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Witching days and abnormal profits in the us stock market

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Abstract: This paper examines price effects related to witching days in the US stock market using both weekly and daily data for three major indices, namely the Dow Jones, S&P500 and Nasdaq, over the period 2000–2021. First it analyses whether or not anomalies in price behaviour arise from witching by using various parametric (Student's t-test, and ANOVA) and non-parametric (Mann-Whitney) tests as well as an event study method and regressions with dummies; then it investigates whether or not any detected anomalies give rise to profit opportunities by applying a trading simulation approach. The results suggest the presence of the anomaly in daily returns on witching days which can be exploited by means of suitably designed trading strategies to earn abnormal profits, especially in the case of the Nasdaq index. Such evidence is inconsistent with the Efficient Market Hypothesis (EMH).

Subjects: Statistical Computing; Investment & Securities; Risk Management

Keywords: Witching Days; Abnormal Returns; Stock Markets; Anomalies; Trading

JEL Classification: G12; C63

1. Introduction

A well-known phenomenon commonly observed in stock markets is the so-called expiration effect, namely the sudden increase in the trading of futures or option contracts and the resulting large price changes which occur immediately before expiration as traders close their positions. For example, arbitrageurs create order imbalances by unwinding their cash positions when futures contracts expire (Chamberlain et al., 1989; Chay & Ryu, 2006; Stoll & Whaley, 1987). Also, market participants with large positions in derivative contracts may have incentives to push the underlying asset prices in a given direction to affect the value of their contracts before they expire (Bollen & Whaley, 1999; Stoll & Whaley, 1991, 1997; Y.F. Chow et al., 2003). Yoo (2017) and Hsieh and Tai (2009) argue that in fact higher trading volumes on expiration days mainly reflect the activities of foreign institutional investors with more complete information sets. Another explanation could be self-fulfilling prophecies: if there is some degree of consensus between market participants about price behaviour, they will all adopt the same strategies to generate profits—for instance, if prices are expected to decrease, agents will sell the asset and if they all do prices will indeed go down.

Of particular interest are the so-called "quadruple witching days" when different types of derivatives (single stock derivatives, stock index futures, stock index options and single stock options) expire simultaneously in the US stock market. This happens on the third Friday of the last month of each quarter (March, June, September and December). This paper focuses on price (rather than volume or volatility) effects related to such days to establish whether or not they create abnormal profit opportunities by analysing weekly and daily data for three major US stock market indices, namely the Dow Jones Index, the S&P500 and the Nasdaq. More specifically, a number of statistical tests (both parametric and non-parametric) as well as an event study method and regressions with dummies are used to detect any witching related anomalies. A trading simulation approach is then applied to examine whether or not those can be exploited to generate abnormal profits.

The layout of the paper is as follows. Section 2 briefly reviews the relevant literature. Section 3 describes the data and outlines the methodology, whilst Section 4 presents the empirical results. Section 5 offers some concluding remarks.

2. Literature Review

Evidence of expiration day effects in the US stock market was initially provided by Stoll and Whaley (1987) in the case of the "triple witching hour" (the last hour of trading on the third Friday of March, June, September and December), with further detection of downward price pressure on expiration days (H. Stoll & Whaley, 1990). Chiang (2014) showed that stock returns drop sharply experience on option expiration dates. Hancock (1993) concluded instead that since June 1987 market activity has not been different on expiration days compared to others. Barclay et al. (2008) showed that on witching days order flows near futures contract expirations cause large, predictable fluctuations in the S&P500 index. Finally, Illueca and LaFuente (2006) reported no significant increase in volatility near expiration for the S&P500 index.

Higher trading volumes on expiration days were found for other stock markets by Karolyi (1996), Hsieh (2009), Singh and Shaik (2020), Alkebäck and Hagelin (2004), and Schlag (1996), and Gurgul and Suliga (2020) and others. Chung and Hseu (2008) detected significant price reversals as well as higher volatility and volumes near expiration in the Singapore and Taiwan Futures Exchanges, whilst Batrinca et al. (2020) reported higher trading activity for futures and options in the European equity markets, and Singh and Shaik (2020) found higher trading volumes in the case of Index Futures in India. However, Y.F. Chow et al. (2003) could not identify any such effects in the Hong Kong stock market.

