2 \times 12 = 26$ effects to our universe.

**Turn-of-the-month:** Another eight effects that relate to turn-of-the-month are added to our universe, one for each of the last four trading days of the month and one for each of the first four trading days of the month. This type of calendar effects are discussed in Ariel (1987), Lakonishok and Smidt (1988), and Hensel and Ziemba (1996).

**End-of-Year:** Again, following Lakonishok and Smidt (1988), we define three categories for the days at the end of December:

1. Pre-Christmas from mid-December: the trading days from mid December up to, but not including, the last trading day before Christmas, (e.g., December 15th – 23rd).
2. Between Christmas and New Year: from the first trading day after Christmas up to, but not including, the last trading day before New Year's Day.
3. Pre-Christmas and New Year: the last trading day before Christmas, and the last trading day before New Year's Day.

**Holiday-effects:** As in STW, we classify the pre- and post-holiday as follows. Pre-holidays are those trading days which directly precede a day where the market is closed, but would normally be open for trading. Post-holidays are those trading days that follow pre-holidays. This adds two calendar effects to our universe.

In total we have included 181 different calendar effects, see Table 1 for an overview. Our universe of calendar-rules is almost identical to that STW used to construct 9,452 trading rules from.

TABLE 1 ABOUT HERE

[3] The definition of semi-months of Lakonishok and Smidt (1988, p.407-8) differs slightly from that of Ariel (1987).

## 3 Statistical Analysis of Calendar Effects

In this section, we describe the notation and the test for calendar specific anomalies. We let $r_t \equiv \log P_t - \log P_{t-1}$ be the continuously compounded returns on a stock index, where $P_t$ denote the closing price of the index on day $t$, (dividends are assumed to be accumulated in $P_t$). The expected return and the variance of $r_t$ are denoted by $\mu_t \equiv E(r_t)$ and $\sigma_t^2 \equiv \mathrm{var}(r_t)$, respectively, $t = 1, \ldots, n$, and throughout we assume that the sequence of returns are uncorrelated, i.e., $\mathrm{cov}(r_s, r_t) = 0$ for $s \neq t$.

### 3.1 Calendar Sets

It is convenient to associate each calender effect with a set, $S_{(k)}$,[4] that contains the days that are associated with the $k$th calendar effect, $k = 1, \ldots, m$. So $m$ is the number of calendar effects that are being considered, and the number of elements in $S_{(k)}$ is denoted by $n_{(k)}$. E.g., if $k = 1$ corresponds to the Monday effect, as it will in our analysis, then $S_{(1)}$ contains all the $t$s that are Mondays, and $n_{(1)}$ is the number of Mondays in the sample. The full sample is associated with the set $S_{(0)} \equiv \{1, \ldots, n\}$.

The average return of calendar effect $k$, is given by $\bar{r}_{(k)} \equiv n_{(k)}^{-1} \sum_{t \in S_{(k)}} r_t$, and its expected value is denoted by $\xi_{(k)} \equiv E(\bar{r}_{(k)}) = n_{(k)}^{-1} \sum_{t \in S_{(k)}} \mu_t$. Similarly, the average variance of calendar effect, $k$, is given by $\bar{\omega}_{(k),n}^2 \equiv n_{(k)}^{-1} \sum_{t \in S_{(k)}} \sigma_t^2$, and the expected standardized return is defined by $\rho_{(k)} \equiv \xi_{(k)} / \bar{\omega}_{(k),n}$, $k = 1, \ldots, m$.

### 3.2 Hypotheses of Interest

We consider two hypotheses. The first hypothesis is that there are *no calendar specific anomalies in returns*, which can be formulated parametrically as,

$$H_0 : \xi_{(0)} = \cdots = \xi_{(m)}.$$

The hypothesis, $H_0$, may not be supported by the data if, for example, there is a risk-premium from holding assets from Friday to Monday. Therefore, we also consider the hypothesis that there are *no calendar specific anomalies in standardized returns*, which can be expressed as

$$H_0' : \rho_{(0)} = \cdots = \rho_{(m)}.$$

[4] Subscripts in parentheses refer to different calendar effects, $k = 0, 1, \ldots, m$, whereas subscripts without parentheses refer to time, $t = 1, \ldots, n$.

### 3.3 The $\chi^2$-Test for Calendar Specific Anomalies

In order to construct the test that we have in mind, we need the covariance matrix of the vector $\bar{r} = (\bar{r}_{(0)}, \bar{r}_{(1)}, \ldots, \bar{r}_{(m)})'$ of average returns for the $m$ calendar effects. This covariance matrix is denoted $\Sigma_n$, so the $(k+1, l+1)$th element of $\Sigma_n$ is given by $\mathrm{cov}(\bar{r}_{(k)}, \bar{r}_{(l)})$, $k, l = 0, \ldots, m$. The following lemma, provides and expression for the elements of $\Sigma_n$.

**Lemma 1** *It holds that*

$$\mathrm{cov}(\bar{r}_{(k)}, \bar{r}_{(l)}) = n_{(k)}^{-1} n_{(l)}^{-1} \sum_{t \in S_{(k)} \cap S_{(l)}} \sigma_t^2, \qquad \text{for } k, l = 0, \ldots, m,$$

*and in particular that*

$$\mathrm{var}(\bar{r}_{(k)}) = n_{(k)}^{-2} \sum_{t \in S_{(k)}} \sigma_t^2, \qquad \text{for } k = 0, \ldots, m.$$

**Proof.** The results from first principles, as $\{r_t\}$ is assumed to be uncorrelated, and $\mathrm{cov}(r_t, r_s) = \sigma_t^2$ if $t = s$, and zero otherwise. ■

Note that $\Sigma_n$ needs to be multiplied by $n$ in order to converge to a nontrivial limit.

Primitive assumptions, which are given in the appendix, ensure that a law of large numbers and a central limit theorem apply, such that we have

$$\begin{aligned} \bar{r} &\overset{p}{\to} \xi \\ \sqrt{n}\,(\bar{r} - \xi) &\overset{d}{\to} N_{m+1}(0, n\Sigma_n), \end{aligned}$$

where $\xi = (\xi_{(0)}, \xi_{(1)}, \ldots, \xi_{(m)})'$.

The new test for calendar anomalies is a simple $\chi^2$-test, and the only complication that arises is that $\Sigma_n$ may be singular. The solution to the potential singularity is given in the following well-known result.

**Lemma 2** *Let $X$ be a normally distributed vector with mean $\lambda$ and covariance matrix $\Omega$. Under the hypothesis, $H : \lambda = B\theta$, where $B$ is a known matrix with full column rank and $\theta$ a vector with proper dimension, it holds that*

$$T = X' B_\perp (B_\perp' \Omega B_\perp)^+ B_\perp' X, \tag{1}$$

*is $\chi^2$-distributed with $f = \mathrm{rank}(B_\perp' \Omega B_\perp)$ degrees of freedom, where $B_\perp$ is the orthogonal compliment matrix to $B$ and where $(B_\perp' \Omega B_\perp)^+$ is the Moore-Penrose inverse of $B_\perp' \Omega B_\perp$.*[5]

[5] The orthogonal matrix, $B_\perp$, to a matrix, $B$, with full column rank, satisfies $B_\perp' B = 0$ and $(B, B_\perp)$ is a squared full rank matrix.

The Moore-Penrose inverse, $A^+$, of a symmetric matrix, $A$, is defined by the identities: $AA^+A = A$ and $A^+A = (A^+A)'$.

The hypotheses of interest can be expressed as, $H_0 : \xi = \imath\theta_\xi$ and $H_0' : \rho = \imath\theta_\rho$, where $\imath$ is a vector with $m+1$ ones (i.e., $\imath = (1, \ldots, 1)'$), and where $\theta_\xi$ and $\theta_\rho$ are unknown scalar parameters. Equation (1) can be used to construct test statistics for the hypotheses $H_0$ and $H_0'$, where the relevant covariance matrix (to use in place of $\Omega$ in (1)) is $\Sigma_n$ under the hypothesis $H_0$, and $\Omega_n = \Lambda_n^{-1}\Sigma_n\Lambda_n^{-1}$ under the hypothesis, $H_0'$, where $\Lambda_n = \text{diag}(\bar{\omega}_{(0),n}, \ldots, \bar{\omega}_{(m),n})$. Note that $\Lambda_n$ is the matrix with the standard deviations that define the expected standardized returns ($\rho = \Lambda_n^{-1}\xi$).

### 3.4 Estimation

The parameters can be estimated by

$$\begin{aligned} \hat{\xi}_{(k)} &= \bar{r}_{(k)}, \\ \hat{\omega}^2_{(k),n} &= n^{-1}_{(k)} \sum_{t=s_{(k)}} (r_t - \bar{r}_{(k)})^2, \\ \hat{\rho}_{(k)} &= \hat{\xi}_{(k)} / \hat{\omega}_{(k),n}. \end{aligned}$$

for $k = 0, \ldots, m$.

The common value for expected returns is estimated by

$$\hat{\theta}_\xi = (\imath'\Sigma_n^{+}\imath)^{-1}\imath'\Sigma_n^{+}\bar{r},$$

(this number actually equals the sample average of returns $\bar{r}_{(0)}$), and the common value for standardized expected returns is estimated by

$$\hat{\theta}_\rho = (\imath'\Omega_n^{+}\imath)^{-1}\imath'\Omega_n^{+}\hat{\rho},$$

where $\hat{\rho}_{(k)} = \bar{r}_{(k)}/\omega_{(k)}$, $k = 0, \ldots, m$.

The estimation of the covariance matrices, $\Sigma_n$ and $\Omega_n$, is also relatively simple. First we define the $n \times m+1$ matrix $A$, with elements

$$A_{t,(k)} = \begin{cases} n^{-1}_{(k)} & \text{if } t \in S_{(k)} \\ 0 & \text{otherwise,} \end{cases} \qquad t = 1, \ldots, n, \quad k = 0, \ldots, m,$$

Note that each column of $A = (a_{(0)}, \ldots, a_{(m)})$ sum to one, and that $a'_{(k)}(r_1, \ldots, r_n)' = \bar{r}_{(k)}$, where $a_{(k)}$ is the $(k+1)$th column of $A$. From Lemma 1 we have $\Sigma_n = A'\text{diag}(\sigma_1^2, \ldots, \sigma_n^2)A$, which shows that it is simple to estimate $\Sigma_n$ given an estimate of $(\sigma_1^2, \ldots, \sigma_n^2)$. In the special case, where $\sigma_t^2$ is assumed to be constant, the expression simplifies to $\Sigma_n = \sigma^2 A'A$, and one can use the estimator $\hat{\sigma}^2 = \frac{1}{n-1}\sum_{t=1}^{n}\left(r_t - \bar{r}_{(0)}\right)^2$.

In the general case, where $\mu_t$ and $\sigma_t^2$ may depend on weekday, month, etc., the estimation of $\Sigma_n$ is slightly more complicated. Let the sample be divided into $q$ distinct groups, and assume that within each of these groups both $\mu_t$ and $\sigma_t^2$ are constant. Define the $n \times q$ matrix, $J$, of zeros and ones where each column is associated with a group, such that $J_{t,i} = 1$ if day $t$ is in group $i$ (and zero otherwise). Note that each row of $J$ has precisely one non-zero entry. Within each group, we estimate the mean by

$$\bar{r}^{(i)} = \frac{\sum_{t=1}^{n} J_{t,i} r_t}{n^{(i)}}, \qquad i = 1, \ldots, q,$$

where $n^{(i)} \equiv \sum_{t=1}^{n} J_{t,i}$ is the number of $t$s in group $i$, and the variance is estimated by

$$\hat{\sigma}^2(i) = \frac{\sum_{t=1}^{n} J_{t,i}(r_t - \bar{r}^{(i)})^2}{n^{(i)} - 1}, \qquad i = 1, \ldots, q.$$

These estimates can be mapped into the estimates $\hat{\sigma}_t^2 = \sum_{i=1}^{q} J_{t,i} \hat{\sigma}^2(i)$, $t = 1, \ldots, n$, which translates into the estimate of $\Sigma_n$,

$$\hat{\Sigma}_n = A' \mathrm{diag}(\hat{\sigma}_1^2, \ldots, \hat{\sigma}_n^2) A.$$

The estimate of $\mathbf{\Omega}_n$ is then given by

$$\hat{\mathbf{\Omega}}_n = \hat{\Lambda}_n^{-1} \hat{\Sigma}_n \hat{\Lambda}_n^{-1},$$

where $\hat{\Lambda}_n = \mathrm{diag}(\hat{\omega}_{(0),n}, \ldots, \hat{\omega}_{(m),n})$.

