Expert Systems with Applications 36 (2009) 6140–6144

Contents lists available at ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

# Testing the significance of solar term effect in the Taiwan stock market

Hui-Miao Cheng [a], Kuo-Ching Ying [b,*]

[a] Department of Information Management, China University of Technology, Taipei, Taiwan
[b] Department of Industrial Management and Management Information, Huafan University, No. 1, Huafan Road, Taipei, Taiwan

ARTICLE INFO

*Keywords:*
Calendar effects
Solar terms
Taiwan stock market

ABSTRACT

This paper examines lunisolar calendar anomalies in the Taiwan stock market, particularly the *solar term effect*. Using the Taiwan Stock Exchange Capitalization Weighted Stock Index (TAIEX), the significance of the *solar term effect* was tested. Statistical results showed that the lowest and the highest average stock returns are observed on *Cold Dew* and *White Dew*, respectively. Additionally, we found that all of the solar terms with negative average stock returns occurred during the period of *Grain Fills* to *Winter Solstice*. Although many investors believe that the *solar term effect* exists in the Taiwan stock market, the results of this study appear to show that the *solar term effect* is a mere superstition. The analytical results may prove useful for future theoretical and empirical work on the stock market in Taiwan and elsewhere.



## 1. Introduction

Since the efficient market hypotheses (EMH) evolved from Fama's dissertation in 1965, topics related to capital market efficiency have been of continuing interest for researchers and the investment community. An efficient capital market is one in which stock prices adjust rapidly to reflect the effect of available information about stocks. Although various stock-price or stock-index forecasting techniques have been proposed (Chang & Liu, 2008; Hassan, Nath, & Kirley, 2007; Kim & Han, 2000; Roh, 2007; Wang, 2002), under the assumption that new information regarding stocks comes to the market in a random fashion, the EMH acknowledges that short term anomalies might exist, though investors cannot predict which will occur at any given time. Further, since many profit-maximizing investors compete against one another, these short term anomalies will disappear rapidly and arbitrage opportunities will not be able to generate any abnormal returns due to the sporadic nature of such anomalies.

During the past two decades, the argument on whether or not the capital market is efficient has grown with the birth of EMH. Several studies have obtained results that do not support the EMH (Enke & Thawornwong, 2005; Quah & Srinivasan, 1999; Reilly & Brown, 2003). One of the most interesting and important anomalies is the calendar effect. A calendar effect is any actual or hypothesized stock market trend based on the calendar, such as rises and falls associated with particular days of the week or months of the year. Since the 1960's a number of different calendar anomalies have been verified. For example, Ariel (1987), Keim (1983), and Haugen and Jorion (1996) verified *month-of-the-year effect* or *January effect* of the stock market wherein stocks, especially small-cap stocks, have historically tended to rise markedly in price during the period starting on the last day of December and ending on the fifth trading day of January. Similarly, Linn and Lockwood (1988) and Hensel and Ziemba (1996) found a *week-of-the-month effect* in which stocks usually have higher rate of returns during the first week-of-the-month than the last three weeks. Several studies proposed by Cross (1973) and French (1980) have confirmed the *day-of-the-Week effect* or *weekend effect* under which, on average, closing prices on Monday evening are lower than Friday's closing prices. More recently, Guin (2005) found trading volumes and prices tend to increase during the last 15 minutes of a day and named it *hour-of-the-day effect* or *the end-of-the-day effect*. Additionally, a *holiday effect* in which stock markets tend to have higher than normal returns before public holidays has also been confirmed by several investigators (Lakonishok & Smidt, 1988; Pettengill, 1989).

Although many existing studies describe theoretical and statistical analysis of various calendar effects, little is known about the lunisolar calendar anomalies. A solar term is one of 24 periods of time in traditional East Asian lunisolar calendars. Though the *solar term effect* is often cited by chartered financial analysts, to the best of our knowledge, no theoretical study has been addressed on this topic to date. Given the lack of research in this area, this study systematically explores lunisolar calendar anomalies in the Taiwan stock market, particularly the *solar term effect*.

The remainder of this paper is organized as follows. The next section introduces the solar terms. Section 3 then presents the empirical methodology. The data used in this study and the empirical results are discussed in Section 4. Finally, this study concludes with recommendations for future research.

* Corresponding author. Tel.: +886 2 26632102x4314; fax: +866 2 26633981.
*E-mail address:* kcying@hfu.edu.tw (K.-C. Ying).

0957-4174/$ - see front matter 
doi:10.1016/j.eswa.2008.07.015

## 2. Solar terms

A lunisolar calendar is a traditional East Asian calendar which originated in China, and then spread to Japan, Korea, and Vietnam. Also known as the *agricultural calendar* or *Yin calendar*, this calendar blends elements of a lunar calendar with those of a solar calendar. To assist farmers in deciding when to plant or harvest crops, the drafters of the calendar put in 24 seasonal markers, named solar terms. Table 1 gives a list of 24 solar terms.