Edwards (1988), Arago and Fernandez (2002), Vipul (2005), and Gurgul and Suliga (2020) all detected higher price volatility of futures contracts near expiration. By contrast, Schlag (1996) and Bollen and Whaley (1999) could not obtain such evidence for the German stock market and the Hong Kong Futures Exchange respectively. Pope and Yadav (1992) found negative returns as well as higher trading volumes on expiration days in the UK stock market, whilst Stoll and Whaley (1997) and Hsieh (2009) provided evidence of price reversals in the Australian and Taiwanese stock markets. Vipul (2005) found that the underlying assets tend to exhibit negative returns the day before expiration, but significant reversal happens on the next trading day. Y.F. Chow et al. (2003) found that expiration days in Hong Kong are characterised by negative price effects, whereas Yoo (2017) concluded that there are none in the Korean stock market. Chay and Ryu (2006) detected statistically significant price reversals near expiration days in the South Korean KOSPI 200 index. By contrast, Karolyi (1996) found no significant price effects in the Japanese stock market and neither did Corredor et al. (2001) in the Spanish one and Kan (2001) in the Hong Kong one. Finally, Caihong (2014) could not detect any significant volume, volatility, or price effects caused by expiration days in general and by the quadruple witching day in particular in the Swedish stock market.

The above papers provide (conflicting) evidence concerning expiration day effects but none of them examines whether or not these give rise to exploitable profit opportunities. This issue is instead the focus of the present study.

3. Data and Methodology

Daily and weekly data for the Dow Jones Index, the S&P500 and the Nasdaq over the period 01.01.2000–20.09.2021 are used for the analysis. The source is the Global Financial Database (https://www.globalfinancialdata.com). At both frequencies three subsamples are created corresponding to (i) the witching day or week when witching occurs, (ii) pre-witching (the day or week before witching) and (iii) post-witching (the day or week after witching). The following notation is used in the tables to denote them:

- d(0)—the witching day;
- d(−1)—the day before the witching day;
- d(+1)—the day after the witching day;
- w(0)—the week including the witching day;
- w(−1)—the week before that including the witching day;
- w(+1)—the week after that including the witching day.

Returns are calculated as follows:

$$R_i = \left(\frac{Open_i}{Close_i} - 1\right) \times 100\% \tag{1}$$

where R_i—returns on the *i-th* day in %;

$Open_i$—open price on the *i-th* day;

$Close_i$—close price on the *i-th* day.

To examine whether witching days are characterised by abnormal price patterns various methods are applied: both parametric (Student's t-test, ANOVA analysis) and non-parametric (Mann-Whitney) tests given the fat tails and kurtosis characterising the distribution of returns—the aim is to make sure that any detected differences are statistically significant, the Null Hypothesis (H0) being in each case that the data on normal and on witching days respectively belong to the same population, a rejection of the null suggesting the presence of an anomaly. It should be noted that the data set for "normal" days excludes the observations corresponding to the event days.

Next we use an event study methodology which is a modified version of the cumulative abnormal returns approach by Mackinlay (1997). Abnormal returns are defined as follows:

$$AR_i = R_i - E(R_i) \tag{2}$$

where R_t is the return at time t and $E(R_t)$ is the corresponding average return computed over the whole sample period as follows:

$$E(R_i) = \left(\frac{1}{T}\right)\sum_{i=1}^{T} R_i \tag{3}$$

where T is the sample size.

The cumulative abnormal return denoted as CAR_i is simply the sum of the abnormal returns:

$$CAR_i = \sum_{i=1}^{T} AR_i \tag{4}$$

The variable CAR_i is then regressed against a trend—a significant p-value for the trend coefficient suggests the presence of an anomaly in price behaviour related to witching days. The rationale is the following: if prices are expected to increase, one should buy the asset; conversely, if they are expected to decrease, one should sell it. Such expectations are based on the evidence provided in the paper concerning price patterns related to expiration days.