This leads the following test statistics,

$$F_\xi = \hat{\xi}' \iota_\perp (\iota_\perp' \hat{\Sigma}_n \iota_\perp)^+ \iota_\perp' \hat{\xi},$$

which is asymptotically $\chi^2$-distributed under $H_0$, and

$$F_\rho = \hat{\rho}' \iota_\perp (\iota_\perp' \hat{\mathbf{\Omega}}_n \iota_\perp)^+ \iota_\perp' \hat{\rho},$$

which is asymptotically $\chi^2$-distributed under $H_0'$. Here, $\iota_\perp$ is an $(m+1) \times m$ matrix that is orthogonal to $\iota$, (the vector of ones). This matrix is not unique, however, any choice of $\iota_\perp$ will produce the same value of the test statistic. A particular choice of $\iota_\perp$ is given by the matrix that has ones in, and right below, the diagonal and zeroes, elsewhere, i.e., $\iota_{\perp_{hh}} = 1$, and $\iota_{\perp_{h+1,h}} = -1$ for $h = 1, \ldots, m$, otherwise $\iota_{\perp_{h,g}} = 0$.

In practice, one must make a choice for the grouping of the date, where the unconditional mean and variance is constant within each group. The assumption of homoskedastic returns is accommodate by selection a single group that contains all dates. In our analysis we use $q = 60$ groups that are the combinations of weekdays and months, e.g., one group contains all $t$s that are Mondays in January.[6]

[6] The Dow-Jones data contains Saturdays in the first part of the sample. So in our full sample analysis of the DJIA returns, we add an additonal group that contains all the $t$s that are Saturdays.

When $\sigma_t^2$ is assumed to be constant, the test statistic, $F_\xi$, is a simple transformation of a standard $F$-test, and the statistics can be obtained by from a regression of $r_t$ on a set of dummy-variables, $1_{\{t \in S_{(k)}\}}$, $k = 1, \ldots, m$, where the relevant $F$-test is the one that tests that all regression parameters, excluding the constant, are zero. When $\sigma_t^2$ is non-constant, the relevant $F$-test can be found by GLS estimation. However, in the regression approach, one must deal with potential collinearities of the regressors. The test statistic, $F_\rho$, of the other hypothesis, $H_0'$, does not have a simple relation to standard regression statistics.

### 3.5 Comparison to Bonferroni Bound Tests

An alternative and simpler way to adjust inference for the universe of calendar effect is to evaluate the calendar effects individually while adjusting the critical values as prescribed by the Bonferroni bound. This can be done by a simple regression, which in our notation is given by,

$$r_t = \beta_0 + \beta_1 1_{\{t \in S_{(1)}\}} + \cdots + \beta_m 1_{\{t \in S_{(m)}\}} + u_t,$$

where $1_{\{\cdot\}}$ is the indicator function. The hypothesis $H_0$, implies that $\beta_1 = \cdots = \beta_m = 0$, so one may consider the $t$-statistics for each of these parameters. To ensure that the overall size of the test is more than $\alpha$, say 5%, one can use $\frac{\alpha}{m}$-critical values from the appropriate $t$-distribution. However, this leads to a conservative test as it ignores the correlation across the $m$ different $t$-statistics. The new test incorporates the correlation structure, whereby it avoids the conservative nature that Bonferroni bound methods have.

It should be noted that our test is an $F$-test of $H_0 : \beta_1 = \cdots = \beta_m = 0$, in the special case where $r_t$ is assumed to be homoskedastic. So the new test can be viewed as a generalized $F$-test.

## 4 Data Description

We have analyzed data from Denmark, France, Germany, Hong Kong, Italy, Japan, Norway, Sweden, United Kingdom, and United States. Most data were extracted from Datastream, the two exceptions are the Danish data, which were extracted from "børsdatabasen",[7] and the French net return series that are from the Paris Stock Exchange.

The data are daily closing prices with observations ranging back to the base date of the indices or alternatively as far back as the data were available to us. Observations are, if available, included up until 06.05.2002 (May 6th, 2002). Summary statistics and the sample period are reported in Table 2.

[7] Børsdata is accessible from The Aarhus School of Business's website: www.asb.dk.

Holidays, which are used to define some of the calendar effects, were determined using the holiday function in Datastream. In the following we give a short description of individual series.

**Denmark:** The KFX is the main index for stocks in Denmark. It comprises the 20-25 most important stock. We use a version of the index that has been adjusted for dividends, this index has been constructed by Tangaard and Belter (2001).

**France:** We include three indices from France. The CAC40 is the main index that is based on 40 of the largest companies in terms of market capitalization. The SBF120 index includes an additional 80 stocks, and this index is typically used as the benchmark for index funds. The MIDCAC index tracks the performance of mid-cap stocks. This index consists of 100 stocks. The indices are available in terms of "net return" and "total return", where the latter incorporates a special "avoir fiscal" tax credit. For comparability with the series from other countries, our analysis is based on the "net return" indices.

**Germany:** Our analysis includes three German indices. The DAX 30 is the main indicator of the blue-chip segment and contains the 30 largest companies in terms of capitalization and turnover. The MDAX represents the mid-cap segment of the German stock market and includes the next 70 companies after those in DAX 30. DAX 100 combines the DAX 30 and the MDAX and is comparable to the French SBF 120. The Deutsche Börse publishes both price indices and performance indices, where the latter are adjusted for dividends and are the indices that we use in our analysis.

**Hong Kong:** The Hang Seng Composite Index contains about 95% of the market capitalization of stocks listed on the Hong Kong Stock Exchange. The Hang Seng Main includes 33 stocks and accounts for about 70% of total market capitalization. The Midcap index includes the companies that are ranked 16th to 50th in the Hang Seng Composite Index by market capitalization.

**Italy:** The MIBTEL is a general national index that contains almost all shares listed on the Italian stock exchange. Italian stocks are ordered according to a measure based on capitalization and transaction volume. The MIB30 index consists of the first 30 stocks and the MIDEX index consists of the next 25 companies. The adjustment for dividends are somewhat complicated as ordinary and extraordinary dividends are treated differently.

**Japan:** The Nikkei All Stock Index includes all stocks listed on the Tokyo, Osaka, Nagoya, Sapporo, and Fukuoka exchanges, as well as Nasdaq Japan, and Mother's. The Nikkei 225 Stock Average contains 225 of the most actively traded stocks on the first section of the Tokyo Stock Exchange. The Tokyo Stock Exchange Small Cap index contains a selection of liquid and small capitalization stocks that are traded on the Tokyo stock exchange.

**Norway:** The All Share index includes all stocks listed on the Oslo Stock Exchange, and the OBX index is based on a smaller number of shares that are thought to be representative for the market. This index is comparable to the Danish KFX index. We also include a small cap index that contains companies with smaller market capitalization.

**Sweden:** The SX-General comprises a large number of companies that are traded on the Stockholm Stock Exchange.[8]. OMX comprises the 30 stocks with the largest turnover on the exchange (during a certain control period). The Swedish indices do not account for dividends, and we were unable to find a small cap index with a sample that was sufficiently long for our analysis.

**United Kingdom:** The FTSE includes a large number of stocks that must satisfy certain criteria, see www.londonstockexchange.com for details. The FTSE100 index is comparable to main indices for other countries, the FTSE350 is a broader index, and the FTSE 250 mid cap index represents smaller companies.

**United States:** The Dow Jones Industrial Average (DJIA) comprises 30 of the largest US stocks. The stocks are selected at the discretion of the editors of The Wall Street Journal and add up to about 29% of the US market capitalization. Unlike most indices the DJIA does not weight the individual stocks by their market capitalization. The S&P 500 Index consists of 500 stocks and the S&P MidCap 400 Index consists of 400 domestic stocks, where the stocks in both indices are selected according to criteria for market size, liquidity, and industry representation.

## 5 Empirical Results

The empirical results for the full universe of calendar effects and two smaller universes with 17 and 5 effects, are given in Tables 3. The smaller universe with 17 possible calendar effects contains the 12 month-of-the-year and the 5 day-of-the-week effects. The smallest universe with 5 effects contains the pre- and post-holiday, and the three end-of-the-year effects. As can be seen from Table 3, we find significant calendar effects in the full universe for almost all series. Out of the 27 indices, the only

[8] SX-General comprise all companies on the A-, OTC-, and O-liston of the Stockholm Stock Exchange. Prior to 1998 in comprised companies on the A-list only.

exceptions are the Hong Kong Composite Index, the Italian MIB 30, the Japanese Nikkei 225, and the S&P 500 composite index. For the Hong Kong Composite Index, the failure to reject the null hypothesis may be explained by the low number of observations ($n = 571$), which causes the power of the test to be relatively low.

TABLE 3 ABOUT HERE

The universe with the 17 calendar effects (weekdays and months) is, in our opinion, the smallest universe that one is required to control for, when evaluating the significance of any particular weekday or month effect, such as the Monday effect or the January effect. From Table 3 it can be seen that the majority of series do not have significant calendar effects within the 17-effect universe, so there is not much evidence in favor of Monday and January effects. The exceptions are: small- and mid-cap indices, the Danish KFX index, and the US DJIA index.

A subsample analysis of the DJIA shows that the significance of calendar effects is not a historical phenomenon, as also recent subsamples contains significant effects. So the significance in the analysis of the DJIA analysis does not rely on an effect that has vanished. See Figure 3.

The overall significance of calendar effects is quite robust, and there are only minor differences between the $p$-values from the analysis of returns and the analysis of standardized returns. It is therefore interesting to identify the calendar effects that deviate most from "normal returns". The calendar effects that had the five largest average sample return are given in Table 4, and their sample return are given in Table 5. Similarly, the five calendar effects that had the smallest sample returns are given in Table 6 and their sample returns in Table 7. The equivalent result for the standardized returns are given in Tables 8-11.

TABLE 4-11 ABOUT HERE

It is striking how the end-of-year effects, such as pre.xmas and pre.xm.ny, are amongst the largest anomalies in for almost all series. These effects significance may be explained by There does not appear to be a similar pattern across countries and series for the calendar effects with the lowest sample returns. Interestingly, the famous Monday effect which has the lowest standardized return for the DJIA series, (see Table 11), does not appear in the bottom-five for any other series.

Because the end-of-year and holiday effects are some of the effects that produce the largest anomalies, across countries, we have constructed a 5-effects universe, that contains the five holiday and end-of-year effects. The results for 5-effect universe are also given in Table 3. Whereas these effects are clearly significant in almost all series for the returns, this finding does not carry over to the analysis of standardized returns. So it seems that the larger returns that these effects have produced historically, are associated with a higher variance in returns, so there is little evidence that standardized returns are significantly different around holidays than the rest of the year. For the DJIA the significance found in the return analysis, does carry over to the analysis of standardized returns. However a subsample analysis reveals that the effect seems to have disappeared after 1978, so the full sample significance appears to rely on anomalies prior to 1978, see Figure 3. Thus, our conclusion is that there is a holiday effect in returns, at least in the full sample, but there is little evidence for a holiday effect in standardized returns.