A solar term begins at the instant when the sun reaches one of 24 equally spaced points along the ecliptic. From the earth's perspective, the Sun moves through a year across the stars or celestial sphere along the ecliptic measuring 360° of longitude on its annual path. Consequently, the 24 solar terms divide the ecliptic into 24 equal segments, with 15° of the Sun's longitude between the solar terms.

Since the speed of the Sun along the ecliptic varies depending on the distance between the Earth and the Sun, the time required for the Sun to travel between each pair of solar terms will vary slightly throughout the year. The solar terms fall around the same date, ±1 day, each year in the Gregorian calendar. However, in the Chinese calendar, a solar term will signify some natural phenomenon or match a particular astronomical event.

## 3. Empirical methodology

In this section, we describe the hypothesis and test for lunisolar calendar anomalies. The *solar term effect* is examined on the basis of a trading time hypothesis whereby stock returns are created only on trading days during solar terms. An adjusted stock return was used in testing the *solar term effect* and is calculated as:

$$R_t = \frac{I_t - I_{t-1}}{I_{t-1}} \times 100\%,$$

where $R_t$ denotes the stock return of solar term $t$, and $I_t$ represents the mean closing value of TAIEX of solar term $t$.

**Table 1**
List of 24 solar terms

| Ecliptic longitude | Solar term | Gregorian date |
|---|---|---|
| 315° | Start of Spring | February 4 |
| 330° | Rain Water | February 19 |
| 345° | Awakening of Insects | March 5 |
| 0° | Spring Equinox | March 21 |
| 15° | Clear and Bright | April 5 |
| 30° | Grain Rains | April 20 |
| 45° | Start of Summer | May 6 |
| 60° | Grain Fills | May 21 |
| 75° | Grain in Ear | June 6 |
| 90° | Summer Solstice | June 21 |
| 105° | Slight Heat | July 7 |
| 120° | Great Heat | July 23 |
| 135° | Start of Autumn | August 7 |
| 150° | Limit of Heat | August 23 |
| 165° | White Dew | September 8 |
| 180° | Autumnal Equinox | September 23 |
| 195° | Cold Dew | October 8 |
| 210° | Descends of Frost | October 23 |
| 225° | Start of Winter | November 7 |
| 240° | Light Snow | November 22 |
| 255° | Heavy Snow | December 7 |
| 270° | Winter Solstice | December 22 |
| 285° | Little Cold | January 6 |
| 330° | Severe Clod | January 20 |

### 3.1. Hypothesis

The hypothesis to be tested is that there is no *solar term effect* in adjusted stock returns of the Taiwan stock market, which can be formulated parametrically as,

$$\mathrm{H}_0 : \mu_1 = \mu_2 = \cdots = \mu_{24},$$

$$\mathrm{H}_1 : \text{ Not all means are equal.}$$

The null hypothesis means that the mean adjusted stock returns on all trading solar terms of the lunisolar calendar years are equal. If the null hypothesis were rejected, it would mean that the *solar term effect* exists and the market is not efficient.

### 3.2. Normality test

The starting point of our analysis is to use the Lilliefors test (Lilliefors, 1967) to examination whether the test data come from a normally distributed population. The Lilliefors test is a well-known normality test that proceeds as follows: first, the population mean and population variance based on the data are estimated. Then, the cumulative distribution function of the normal distribution and the maximum discrepancy between the empirical distribution function are found. Finally, the question of whether the maximum discrepancy is large enough to be statistically significant is confronted, thus requiring rejection of the normality hypothesis.

Notably, the *F*-test is extremely non-robust to non-normality (Lindman, 1974). Even if the data displays only modest departures from the normal distribution, the test is unreliable and should not be used. Under such circumstances, the Kruskal–Wallis test is a non-parametric alternative which does not rely on an assumption of normality.

### 3.3. Homogeneity of variance test

Occasionally, the seasonal risk is a major cause of calendar anomalies. Hence, the Levene's test is used to assess the equality of variance in different samples before a comparison of means. In statistics, if the resulting *p*-value of the Levene's test is less than some critical value (typically 0.05), it would be improbable that the obtained differences in sample variances occurred based on random sampling. Under such circumstances, modified procedures are used that do not assume equality of variance.

### 3.4. Independence test

This study uses the runs test (also called the Wald–Wolfowitz test) to check the hypothesis that the elements of the data sequence are mutually independent. The runs test is a non-parametric test in which a "run" of a sequence is a maximal non-empty segment of the sequence comprising adjacent equal elements. If there are more runs than expected, the hypothesis of statistical independence of the elements may be rejected.

### 3.5. F-test

By means of an *F*-test, we can test the hypothesis that there are no differences among the group means, and thus assess the possibility of lunisolar calendar anomalies. More precisely, the test statistic for an *F*-test, termed *F*, is

$$F = \frac{\mathrm{MSTR}}{\mathrm{MSE}},$$

where MSTR denotes the treatment mean square, and MSE represents the error mean square.