To provide additional evidence a multiple regression analysis with dummy variables is carried out:

$$R_i = a_0 + a_1 D_{1i} + \varepsilon_i \tag{5}$$

where $R_i$is the mean return in period *i*, a_0 and a_1 stand for returns on normal and witching days respectively, D_i is a dummy variable equal to 1 on a witching day and 0 on a normal day, and ε_t is the random error on the *i*-th day. The statistical significance and the sign of the dummy coefficient indicate the existence and the direction of price effects occurring on witching days.

Finally, in order to determine whether any detected anomalies give rise to exploitable profit opportunities a trading simulation approach is used. To see whether market participants can "beat the market" we use the following trading algorithm: sell right at the start of the witching day, and close positions at the end of the day.

It should be mentioned that in the case of open-ended mutual funds (whose shares can only be bought and sold at the end of the day, at the NAV of the fund) trading takes place "at the end of the pre-witching day" instead of "at the start of the witching day". We have in fact compared mean returns based on the open/close approach with those based on the close/close approach in the case of DJI daily data using 6000+ observations. In both cases they were found to be equal to 0.02%. As a further check, we have also performed an ANOVA test. The F-statistic turns out to be 0.06 (and the p-value 0.80), which means that there are no statistically significant differences between the data sets.

An anomaly is said to be present if this strategy results in more than 50 per cent of profitable trades. The approach used here does not incorporate transaction costs (spread, fees to the broker or bank, swaps, etc.) and is only a proxy for actual trading. Nevertheless, it is informative about real trading, given the fact that, thanks to the development of Internet, high-frequency transaction costs and trading spreads tend to be small, typically ranging between 0.01% and 0.02%. Banking and broker fees can affect profitability in the case of a small number of trades but become insignificant for larger numbers (this is the so-called scale effect in trading) and thus overlooking them does not affect our results significantly.

The trading simulation approach consists of the following steps. First the percentage result from each trade is defined as:

$$\%result = \frac{100\% \times P_{open}}{P_{close}} \tag{6}$$

where P_{open} —opening price

P_{close} —closing price

Next, the sum of the results from each deal is taken. A positive total result is an indication of exploitable profits based on that specific market anomaly. To establish whether or not the generated results differ from those associated to random trading a t-test is carried out; this compares the means from two samples (the average profit/loss from a trade applying the trading strategy, and that from random trading without transaction costs, which should be zero) to test whether they belong to the same population; a failure to reject H0 implies that the means from the two samples are not significantly different, i.e. that the detected anomaly does not generate exploitable profit opportunities.

Although strictly speaking stock market indices do not have a price (only a value), nowadays there exist many ETFs based on them. That is why any anomalies detected in them can be exploited by means of appropriate trading strategies. Also, specific financial instruments called CFDs (these being financial contracts that pay the difference in the settlement price between the open and closing trades) can be used. In this case the stock market index becomes a trading asset and can be bought/sold at the initial price.

This methodology was used in a number of papers analysing price anomalies in different financial markets, specifically in the case of passion investment (Plastun et al., 2022a), cryptocurrencies (Alex Plastun et al., 2022b), commodities (Caporale & Plastun, 2021a), and the FOREX (Caporale & Plastun, 2021b). Note that all calculations have been carried out using MS Excel tools and templates developed as required for our purposes.

4. Empirical Results

This section provides a summary of the main findings, whilst the complete set of results for the three indices can be found in a Supplementary file containing Appendix A, B and C.

Descriptive statistics for the analysed data are provided in Table 1. As can be seen, average returns are positive for all indices, for both both daily and weekly data.

Table 2 summarises the results for the Dow Jones Index.