FIGURES 1-2 ABOUT HERE

Figures 1-4 show subsample analyses of four selected indices.[9] The figures plot dynamic $p$-values of the hypotheses $H_0$ and $H_0'$, based on rolling subsamples with 1000 observations (approximately four years of data). The upper, middle, and lower panels contain dynamic $p$-values for $H_0$ and $H_o'$ using the full universe, the 17-effect universe and the 5-effect universe, respectively. The panels also display the level of the the relevant index. Figure 1 contains the analysis of the Tokyo small cap index, and it can be seen that the significance in the full universe is robust to our subsample analysis. Also, the significance in the 17-effect universe is fairly robust, although there is a short period where the effects are insignificant, but this is to be expected due to sample variation (unless the anomalies are large). However, the significance within the 5-effect universe is not convincing, as it seem to be driven by a few observations towards the end of the sample, and none of the subsample tests that are based on data from the period 1986-1997 yield significant effects in this universe.

Figure 2 contains the subsample analysis of FTSE-250, and the results for this index are very similar to those in Figure 1. Both the full and the 17-effect universes contain significant calendar effects, whereas the 5-universe does not yield robust significance over the sample period. Recall that the full sample analysis of the 5-effect universe rejected $H_0$. The lower panel of Figure 2 shows that this significance may be a result of a few isolated events.

[9] A technical appendix, which contains the figures with subsample $p$-values for all series, is available upon request.

FIGURES 3-4 ABOUT HERE

Figure 3 contains the analysis of DJIA. In this plot we also see long periods where none of the calendar effects are significant. Naturally, being “significant” is a much stricter criterion when the analysis us based on 1000 observations only, as oppose to the full sample. So the lack of significance is subsamples, should not necessarily be taken as evidence in favor of the null hypothesis. From the mid 40ies to the mid 70ies the calendar effects in the full, and the 17-effect, universes are significant almost constantly. But the effect may have disappeared, as the subsequent period, up until the 90ies showed little evidence in favor of calendar effects, though the significance returns for a brief period in the mid 90ies.

Figure 4 contains the subsample analysis for the S&P 500 index. The dynamic $p$-values in this figure are very similar to those of the DJIA in Figure 3 (the last fourth of Figure 3 covers about the same sample period as that in Figure 4). When viewing our full sample period of the S&P 500 returns, there is not much evidence for the existence of calendar effects. The fact that the $p$-values fall below 5% for part of the sample, is to be expected, even if the null hypothesis is correct, and these result are consistent with the full sample results in Table 3, where five of the six test did not find evidence of calendar effects. The significance of a calendar effect in the 5-effect universe for the return data, appears to be driven by a few observations in the mid 90’ies, and the results are not robust to the subsample analysis.

The fact that the dynamic $p$-values of the S&P 500 index and the DJIA are quite similar, supports our claim in the introduction that an analysis of different indices cannot be views as independent tests, and hence, cross-indices studies is not necessarily a good way to control for the danger of data mining.

## 6 Concluding Remarks

We have argued that in order to evaluate the significance of calendar effects, it is necessary to control for the full universe, to avoid data mining biases and spurious results. For this purpose, we have derived a simple $\chi^2$-test that we argue is superior to Bonferroni bound tests, because of its better power properties. This power is gained by exploiting a particular correlation structure, which Bonferroni bound tests ignore. This test is specifically designed to evaluate significance of calendar effects that are robust to data mining.

In our analysis of 27 stock indices from 10 countries, we find calendar effects to be significant in most return series, and it is particularly end-of-the-year effects that produce the largest anomalies.

The most solid evidence in favor of calendar effects is found in small-cap indices. In these series, we find significant calendar effects and these findings are found to be robust in our subsample analyses.

The analysis of standardized returns reveals less evidence in favor of calendar effects, however, calendar effects are still found to be significant in small-cap indices.

## APPENDIX: TECHNICAL ASSUMPTIONS AND PROOFS

In this appendix we present some assumptions and the proofs of the Lemma and the Theorem applied in the paper.

**Proof of Lemma 2.** We have $X \sim N(\lambda, \Omega)$ and under the hypothesis that $\lambda = B\theta$ it holds that $B_\perp' X \sim N(0, B_\perp' \Omega B_\perp)$. Since $B_\perp' \Omega B_\perp$ is symmetric and positive semi-definite, we can write $B_\perp' \Omega B_\perp = Q\Lambda Q'$ where $\Lambda$ is a diagonal matrix with non-negative elements, $\Lambda = \text{diag}(\lambda_1, \ldots, \lambda_q)$, and $Q$ orthonormal, i.e., $Q'Q = I$. Let the elements of $\Lambda$ be ordered, such that $\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_r > \lambda_{r+1} = \cdots 0$, then clearly $r = \text{rank}(B_\perp' \Omega B_\perp)$. Next, define the $q \times q$ diagonal matrix $D = \text{diag}(d_1, \ldots, d_r, 0, \ldots, 0)$, where $d_i = 1/\sqrt{\lambda_i}$ for $i = 1, \ldots, r$. It then follows that $(B_\perp' \Omega B_\perp)^+ = QDDQ'$ and that $DQ'B_\perp' X$ is a vector of independent and normally distributed variables, with mean zero and where the first $r$ elements, $u_1, \ldots, u_r$ say, have unit variance and the last $q - r$ elements have zero variance (equals zero with probability one). Finally, it follows that

$$
\begin{aligned}
T &= X' B_\perp (B_\perp' \Omega B_\perp)^+ B_\perp' X, \\
&= X' B_\perp Q D D Q' B_\perp' X = \sum_{i=1}^{r} u_i^2,
\end{aligned}
$$

which is $\chi^2(q)$ distributed. ■

The assumption below, (Assumption 1), provides conditions that are similar to those needed for a central limit theorem for martingale difference sequences, (see, e.g., Davidson, 2000, p. 124 ). The difference is that we have formulated it in terms of the sets, $S_{(k)}$, $k = 1, \ldots, m$, and the formulations is for all sets simultaneously.

Define the $\sigma$-algebra $\mathcal{F}_t = \sigma(r_t, r_{t-1}, \ldots)$, and recall that $n_{(k)}$ is the number of elements in $S_{(k)}$, and recall the definitions $\bar{r}_{(k)} \equiv n_{(k)}^{-1} \sum_{t \in S_{(k)}} r_t$, $\xi_{(k)} \equiv \lim_{n_{(k)} \to \infty} E(\bar{r}_{(k)})$, and $\bar{\omega}_{(k),n}^2 \equiv n_{(k)}^{-1} \sum_{t \in S_{(k)}} \sigma_t^2$, $k = 0, 1, \ldots, m$, and the definition of $A_{(k),t}$ (equal to $n_{(k)}^{-1}$ if $t \in S_{(k)}$, zero otherwise).

**Assumption 1** *The process,* $\left\{r_t - \mu_t, \mathcal{F}_t\right\}$ *is a martingale difference sequence, and*

(*i*) $\bar{\omega}_{(k),n}^2 - n_{(k)}^{-1} \sum_{t \in S_{(k)}} (r_t - \mu_t)^2 \xrightarrow{p} 0$, *where* $\bar{\omega}_{(k),n}^2 \equiv n_{(k)}^{-1} \sum_{t \in S_{(k)}} \sigma_t^2$, *and*

(*ii*) *For some* $\delta > 0$ *and some* $C > 0$, *it holds that* $\max_{t \in S_{(k)}} E\left|r_t - \mu_t\right|^{2+\delta} / \bar{\omega}_{(k),n}^2 \leq C < \infty$ *for all* $n \geq 1$.

From Davidson (2000) it follows directly that

$$n_{(k)}^{1/2}\frac{\bar{r}_{(k)}-\xi_{(k)}}{\bar{\omega}_{(k),n}} \xrightarrow{d} N(0,1).$$

The multivariate theorem, which is needed for the analysis of calendar effects, is the following.

**Theorem A.1** *Under Assumption 1 it holds that*

$$\sqrt{n}\begin{pmatrix} \bar{r}_{(0)}-\xi_{(0)} \\ \vdots \\ \bar{r}_{(m)}-\xi_{(m)} \end{pmatrix} \xrightarrow{d} N_{m+1}(0, n\Sigma_n),$$

*where*

$$\Sigma_n = \left[ n_{(k)}^{-1} n_{(k')}^{-1} \sum_{t\in S_{(k)}\cap S_{(k')}} \sigma_t^2 \right]_{k,k'=0,\ldots,m}.$$

**Proof.** The theorem is proven by employing a Cramer-Wold device. Let $\lambda \in \mathbb{R}^{l+1}$, where $\lambda'\lambda = 1$ and consider the linear combination

$$\sum_{k=0}^{m} \lambda_{(k)}\bar{r}_{(k)} = \sum_{k=0}^{m} \lambda_{(k)} \sum_{t=1}^{n} A_{(k),t} r_t = \sum_{t=1}^{n} b_{n,t} r_t,$$

where $b_{n,t} = \sum_{k=0}^{m} \lambda_k A_{(k),t}$. The sequence $\{b_{n,t}\}$ satisfies $\lim_n \sup_{1\leq t\leq n} b_{n,t} = 0$, such that

$$\frac{\sum_{t=1}^{n} b_{n,t}(r_t-\mu_\lambda)}{\omega_n} \xrightarrow{d} N(0,1),$$

where $\omega_n^2 = \lambda'\Sigma_n\lambda$, and where $\mu_\lambda = \sum_{k=0}^{m}\lambda_{(k)}\mu_{(k)} = E(\sum_{k=0}^{m}\lambda_{(k)}\bar{r}_{(k)})$.

Since

$$\left(\sum_{k=0}^{m}\lambda_{(k)}A_{(k),t}\right)^2 = \left(\sum_{k=0}^{m}\sum_{k'=0}^{m}\lambda_{(k)}\lambda_{(k')}A_{(k),t}A_{(k'),t}\right),$$

it holds that

$$\operatorname{var}(\sum_{k=0}^{m}\lambda_k\bar{r}_{(k)}) = \sum_{t=1}^{n} b_{n,t}^2 \operatorname{var}(r_t) = \sum_{t=1}^{n}\left(\sum_{k=0}^{m}\sum_{k'=0}^{m}\lambda_{(k)}\lambda_{(k')}A_{(k),t}A_{(k'),t}\right)\sigma_t^2$$

which equals

$$\lambda'\Sigma_n\lambda = \sum_{k=0}^{m}\sum_{k'=0}^{m}\lambda_{(k)}\lambda_{(k')}n_{(k)}^{-1}n_{(k')}^{-1}\sum_{t\in S_{(k)}\cap S_{(k')}}\sigma_t^2.$$

This completes the proof. ■

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## APPENDIX: TABLES AND FIGURES

Table 1: Summary of calendar effects.

| Name of Effect | # Effect | Individual Effect Names/Apprehensions |
|---|---|---|
| Day-of-the-week | 5 | `monday, ⋯, friday` |
| Month-of-the-year | 12 | `january, ⋯, december` |
| End-of-December | 3 | `pre.xmas, pre.xm.ny, inter.xm.ny` |
| Turn-of-the-month | 8 | `mo.first.4, ⋯, mo.first.1, mo.last.1, ⋯, mo.last.4` |
| Holiday-effects | 2 | `preholiday, postholiday` |
| Semi-month | 2 | `mo.1.half, mo.2.half` |
| Semi-month-of-the-year | 24 | `mo.1.jan, ⋯, mo.1.dec, mo.2.jan, ⋯, mo.2.dec` |
| Week-of-the-month | 5 | `week1, ⋯, week5` |
| Week-of-the-month-of-the-year | 60 | `week1.jan, ⋯, week1.dec, week2.jan, ⋯, week4.dec, ⋯, week5.dec` |
| Week-day-of-the-month | 60 | `mon.jan, ⋯, mon.dec, tue.jan, ⋯, thu.dec, fri.jan, ⋯, fri.dec` |

This table summarizes the calendar effects we analyze in the paper. The first column lists the type of effect, the second gives the number of this type of effects, and the last column contains the abbreviations we use for the individual effects.