As can be seen, there is prima facie evidence of differences in returns between normal and witching days (see Figure A.1 for details); however, in most cases these are not statistically significant, and they do not provide profitable trading opportunities (statistically different from those generated by random trading). The single exception concerns the Dow Jones index, for which prices decrease on witching days in 55% of the cases and a trading strategy based on this anomaly generates abnormal profits different from those associated with random trading.

Table 3 shows the corresponding results for the S&P500 Index. Visual inspection points to differences between normal and witching days (see Figure B.1 for details), but these are not statistically significant except for d(0), when in 57% of cases negative returns are observed which are significantly different from those on other days; moreover, the detected anomaly can be exploited to generate abnormal profits significantly different from those arising from random trading (see Table B.7 and Figure B.2 for details).

Finally, Table 4 displays the findings for the Nasdaq Index. Once again the differences in returns (see Figure C.1 for details) are not statistically significant, and again the one exception is d(0), for which in 67% of the cases price decrease; exploiting this anomaly generates abnormal profits.

These results are in contrast to those provided by Hancock (1993) since market activity is found to be different on expiration days compared to others, whilst are in line with the evidence of fluctuations in the S&P500 index reported by Barclay et al. (2008) and of a significant drop in stock returns on option expiration dates as in Chiang (2014).

5. Conclusions

This paper examines price effects related to witching days in the US stock market using both weekly and daily data for three major indices, namely the Dow Jones, SP500 and Nasdaq over the period 2000–2021. The aim is to establish whether or not anomalies in price behaviour arise from witching, and whether or not these can be exploited to generate abnormal profits. The first issue is analysed using various parametric (Student's t-test, and ANOVA) and non-parametric (Mann-Whitney) tests as well as an event study method and regressions with dummies, whilst the second is investigated applying a trading simulation approach.

Table 1. Descriptive statistics for the analyzed data

Parameter	Dow Jones Index		SP500		Nasdaq	
	Daily	Weekly	Daily	Weekly	Daily	Weekly
Mean	0.02%	0.13%	0.02%	0.14%	0.01%	0.17%
Standard Error	0.01%	0.07%	0.01%	0.07%	0.02%	0.10%
Mode	0.00%	0.25%	0.02%	0.21%	0.06%	0.29%
Standard Deviation	1.00%	2.35%	1.02%	2.37%	1.51%	3.42%
Sample Variance	0.01%	0.06%	0.01%	0.06%	0.02%	0.12%
Kurtosis	7.80	6.33	8.25	5.77	12.25	5.95
Skewness	−0.10	−0.36	−0.30	−0.30	0.45	−0.18
Range	16.54%	31.71%	16.46%	29.48%	30.48%	46.43%
Minimum	−7.75%	−17.09%	−8.42%	−16.29%	−9.35%	−25.34%
Maximum	8.79%	14.61%	8.04%	13.19%	21.13%	21.09%
Sum	119.39%	142.99%	107.98%	146.75%	28.98%	188.49%
Count	6125	1126	5540	1068	5439	1131

Note: Authors' calculations.

Our results suggest the presence of the anomaly in daily returns on witching days (prices tend to decrease on these days). These findings are in line with those reported by Barclay et al. (2008) and Chiang (2014). Detected anomaly can be exploited by means of suitably designed trading strategies to earn abnormal profits, especially in the case of the Nasdaq index. Such evidence of exploitable profit opportunities is inconsistent with the Efficient Market Hypothesis (EMH), according to which there should not be any price predictability and price patterns. The presence of stable negative returns on witching days is direct evidence against this hypothesis.

The limitations of this study include using a relatively simple methodology (more sophisticated methods could be applied in follow-up papers), analysing only 3 US stock market indices, not incorporating transaction costs (spreads, fees and commissions etc.) in the trading simulations, assessing the efficiency of the trading strategy by comparing it to random trading (instead of "buy-and-hold" strategies, historical performance of passively/actively managed portfolios, etc.). Future work should address all these issues. In particular, note that our results for the US stock market differ from those for the cryptocurrency market (Alex Plastun et al., 2022b), where differences in returns between expiration-related periods and average returns are statistically insignificant. Whether expiration effects differ across financial markets should also be investigated further in future work on the role of witching days in other stock markets as well as FOREX, commodity markets etc.