Table 2: Summary Statistics for Index Returns

| Series | Mean | Med. | Min | Max | Std. | Skew. | Kurt. | #Obs. | Sample Period |
|---|---|---|---|---|---|---|---|---|---|
| *DENMARK* | | | | | | | | | |
| KFX | 0.05 | 0.06 | -10.91 | 7.21 | 1.01 | -0.69 | 12.04 | 3861 | 03.06.1985-30.10.2000 |
| *FRANCE* | | | | | | | | | |
| SBF120 | 0.05 | 0.05 | -7.69 | 6.20 | 1.16 | -0.26 | 5.98 | 2839 | 28.12.1990-30.04.2002 |
| CAC40 | 0.05 | 0.06 | -7.68 | 6.81 | 1.25 | -0.21 | 5.36 | 3586 | 31.12.1987-30.04.2002 |
| MIDCAC | 0.03 | 0.05 | -7.71 | 5.90 | 0.84 | -0.98 | 15.09 | 2839 | 28.12.1990-30.04.2002 |
| *GERMANY* | | | | | | | | | |
| DAX 100 | 0.04 | 0.09 | -14.05 | 6.65 | 1.24 | -0.81 | 12.17 | 3599 | 30.12.1987-06.05.2002 |
| DAX 30 | 0.03 | 0.08 | -13.71 | 7.29 | 1.37 | -0.68 | 10.07 | 4095 | 02.01.1986-06.05.2002 |
| MDAX | 0.04 | 0.07 | -15.16 | 8.12 | 0.89 | -2.14 | 36.86 | 3599 | 30.12.1987-06.05.2002 |
| *HONG KONG* | | | | | | | | | |
| HS COMP | -0.06 | -0.05 | -9.51 | 5.24 | 1.74 | -0.56 | 6.06 | 571 | 03.01.2000-06.05.2002 |
| HS MAIN | 0.05 | 0.08 | -40.54 | 17.25 | 1.85 | -3.36 | 74.56 | 4036 | 01.01.1986-06.05.2002 |
| HS MIDCAP | -0.03 | 0.08 | -9.06 | 4.88 | 1.50 | -0.92 | 7.85 | 571 | 03.01.2000-06.05.2002 |
| *ITALY* | | | | | | | | | |
| MIBTEL | 0.04 | 0.05 | -7.71 | 6.83 | 1.38 | -0.20 | 5.24 | 2222 | 16.07.1993-06.05.2002 |
| MIB 30 | 0.04 | 0.02 | -8.11 | 7.77 | 1.52 | -0.12 | 5.15 | 1903 | 17.10.1994-06.05.2002 |
| MIDEX | 0.06 | 0.05 | -7.71 | 4.99 | 1.18 | -0.45 | 7.33 | 1851 | 02.01.1995-06.05.2002 |
| *JAPAN* | | | | | | | | | |
| NIKKEI ALL | -0.01 | -0.05 | -6.51 | 7.13 | 1.23 | 0.17 | 6.24 | 2793 | 01.01.1990-06.05.2002 |
| NIKKEI 225 | $-3*10^{-3}$ | 0.02 | -16.14 | 12.43 | 1.45 | -0.10 | 10.65 | 4024 | 01.01.1986-06.05.2002 |
| TOKYO CAP | -0.01 | 0.02 | -11.95 | 5.49 | 1.01 | -0.82 | 12.63 | 4024 | 01.01.1986-06.05.2002 |
| *NORWAY* | | | | | | | | | |
| ALL SHARE | 0.03 | 0.07 | -6.34 | 5.64 | 1.14 | -0.60 | 6.83 | 1588 | 29.12.1995-06.05.2002 |
| OBX | 0.03 | 0.04 | -7.24 | 6.34 | 1.31 | -0.44 | 6.59 | 1586 | 03.01.1995-06.05.2002 |
| OSLO CAP | 0.05 | 0.08 | -7.28 | 5.54 | 0.89 | -0.81 | 10.69 | 1588 | 29.12.1995-06.05.2002 |
| *SWEDEN* | | | | | | | | | |
| SX-GEN | 0.05 | 0.08 | -8.07 | 9.88 | 1.40 | 0.06 | 6.88 | 1839 | 02.01.1995-06.05.2002 |
| OMX | 0.05 | 0.07 | -8.53 | 11.02 | 1.58 | 0.04 | 5.83 | 1839 | 02.01.1995-06.05.2002 |
| *UK* | | | | | | | | | |
| FTSE 350 | 0.03 | 0.07 | -11.98 | 5.81 | 0.95 | -1.09 | 16.01 | 4129 | 01.01.1986-06.05.2002 |
| FTSE 100 | 0.03 | 0.06 | -13.03 | 7.60 | 1.02 | -0.97 | 15.77 | 4129 | 01.01.1986-06.05.2002 |
| FTSE 250 | 0.04 | 0.09 | -11.28 | 7.25 | 0.79 | -2.03 | 32.17 | 4129 | 01.01.1986-06.05.2002 |
| *USA* | | | | | | | | | |
| DJIA | 0.02 | 0.04 | -27.96 | 14.27 | 1.09 | -1.17 | 39.31 | 29380 | 26.05.1896-06.05.2002 |
| S&P 500 | 0.03 | 0.03 | -22.83 | 8.71 | 1.01 | -1.69 | 42.05 | 7409 | 01.01.1973-06.05.2002 |
| S&P 400 MID | 0.05 | 0.08 | -7.33 | 5.97 | 1.03 | -0.30 | 7.24 | 2748 | 12.06.1991-06.05.2002 |

This table reports summary statistics for the 27 stock indices.

Table 3: $p$-values from tests for calendar effects, Three different spaces.

| Series | #Obs. | $p$-value return | | | $p$-value std. return | | |
|---|---|---|---|---|---|---|---|
| | | All | 17 | 5 | All | 17 | 5 |
| *DENMARK* | | | | | | | |
| KFX | 3861 | **0.0081** | **0.0494** | **0.0067** | **0.0010** | **0.0022** | 0.0727 |
| *FRANCE* | | | | | | | |
| SBF 120 | 2839 | **0.0191** | 0.4889 | **0.0056** | **0.0083** | 0.1848 | 0.7531 |
| CAC 40 | 3586 | **0.0240** | 0.3763 | **0.0104** | **0.0085** | 0.0789 | 0.5923 |
| MIDCAC | 2839 | <**0.0001** | <**0.0001** | <**0.0001** | <**0.0001** | <**0.0001** | **0.0010** |
| *GERMANY* | | | | | | | |
| DAX 100 | 3599 | **0.0368** | 0.1569 | **0.0015** | **0.0110** | **0.0208** | 0.4416 |
| DAX 30 | 4095 | 0.0580 | 0.3005 | **0.0069** | **0.0365** | 0.1301 | 0.3106 |
| MDAX | 3599 | **0.0001** | **0.0269** | **0.0115** | <**0.0001** | **0.0001** | 0.1332 |
| *HONG KONG* | | | | | | | |
| HS COMP | 571 | 0.1886 | 0.9320 | 0.3894 | 0.2053 | 0.9518 | 0.3128 |
| HS MAIN | 4036 | **0.0203** | **0.0243** | 0.1714 | **0.0036** | **0.0025** | 0.1567 |
| HS MIDCAP | 571 | **0.0080** | 0.6065 | 0.6394 | **0.0093** | 0.6760 | 0.6226 |
| *ITALY* | | | | | | | |
| MIBTEL | 2222 | **0.0031** | 0.0714 | **0.0003** | **0.0024** | 0.0542 | 0.7005 |
| MIB 30 | 1903 | 0.2211 | 0.4382 | **0.0033** | 0.2127 | 0.4021 | 0.5852 |
| MIDEX | 1851 | **0.0006** | **0.0181** | **0.0002** | **0.0003** | **0.0060** | 0.3499 |
| *JAPAN* | | | | | | | |
| NIKKEI ALL | 2793 | **0.0166** | 0.6646 | 0.1022 | **0.0192** | 0.7138 | 0.1324 |
| NIKKEI 225 | 4024 | 0.0926 | 0.3243 | 0.3025 | 0.1014 | 0.3893 | 0.3039 |
| TOKYO S.-C. | 4024 | <**0.0001** | <**0.0001** | **0.0227** | <**0.0001** | <**0.0001** | 0.0531 |
| *NORWAY* | | | | | | | |
| OSLO ALL | 1588 | 0.0632 | 0.2693 | <**0.0001** | **0.0481** | 0.2090 | **0.0221** |
| OBX | 1586 | 0.1101 | 0.5665 | **0.0001** | 0.1015 | 0.5130 | 0.0889 |
| OSLO S.-C. | 1588 | <**0.0001** | <**0.0001** | <**0.0001** | <**0.0001** | <**0.0001** | <**0.0001** |
| *SWEDEN* | | | | | | | |
| SX-GEN | 1839 | **0.0160** | 0.1921 | 0.1311 | **0.0113** | 0.1167 | 0.5060 |
| OMX | 1839 | **0.0224** | 0.2974 | 0.2096 | **0.0175** | 0.2256 | 0.6830 |
| *UK* | | | | | | | |
| FTSE 350 | 4129 | **0.0038** | 0.2601 | **0.0150** | **0.0007** | 0.0506 | 0.7426 |
| FTSE 100 | 4129 | **0.0063** | 0.3670 | **0.0239** | **0.0018** | 0.1176 | 0.7323 |
| FTSE 250 | 4129 | <**0.0001** | <**0.0001** | **0.0021** | <**0.0001** | <**0.0001** | 0.5668 |
| *USA* | | | | | | | |
| DJIA | 28899 | <**0.0001** | <**0.0001** | <**0.0001** | <**0.0001** | <**0.0001** | <**0.0001** |
| S&P 500 | 7409 | 0.2296 | 0.3328 | **0.0442** | 0.1240 | 0.0579 | 0.1028 |
| S&P 400 MID | 2748 | **0.0102** | 0.5473 | <**0.0001** | **0.0036** | 0.1748 | <**0.0001** |

This table reports $p$-values for the chi-squared test. In columns 3-5 test are performed on returns, and in columns 6-8 it is performed on standardized returns. “All" denotes the full space, “17" denotes the space which day-of-the-week and month-of-the-year effects. “5" denotes the xmas, new year and holiday effects.

Table 4: Performance of Calendar Effects: The Best five in terms of Returns.

| Series | Best | 2. Best | 3. Best | 4. Best | 5. Best |
|---|---|---|---|---|---|
| *DENMARK* | | | | | |
| KFX | pre.xm.ny | inter.xm.ny | week5.dec | week4.dec | week3.jan |
| *FRANCE* | | | | | |
| SBF 120 | pre.xm.ny | week4.dec | tue.oct | week5.apr | week5.feb |
| CAC 40 | pre.xm.ny | week1.feb | week4.dec | week5.apr | week5.feb |
| MIDCAC | pre.xm.ny | week5.dec | inter.xm.ny | week5.feb | week4.feb |
| *GERMANY* | | | | | |
| DAX 100 | pre.xm.ny | week4.dec | week5.dec | week1.feb | inter.xm.ny |
| DAX 30 | pre.xm.ny | week4.dec | thu.nov | week3.nov | tue.oct |
| MDAX | week1.feb | pre.xm.ny | tue.oct | week4.dec | inter.xm.ny |
| *HONG KONG* | | | | | |
| HS COMP | week5.sep | week1.dec | week1.jun | week1.nov | week2.jun |
| HS MAIN | fri.oct | pre.xm.ny | week1.oct | week1.jul | week4.dec |
| HS MIDCAP | week5.sep | week1.dec | wed.dec | week1.jun | week2.mar |
| *ITALY* | | | | | |
| MIBTEL | fri.jan | mon.dec | week4.dec | pre.xm.ny | pre.xmas |
| MIB 30 | fri.jan | pre.xm.ny | preholiday | mon.sep | inter.xm.ny |
| MIDEX | inter.xm.ny | week5.dec | week1.feb | mon.dec | week3.jan |
| *JAPAN* | | | | | |
| NIKKEI ALL | week5.jan | week1.may | week5.dec | inter.xm.ny | mo.last.1 |
| NIKKEI 225 | week1.may | week5.jan | wed.apr | wed.dec | thu.jul |
| TOKYO S.C. | week1.may | week5.jan | week5.mar | fri.apr | mo.1.may |
| *NORWAY* | | | | | |
| OSLO ALL | pre.xm.ny | inter.xm.ny | week5.dec | postholiday | week1.jan |
| OBX | pre.xm.ny | inter.xm.ny | week5.dec | postholiday | mo.2.dec |
| OSLO S.C. | pre.xm.ny | week5.dec | inter.xm.ny | week1.jan | preholiday |
| *SWEDEN* | | | | | |
| SX-GEN | inter.xm.ny | pre.xm.ny | week5.dec | week3.nov | thu.jan |
| OMX | week3.nov | inter.xm.ny | week5.dec | pre.xm.ny | mon.sep |
| *UK* | | | | | |
| FTSE 350 | inter.xm.ny | week5.jan | week4.dec | week1.jul | week1.mar |
| FTSE 100 | inter.xm.ny | week5.jan | week1.jul | week4.dec | week1.mar |
| FTSE 250 | week1.jan | inter.xm.ny | week4.dec | week1.mar | mo.2.dec |
| *USA* | | | | | |
| DJIA | pre.xm.ny | preholiday | week5.dec | week1.jul | inter.xm.ny |
| SP 500 | week5.jan | fri.dec | week1.jun | inter.xm.ny | week3.apr |
| SP 400 MID | pre.xm.ny | week5.dec | inter.xm.ny | week4.dec | mo.2.dec |

This table reports the names of the five best performing calendar effects in terms of returns. The abbreviations of the calendar effecs are described in Section 2 and Table 1.

Table 5: Performance of Calendar Effects: The Best five Returns.

| Series | Bench. | Best | 2. Best | 3. Best | 4. Best | 5. Best |
|---|---|---|---|---|---|---|
| *DENMARK* | | | | | | |
| KFX | 0.046 | 0.497 | 0.496 | 0.419 | 0.377 | 0.371 |
| *FRANCE* | | | | | | |
| SBF 120 | 0.047 | 0.625 | 0.561 | 0.493 | 0.472 | 0.456 |
| CAC 40 | 0.049 | 0.662 | 0.628 | 0.543 | 0.503 | 0.476 |
| MIDCAC | 0.033 | 0.674 | 0.572 | 0.488 | 0.482 | 0.410 |
| *GERMANY* | | | | | | |
| DAX 100 | 0.044 | 0.965 | 0.560 | 0.550 | 0.464 | 0.454 |
| DAX 30 | 0.031 | 0.935 | 0.580 | 0.465 | 0.397 | 0.389 |
| MDAX | 0.035 | 0.446 | 0.426 | 0.318 | 0.299 | 0.294 |
| *HONG KONG* | | | | | | |
| HS COMP | -0.061 | 1.429 | 1.355 | 1.292 | 1.142 | 1.087 |
| HS MAIN | 0.047 | 0.700 | 0.610 | 0.602 | 0.533 | 0.524 |
| HS MIDCAP | -0.026 | 1.468 | 1.407 | 1.343 | 0.944 | 0.915 |
| *ITALY* | | | | | | |
| MIBTEL | 0.041 | 0.626 | 0.617 | 0.578 | 0.577 | 0.555 |
| MIB 30 | 0.040 | 0.700 | 0.700 | 0.637 | 0.610 | 0.606 |
| MIDEX | 0.058 | 0.864 | 0.815 | 0.733 | 0.633 | 0.628 |
| *JAPAN* | | | | | | |
| NIKKEI ALL | -0.014 | 0.715 | 0.644 | 0.355 | 0.351 | 0.344 |
| NIKKEI 225 | -0.003 | 0.504 | 0.471 | 0.407 | 0.405 | 0.373 |
| TOKYO S.C. | -0.008 | 0.656 | 0.550 | 0.411 | 0.336 | 0.302 |
| *NORWAY* | | | | | | |
| OSLO ALL | 0.033 | 1.241 | 1.070 | 0.975 | 0.749 | 0.704 |
| OBX | 0.028 | 1.220 | 1.096 | 0.964 | 0.829 | 0.663 |
| OSLO S.C. | 0.046 | 1.375 | 1.028 | 0.896 | 0.785 | 0.617 |
| *SWEDEN* | | | | | | |
| SX-GEN | 0.048 | 0.848 | 0.839 | 0.780 | 0.777 | 0.647 |
| OMX | 0.048 | 0.882 | 0.877 | 0.794 | 0.778 | 0.717 |
| *UK* | | | | | | |
| FTSE 350 | 0.032 | 0.444 | 0.357 | 0.309 | 0.296 | 0.294 |
| FTSE 100 | 0.031 | 0.463 | 0.371 | 0.313 | 0.300 | 0.298 |
| FTSE 250 | 0.036 | 0.418 | 0.345 | 0.321 | 0.319 | 0.283 |
| *USA* | | | | | | |
| DJIA | 0.019 | 0.250 | 0.239 | 0.233 | 0.222 | 0.215 |
| SP 500 | 0.029 | 0.278 | 0.230 | 0.223 | 0.220 | 0.207 |
| SP 400 MID | 0.053 | 0.627 | 0.598 | 0.587 | 0.469 | 0.457 |

This table reports the returns of the five best performing calendar effects in terms of returns. The corresponding calendar effects are listed in Table 4.

Table 6: Performance of Calendar Effects: The Worst five in terms of Returns.

| Series | Worst | 2. Worst | 3. Worst | 4. Worst | 5. Worst |
|---|---|---|---|---|---|
| *DENMARK* | | | | | |
| KFX | mon.apr | week5.aug | week4.feb | week2.aug | fri.aug |
| *FRANCE* | | | | | |
| SBF 120 | week5.nov | thu.sep | thu.aug | week2.sep | mon.aug |
| CAC 40 | mon.aug | thu.aug | thu.sep | mon.nov | week5.nov |
| MIDCAC | fri.sep | week5.nov | week2.sep | thu.sep | week3.sep |
| *GERMANY* | | | | | |
| DAX 100 | thu.sep | mon.aug | tue.sep | week3.sep | fri.sep |
| DAX 30 | thu.sep | thu.oct | fri.sep | week3.sep | tue.sep |
| MDAX | week3.sep | mon.aug | thu.sep | week4.aug | fri.sep |
| *HONG KONG* | | | | | |
| HS COMP | mon.apr | week3.sep | wed.jan | mo.1.sep | week2.oct |
| HS MAIN | week5.oct | mon.oct | mon.jun | mon.aug | mon.apr |
| HS MIDCAP | week3.sep | wed.jan | mon.apr | mo.1.sep | week2.oct |
| *ITALY* | | | | | |
| MIBTEL | thu.sep | week2.sep | wed.may | week1.oct | mon.jun |
| MIB 30 | thu.sep | wed.may | week2.sep | week5.aug | week1.oct |
| MIDEX | thu.sep | mon.jun | mon.oct | week3.sep | week2.sep |
| *JAPAN* | | | | | |
| NIKKEI ALL | week1.jan | week4.jul | week3.jun | tue.jan | mon.aug |
| NIKKEI 225 | mon.apr | mon.jun | wed.sep | week4.jul | fri.aug |
| TOKYO S.C. | week4.jul | wed.sep | pre.xmas | week4.sep | mon.aug |
| *NORWAY* | | | | | |
| OSLO ALL | week3.sep | thu.sep | week3.mar | week2.oct | mo.2.sep |
| OBX | week3.sep | thu.sep | week2.oct | week3.mar | fri.sep |
| OSLO S.C. | pre.xmas | thu.sep | week3.dec | week3.sep | tue.sep |
| *SWEDEN* | | | | | |
| SX-GEN | wed.mar | thu.sep | thu.aug | week3.mar | wed.may |
| OMX | thu.sep | wed.mar | thu.aug | wed.may | week5.aug |
| *UK* | | | | | |
| FTSE 350 | mon.oct | week4.oct | week2.sep | tue.sep | week4.jul |
| FTSE 100 | mon.oct | week4.oct | week2.sep | tue.sep | week4.jul |
| FTSE 250 | mon.oct | week4.oct | week3.sep | tue.sep | mon.aug |
| *USA* | | | | | |
| DJIA | mon.sep | mon.oct | mon.may | mon.jun | thu.sep |
| SP 500 | week4.oct | mon.oct | thu.dec | thu.aug | thu.sep |
| SP 400 MID | fri.feb | week1.oct | mon.apr | week4.jul | week1.jan |

This table reports the names of the five worst performing calendar effects in terms of returns. The abbreviations of the calendar effecs are described in Section 2 and Table 1.

Table 7: Performance of Calendar Effects: The Worst five Returns.

| Series | Bench. | Worst | 2. Worst | 3. Worst | 4. Worst | 5. Worst |
|---|---|---|---|---|---|---|
| *DENMARK* | | | | | | |
| KFX | 0.046 | -0.236 | -0.209 | -0.199 | -0.198 | -0.192 |
| *FRANCE* | | | | | | |
| SBF 120 | 0.047 | -0.450 | -0.395 | -0.384 | -0.360 | -0.321 |
| CAC 40 | 0.049 | -0.421 | -0.377 | -0.328 | -0.327 | -0.311 |
| MIDCAC | 0.033 | -0.369 | -0.364 | -0.354 | -0.325 | -0.282 |
| *GERMANY* | | | | | | |
| DAX 100 | 0.044 | -0.507 | -0.318 | -0.314 | -0.272 | -0.255 |
| DAX 30 | 0.031 | -0.520 | -0.293 | -0.284 | -0.251 | -0.249 |
| MDAX | 0.035 | -0.420 | -0.354 | -0.301 | -0.264 | -0.238 |
| *HONG KONG* | | | | | | |
| HS COMP | -0.061 | -1.666 | -1.492 | -1.243 | -1.073 | -0.979 |
| HS MAIN | 0.047 | -0.992 | -0.931 | -0.531 | -0.475 | -0.409 |
| HS MIDCAP | -0.026 | -1.722 | -1.124 | -1.112 | -1.073 | -1.037 |
| *ITALY* | | | | | | |
| MIBTEL | 0.041 | -0.625 | -0.625 | -0.591 | -0.565 | -0.522 |
| MIB 30 | 0.040 | -0.874 | -0.576 | -0.529 | -0.458 | -0.454 |
| MIDEX | 0.058 | -0.557 | -0.405 | -0.390 | -0.389 | -0.384 |
| *JAPAN* | | | | | | |
| NIKKEI ALL | -0.014 | -0.453 | -0.397 | -0.345 | -0.302 | -0.295 |
| NIKKEI 225 | -0.003 | -0.422 | -0.371 | -0.341 | -0.322 | -0.319 |
| TOKYO S.C. | -0.008 | -0.433 | -0.345 | -0.328 | -0.314 | -0.310 |
| *NORWAY* | | | | | | |
| OSLO ALL | 0.033 | -0.603 | -0.571 | -0.444 | -0.359 | -0.343 |
| OBX | 0.028 | -0.774 | -0.656 | -0.532 | -0.492 | -0.430 |
| OSLO S.C. | 0.046 | -0.528 | -0.412 | -0.394 | -0.392 | -0.320 |
| *SWEDEN* | | | | | | |
| SX-GEN | 0.048 | -0.511 | -0.493 | -0.453 | -0.450 | -0.444 |
| OMX | 0.048 | -0.559 | -0.559 | -0.529 | -0.521 | -0.515 |
| *UK* | | | | | | |
| FTSE 350 | 0.032 | -0.355 | -0.338 | -0.272 | -0.261 | -0.229 |
| FTSE 100 | 0.031 | -0.345 | -0.340 | -0.290 | -0.258 | -0.232 |
| FTSE 250 | 0.036 | -0.390 | -0.352 | -0.285 | -0.263 | -0.255 |
| *USA* | | | | | | |
| DJIA | 0.019 | -0.244 | -0.188 | -0.162 | -0.152 | -0.136 |
| SP 500 | 0.029 | -0.171 | -0.150 | -0.147 | -0.122 | -0.116 |
| SP 400 MID | 0.053 | -0.352 | -0.250 | -0.238 | -0.226 | -0.221 |

This table reports the returns of the five worst performing calendar effects in terms of returns. The corresponding calendar effects are listed in Table 6.

Table 8: Performance of Calendar Effects: The Best five in terms of Standardized Returns.

| Series | Best | 2. Best | 3. Best | 4. Best | 5. Best |
|---|---|---|---|---|---|
| *DENMARK* | | | | | |
| KFX | mo.first.2 | mo.1.jul | inter.xm.ny | week1.jul | week5.dec |
| *FRANCE* | | | | | |
| SBF 120 | mo.2.dec | week4.dec | pre.xm.ny | mo.last.1 | preholiday |
| CAC 40 | week1.feb | week4.dec | mo.2.dec | pre.xm.ny | preholiday |
| MIDCAC | week5.dec | february | inter.xm.ny | mo.last.1 | january |
| *GERMANY* | | | | | |
| DAX 100 | mo.1.jul | preholiday | mo.2.dec | week1.jun | pre.xm.ny |
| DAX 30 | preholiday | mo.1.jul | pre.xm.ny | week4.dec | mo.2.dec |
| MDAX | week1.feb | mo.last.1 | preholiday | week1 | mo.1.jul |
| *HONG KONG* | | | | | |
| HS COMP | week2.jun | mo.2.apr | inter.xm.ny | fri.jan | week2.mar |
| HS MAIN | pre.xm.ny | mo.first.2 | week4.dec | friday | mo.last.1 |
| HS MIDCAP | week1.dec | pre.xm.ny | week5.dec | inter.xm.ny | mo.2.apr |
| *ITALY* | | | | | |
| MIBTEL | mo.2.dec | preholiday | pre.xm.ny | thu.nov | pre.xmas |
| MIB 30 | preholiday | mo.2.dec | pre.xm.ny | thu.nov | week3.nov |
| MIDEX | pre.xm.ny | preholiday | mo.last.1 | week1.feb | week5.dec |
| *JAPAN* | | | | | |
| NIKKEI ALL | mo.last.1 | week1.may | mo.last.4 | inter.xm.ny | thu.feb |
| NIKKEI 225 | thu.jul | wed.dec | thu.feb | wed.apr | week1.may |
| TOKYO S.C. | week1.may | mo.1.may | may | mo.last.1 | fri.apr |
| *NORWAY* | | | | | |
| OSLO ALL | pre.xm.ny | postholiday | preholiday | week2.mar | fri.mar |
| OBX | pre.xm.ny | postholiday | week1.jul | mo.2.dec | week2.mar |
| OSLO S.C. | pre.xm.ny | preholiday | mo.last.1 | week4.jan | inter.xm.ny |
| *SWEDEN* | | | | | |
| SX-GEN | inter.xm.ny | week3.nov | week5.dec | week1.feb | mo.last.1 |
| OMX | week3.nov | mon.sep | inter.xm.ny | week1.feb | week5.dec |
| *UK* | | | | | |
| FTSE 350 | mo.2.dec | week4.dec | mo.1.jul | week5.jan | december |
| FTSE 100 | mo.2.dec | week4.dec | mo.1.jul | week5.jan | december |
| FTSE 250 | week4.dec | mo.2.dec | week1.jan | week1 | week1.mar |
| *USA* | | | | | |
| DJIA | preholiday | week1 | pre.xm.ny | mo.first.2 | week5.dec |
| SP 500 | mo.2.dec | fri.dec | week5.jan | week1.jun | wednesday |
| SP 400 MID | mo.2.dec | inter.xm.ny | week5.dec | mo.last.2 | pre.xm.ny |

This table reports the names of the five best performing calendar effects in terms of standardized returns. The abbreviations of the calendar effecs are described in Section 2 and Table 1.

Table 9: Performance of Calendar Effects: The Best five Standardized Returns.

| Series | Best | 2. Best | 3. Best | 4. Best | 5. Best |
|---|---|---|---|---|---|
| *DENMARK* | | | | | |
| KFX | 4.873 | 4.455 | 4.317 | 3.795 | 3.383 |
| *FRANCE* | | | | | |
| SBF 120 | 3.815 | 3.606 | 3.517 | 3.392 | 3.008 |
| CAC 40 | 3.730 | 3.649 | 3.552 | 3.504 | 3.220 |
| MIDCAC | 5.852 | 5.669 | 4.790 | 4.757 | 4.725 |
| *GERMANY* | | | | | |
| DAX 100 | 4.370 | 4.287 | 3.971 | 3.654 | 3.570 |
| DAX 30 | 3.923 | 3.907 | 3.696 | 3.611 | 3.267 |
| MDAX | 5.056 | 5.038 | 4.792 | 4.704 | 4.297 |
| *HONG KONG* | | | | | |
| HS COMP | 3.160 | 2.585 | 2.549 | 2.522 | 2.457 |
| HS MAIN | 3.466 | 3.410 | 3.370 | 3.174 | 3.144 |
| HS MIDCAP | 4.634 | 4.462 | 3.967 | 3.696 | 3.422 |
| *ITALY* | | | | | |
| MIBTEL | 3.814 | 3.627 | 3.079 | 3.019 | 2.932 |
| MIB 30 | 4.078 | 3.063 | 3.052 | 2.882 | 2.643 |
| MIDEX | 5.958 | 4.836 | 4.369 | 3.905 | 3.705 |
| *JAPAN* | | | | | |
| NIKKEI ALL | 3.419 | 2.526 | 2.143 | 1.968 | 1.962 |
| NIKKEI 225 | 2.634 | 2.479 | 2.432 | 2.421 | 2.249 |
| TOKYO S.C. | 5.056 | 4.532 | 3.712 | 3.676 | 3.662 |
| *NORWAY* | | | | | |
| OSLO ALL | 5.029 | 3.679 | 3.670 | 3.045 | 2.989 |
| OBX | 4.147 | 3.609 | 3.163 | 3.141 | 2.969 |
| OSLO S.C. | 4.984 | 4.768 | 4.573 | 4.539 | 4.365 |
| *SWEDEN* | | | | | |
| SX-GEN | 3.839 | 3.794 | 3.660 | 3.075 | 2.942 |
| OMX | 3.811 | 2.826 | 2.742 | 2.674 | 2.556 |
| *UK* | | | | | |
| FTSE 350 | 3.929 | 3.563 | 3.283 | 3.239 | 2.962 |
| FTSE 100 | 3.613 | 3.167 | 3.145 | 3.049 | 2.794 |
| FTSE 250 | 5.664 | 5.428 | 4.381 | 4.177 | 4.163 |
| *USA* | | | | | |
| DJIA | 7.601 | 6.551 | 5.044 | 4.906 | 4.797 |
| SP 500 | 3.697 | 3.015 | 2.889 | 2.799 | 2.732 |
| SP 400 MID | 4.876 | 4.222 | 3.822 | 3.508 | 3.475 |

This table reports the returns of the five best performing calendar effects in terms of standardized returns. The corresponding calendar effects are listed in Table 8.

Table 10: Performance of Calendar Effects: The Worst five in terms of Standardized Returns.

| Series | Worst | 2. Worst | 3. Worst | 4. Worst | 5. Worst |
|---|---|---|---|---|---|
| *DENMARK* | | | | | |
| KFX | week5.aug | august | week4.feb | week4.jul | mo.1.aug |
| *FRANCE* | | | | | |
| SBF 120 | thu.aug | week5.nov | week5.aug | week3.jun | mo.2.sep |
| CAC 40 | thu.aug | week3.jun | week5.nov | mo.2.sep | mon.aug |
| MIDCAC | week5.nov | week3.jun | wed.jul | september | week3.dec |
| *GERMANY* | | | | | |
| DAX 100 | thu.sep | september | mo.2.sep | week4.jul | week3.aug |
| DAX 30 | thu.sep | september | mo.2.sep | fri.sep | week3.aug |
| MDAX | week3.sep | september | thu.sep | mo.2.sep | week3.jun |
| *HONG KONG* | | | | | |
| HS COMP | fri.aug | week3.sep | mo.last.2 | mo.1.sep | wed.jan |
| HS MAIN | mo.last.2 | week3.sep | week4.jul | thu.mar | week5.nov |
| HS MIDCAP | week3.sep | week5.jan | fri.aug | wed.jan | week4.aug |
| *ITALY* | | | | | |
| MIBTEL | wed.may | mon.jun | week5.aug | thu.sep | week2.sep |
| MIB 30 | week5.aug | wed.may | thu.sep | week2.dec | mo.2.aug |
| MIDEX | week2.dec | mon.jun | thu.sep | week5.aug | mo.1.jun |
| *JAPAN* | | | | | |
| NIKKEI ALL | week4.jul | mo.first.4 | monday | week3.jun | mo.2.jul |
| NIKKEI 225 | mon.jun | monday | week3.jun | mo.first.4 | week4 |
| TOKYO S.C. | week4.jul | mo.2.jul | september | pre.xmas | week4 |
| *NORWAY* | | | | | |
| OSLO ALL | week3.mar | week3.sep | week3.jun | week5.aug | mo.2.sep |
| OBX | week3.mar | week3.sep | wed.may | week2.oct | thu.jun |
| OSLO S.C. | week3.jun | pre.xmas | september | week3.dec | week4.jun |
| *SWEDEN* | | | | | |
| SX-GEN | week5.aug | wed.mar | wed.may | week3.jun | thu.aug |
| OMX | week5.aug | wed.may | wed.mar | thu.aug | thu.sep |
| *UK* | | | | | |
| FTSE 350 | week4.jul | week2.sep | tue.sep | mo.2.jun | thu.aug |
| FTSE 100 | week4.jul | week2.sep | thu.aug | tue.sep | mo.2.jun |
| FTSE 250 | tue.sep | week4.jul | september | mon.aug | week4.jun |
| *USA* | | | | | |
| DJIA | monday | mon.sep | mon.may | mon.jun | september |
| SP 500 | thu.dec | thu.aug | week4.jul | week4.sep | tue.jul |
| SP 400 MID | fri.feb | week4.jul | week2.jun | postholiday | week1.oct |

This table reports the names of the five worst performing calendar effects in terms of standardized returns. The abbreviations of the calendar effecs are described in Section 2 and Table 1.

Table 11: Performance of Calendar Effects: The Worst five Standardized Returns.

| Series | Worst | 2. Worst | 3. Worst | 4. Worst | 5. Worst |
|---|---|---|---|---|---|
| *DENMARK* | | | | | |
| KFX | -2.303 | -1.960 | -1.933 | -1.768 | -1.727 |
| *FRANCE* | | | | | |
| SBF 120 | -2.442 | -2.192 | -1.933 | -1.832 | -1.814 |
| CAC 40 | -2.471 | -1.881 | -1.823 | -1.800 | -1.775 |
| MIDCAC | -3.358 | -2.977 | -2.672 | -2.590 | -2.500 |
| *GERMANY* | | | | | |
| DAX 100 | -2.744 | -2.197 | -1.954 | -1.717 | -1.712 |
| DAX 30 | -2.930 | -2.417 | -2.105 | -1.672 | -1.578 |
| MDAX | -3.017 | -2.311 | -2.230 | -2.094 | -1.977 |
| *HONG KONG* | | | | | |
| HS COMP | -2.651 | -2.369 | -2.094 | -2.069 | -1.999 |
| HS MAIN | -2.184 | -2.182 | -2.066 | -1.940 | -1.797 |
| HS MIDCAP | -2.961 | -2.457 | -2.343 | -2.270 | -2.152 |
| *ITALY* | | | | | |
| MIBTEL | -3.015 | -2.554 | -2.372 | -2.125 | -2.055 |
| MIB 30 | -2.499 | -2.472 | -2.187 | -2.053 | -1.785 |
| MIDEX | -2.486 | -2.302 | -2.202 | -2.036 | -1.771 |
| *JAPAN* | | | | | |
| NIKKEI ALL | -2.607 | -2.562 | -2.403 | -2.382 | -2.155 |
| NIKKEI 225 | -2.481 | -2.224 | -2.070 | -1.947 | -1.930 |
| TOKYO S.C. | -4.768 | -4.245 | -3.316 | -3.086 | -2.898 |
| *NORWAY* | | | | | |
| OSLO ALL | -2.338 | -1.924 | -1.828 | -1.770 | -1.720 |
| OBX | -2.500 | -1.869 | -1.767 | -1.740 | -1.555 |
| OSLO S.C. | -2.945 | -2.937 | -2.630 | -2.555 | -2.318 |
| *SWEDEN* | | | | | |
| SX-GEN | -2.369 | -2.143 | -2.135 | -1.892 | -1.891 |
| OMX | -3.053 | -2.155 | -2.094 | -2.028 | -1.868 |
| *UK* | | | | | |
| FTSE 350 | -2.633 | -2.145 | -2.123 | -2.030 | -1.795 |
| FTSE 100 | -2.506 | -2.136 | -1.986 | -1.961 | -1.868 |
| FTSE 250 | -2.679 | -2.470 | -2.365 | -2.342 | -2.227 |
| *USA* | | | | | |
| DJIA | -6.021 | -3.571 | -3.148 | -2.673 | -2.566 |
| SP 500 | -1.948 | -1.498 | -1.442 | -1.331 | -1.331 |
| SP 400 MID | -2.610 | -1.835 | -1.570 | -1.566 | -1.373 |

This table reports the returns of the five worst performing calendar effects in terms of standardized returns. The corresponding calendar effects are listed in Table 10.

Table 12: Return Performance of selected Calendar Effects.

| Series | Bench. | monday | january | p.xmas | p.xm.ny | int.xm.ny | prehol. | posthol. |
|---|---|---|---|---|---|---|---|---|
| *DENMARK* | | | | | | | | |
| KFX | 0.046 | 0.021 | 0.161 | -0.011 | 0.497 | 0.496 | 0.221 | 0.195 |
| *FRANCE* | | | | | | | | |
| SBF 120 | 0.047 | 0.018 | 0.114 | 0.233 | 0.625 | 0.340 | 0.315 | 0.219 |
| CAC 40 | 0.049 | -0.033 | 0.042 | 0.224 | 0.662 | 0.207 | 0.313 | 0.151 |
| MIDCAC | 0.033 | 0.003 | 0.241 | -0.117 | 0.674 | 0.488 | 0.315 | 0.143 |
| *GERMANY* | | | | | | | | |
| DAX 100 | 0.044 | 0.050 | 0.062 | 0.221 | 0.965 | 0.454 | 0.376 | 0.179 |
| DAX 30 | 0.031 | -0.001 | 0.030 | 0.233 | 0.935 | 0.266 | 0.347 | 0.100 |
| MDAX | 0.035 | -0.031 | 0.063 | 0.072 | 0.426 | 0.294 | 0.279 | 0.077 |
| *HONG KONG* | | | | | | | | |
| HS COMP | -0.061 | -0.228 | -0.139 | -0.699 | 0.144 | 0.797 | 0.423 | 0.053 |
| HS MAIN | 0.047 | -0.151 | -0.012 | 0.216 | 0.610 | 0.174 | 0.299 | -0.042 |
| HS MIDCAP | -0.026 | -0.132 | -0.053 | -0.256 | 0.445 | 0.742 | 0.270 | 0.020 |
| *ITALY* | | | | | | | | |
| MIBTEL | 0.041 | 0.029 | 0.247 | 0.555 | 0.577 | 0.541 | 0.528 | 0.418 |
| MIB 30 | 0.040 | 0.027 | 0.215 | 0.541 | 0.700 | 0.606 | 0.637 | 0.394 |
| MIDEX | 0.058 | -0.006 | 0.296 | 0.310 | 0.587 | 0.864 | 0.619 | 0.403 |
| *JAPAN* | | | | | | | | |
| NIKKEI ALL | -0.014 | -0.144 | -0.000 | -0.222 | 0.116 | 0.351 | 0.121 | 0.147 |
| NIKKEI 225 | -0.003 | -0.130 | 0.091 | -0.239 | -0.012 | 0.151 | 0.154 | 0.059 |
| TOKYO S.C. | -0.008 | -0.073 | 0.103 | -0.328 | -0.176 | 0.071 | 0.070 | -0.024 |
| *NORWAY* | | | | | | | | |
| OSLO ALL | 0.033 | 0.064 | 0.119 | -0.050 | 1.241 | 1.070 | 0.541 | 0.749 |
| OBX | 0.028 | 0.093 | 0.040 | 0.084 | 1.220 | 1.096 | 0.417 | 0.829 |
| OSLO S.C. | 0.046 | -0.008 | 0.315 | -0.528 | 1.375 | 0.896 | 0.617 | 0.597 |
| *SWEDEN* | | | | | | | | |
| SX-GEN | 0.048 | 0.168 | 0.103 | -0.002 | 0.839 | 0.848 | 0.348 | 0.361 |
| OMX | 0.048 | 0.207 | 0.092 | -0.024 | 0.778 | 0.877 | 0.284 | 0.447 |
| *UK* | | | | | | | | |
| FTSE 350 | 0.032 | -0.042 | 0.086 | 0.236 | 0.207 | 0.444 | 0.179 | 0.088 |
| FTSE 100 | 0.031 | -0.050 | 0.077 | 0.232 | 0.194 | 0.463 | 0.194 | 0.088 |
| FTSE 250 | 0.036 | -0.066 | 0.127 | 0.241 | 0.252 | 0.345 | 0.136 | 0.095 |
| *USA* | | | | | | | | |
| DJIA | 0.019 | -0.102 | 0.046 | 0.010 | 0.250 | 0.215 | 0.239 | -0.052 |
| SP 500 | 0.029 | -0.028 | 0.088 | 0.152 | 0.125 | 0.220 | 0.142 | -0.016 |
| SP 400 MID | 0.053 | -0.014 | 0.015 | 0.256 | 0.627 | 0.587 | 0.149 | -0.214 |

This table reports the performance on six selected calendar effects in terms of returns. See Table 1 and Section 2 for an explanation of the effect apprehensions.

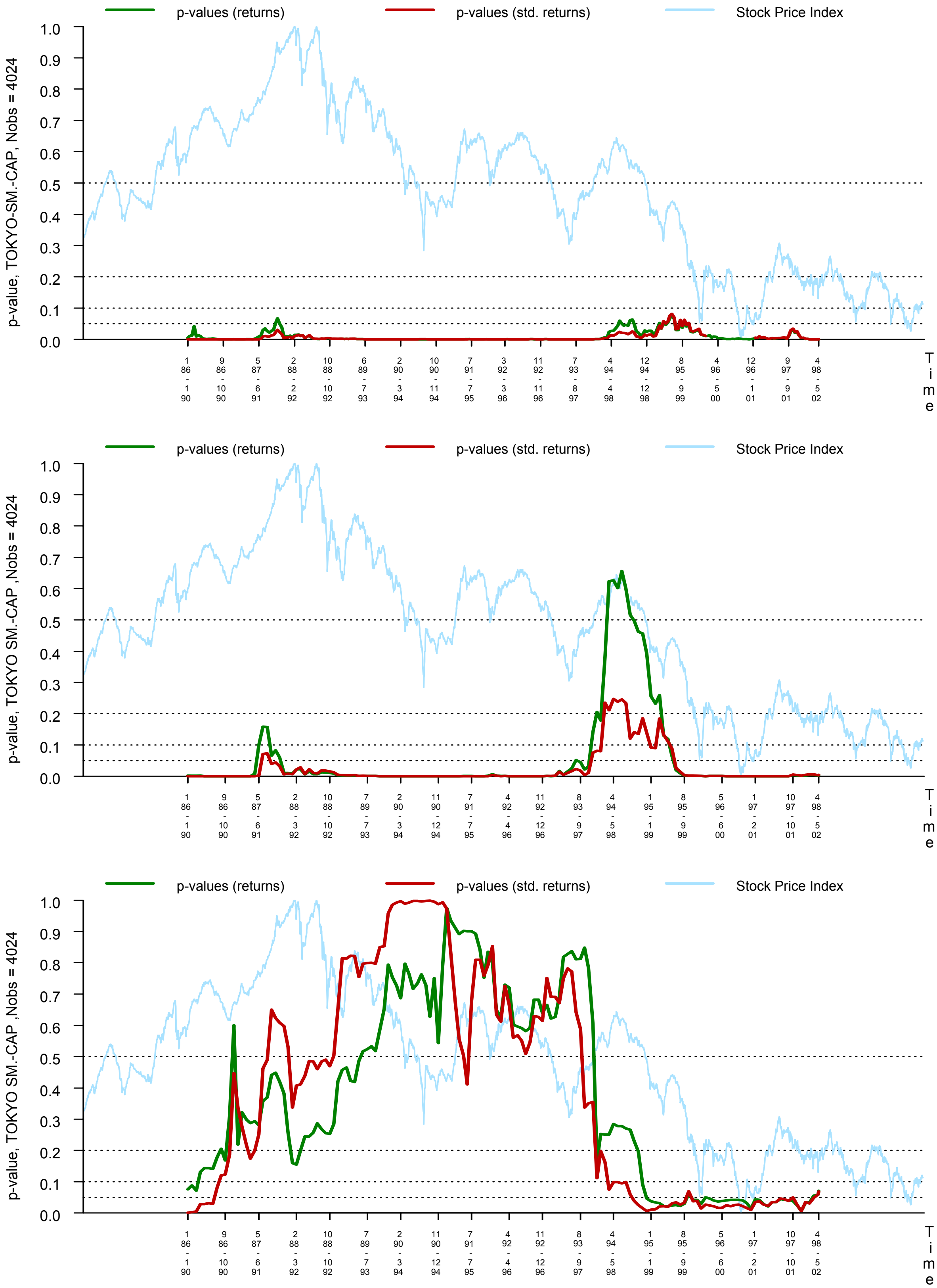


Figure 1 This figure present rolling-sample $p$-values for TOKYO-SM.-CAP. Each $p$-value is based on 1000 daily returns, and calculated in step of 20 obsevations. The top plot has all rules , the middel plot has 17 effects (day-of-the-week and month-of-the-year), and the bottom plot has 5 effects (xmas, new year and holiday).

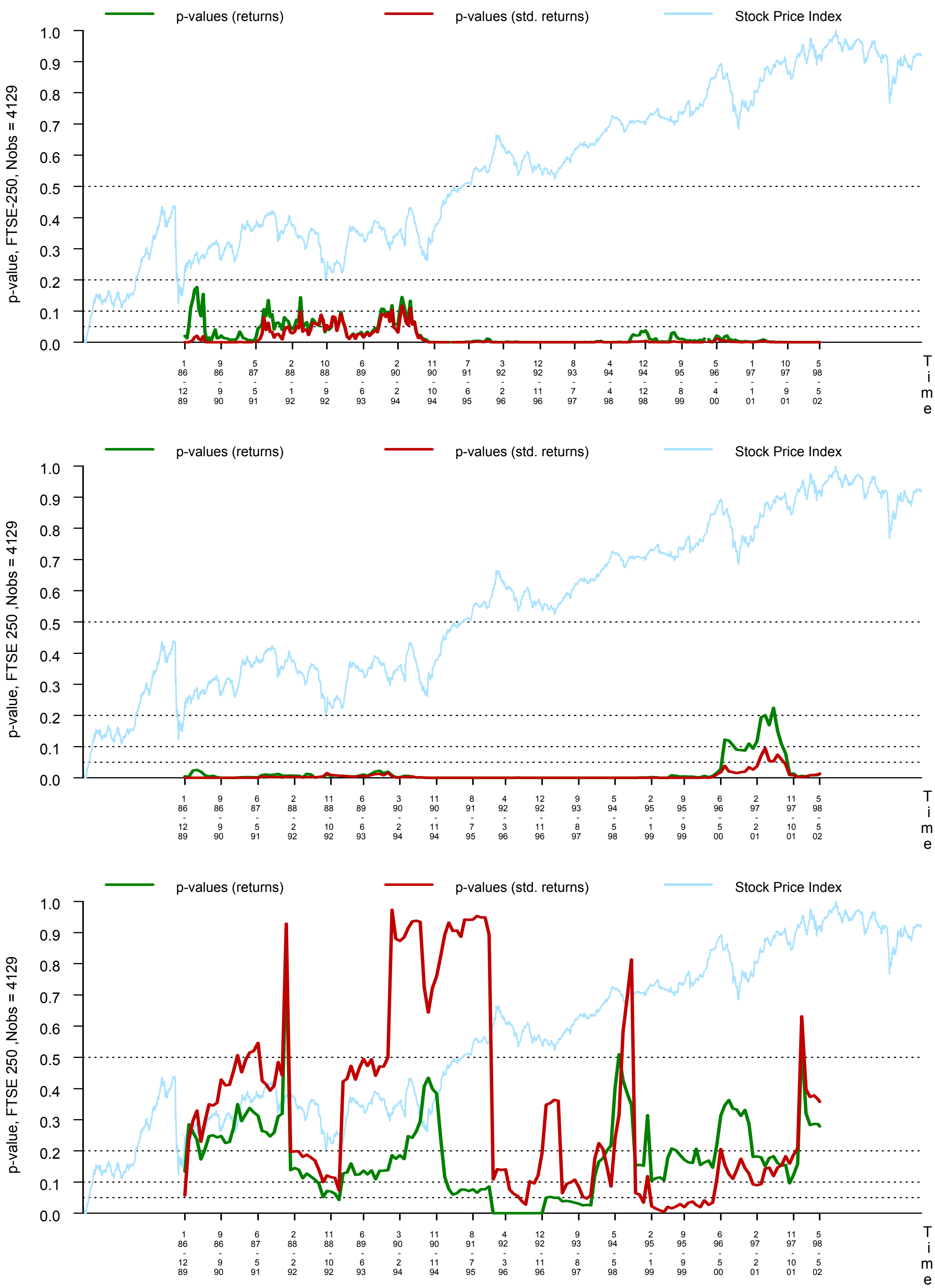


Figure 2 This figure present rolling-sample $p$-values for FTSE-250. Each $p$-value is based on 1000 daily returns, and calculated in step of 20 obsevations. The top plot has all rules , the middel plot has 17 effects (day-of-the-week and month-of-the-year), and the bottom plot has 5 effects (xmas, new year and holiday).

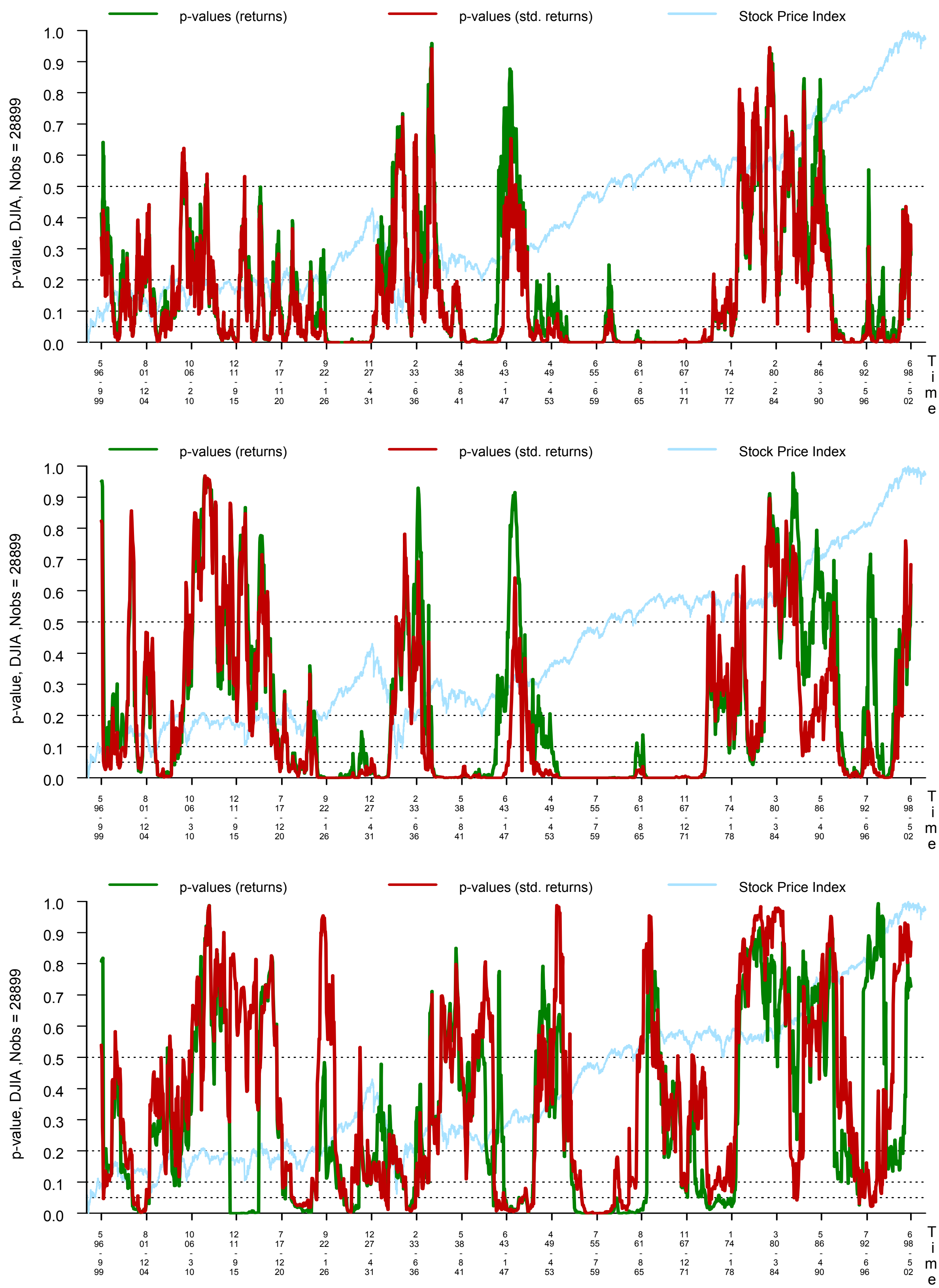


Figure 3 This figure present rolling-sample $p$-values for DJIA. Each $p$-value is based on 1000 daily returns, and calculated in step of 20 obsevations. The top plot has all rules , the middel plot has 17 effects (day-of-the-week and month-of-the-year), and the bottom plot has 5 effects (xmas, new year and holiday).

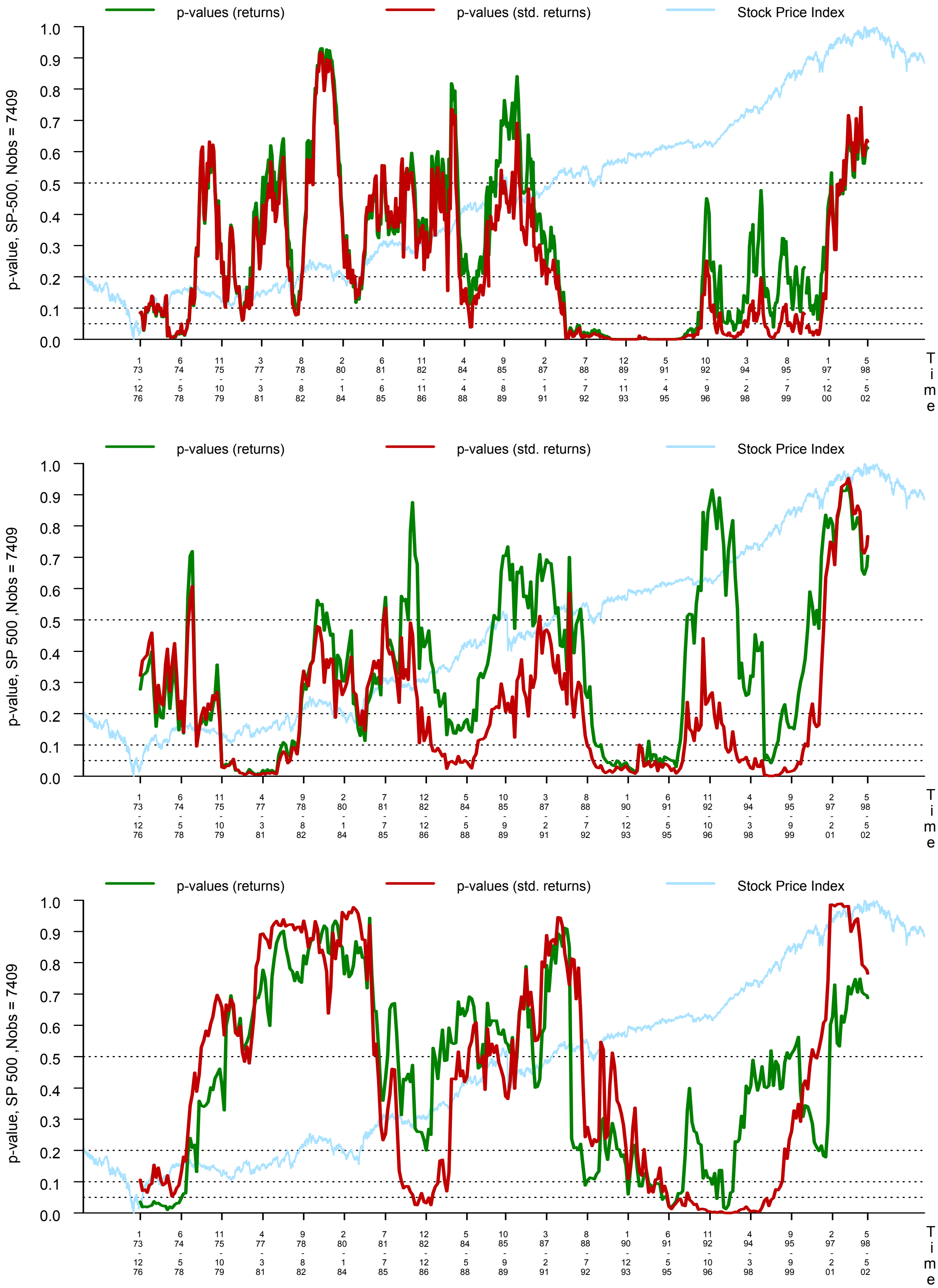


Figure 4 This figure present rolling-sample $p$-values for SP-500. Each $p$-value is based on 1000 daily returns, and calculated in step of 20 obsevations. The top plot has all rules , the middel plot has 17 effects (day-of-the-week and month-of-the-year), and the bottom plot has 5 effects (xmas, new year and holiday).