Another important issue is whether price patterns differ between normal and crisis periods. For instance, Plastun et al. (2022c) provided some evidence of such differences in the case of pre-crisis, post-crisis and crisis periods in the US, Japanese, Chinese, Russian and Brazilian stock markets. Such findings imply that different trading strategies might be appropriate in different periods, an issue which would also be worth investigating in follow-up papers.

Our analysis has implications for both practitioners and academics. In particular, the detected price patterns can be used by traders or investors to earn abnormal profits, analysts having additional information to generate trading signals based on the detected price patterns. As for academics, the results of this study are interesting not only as additional evidence against the EMH, but also because they may help improve the forecasting accuracy of models for the US stock market by incorporating expiration periods as an additional variable.

Table 2. Overall results for witching day price effects: the case of the Dow Jones Index

Case analysed	Students t-test	ANOVA	Mann- Whitney test	Modified CAR	Regression with dummy variables	Trading simulation	Overall
d(0)	+	+	-	+	+	+	5
d(−1)	-	-	-	+	-	-	1
d(+1)	-	-	-	+	-	-	1
w(0)	-	-	-	+	-	-	1
w(−1)	-	-	-	+	+	-	2
w(+1)	-	-	+	+	-	-	2

Note: This table presents the overall results for the Dow Jones Index. + (-) indicates that an anomaly is (not) detected. For the statistical tests (both parametric and non-parametric) the null hypothesis is that data for the witching related days and for normal ones belong to the same population; a rejection of the null implies the presence of a statistically significant anomaly. The regression analysis with dummy variables provides evidence of an anomaly if a1 (the dummy coefficient) is statistically significant ($p < 0.05$). The MCAR approach implies the existence of an anomaly if the trend model based on cumulative abnormal returns data has a high multiple R-squared, passes the F test, and the regression coefficients are statistically significant (*p-value* < 0.05). Authors' calculations.

Table 3. Overall results for witching day price effects: the case of the S&P500 Index

Case analysed	Students t-test	ANOVA	Mann- Whitney test	Modified CAR	Regression with dummy variables	Trading simulation	Overall
d(0)	+	+	+	+	+	+	6
d(−1)	-	-	-	+	-	-	1
d(+1)	-	-	-	+	-	-	1
w(0)	-	-	-	+	-	-	1
w(−1)	-	-	-	-	-	-	0
w(+1)	-	-	+	+	-	-	2

Note: This table presents the overall results for the S&P500 Index. + (-) indicates that an anomaly is (not) detected. For the statistical tests (both parametric and non-parametric) the null hypothesis is that data for the witching related day and for normal ones belong to the same population; a rejection of the null implies the presence of a statistically significant anomaly. The regression analysis with dummy variables provides evidence of an anomaly if a1 (the dummy coefficient) is statistically significant ($p < 0.05$). The MCAR approach implies the existence of an anomaly if the trend model based on cumulative abnormal returns data has a high multiple R-squared, passes the F test, and the regression coefficients are statistically significant (*p-value* < 0.05). Authors calculations.

Table 4. Overall results for witching day price effects: the case of the Nasdaq Index

Case analysed	Students t-test	ANOVA	Mann- Whitney test	Modified CAR	Regression with dummy variables	Trading simulation	Overall
d(0)	+	+	+	+	+	+	6
d(−1)	-	-	-	-	-	-	0
d(+1)	-	-	-	+	-	-	1
w(0)	-	-	-	+	-	-	1
w(−1)	-	-	-	+	-	-	1
w(+1)	-	-	-	+	-	-	1

Note: This table presents the overall results for the Nasdaq Index. + (-) indicates that an anomaly is (not) detected. For the statistical tests (both parametric and non-parametric) the null hypothesis is that data for the witching related day and for normal ones belong to the same population; a rejection of the null implies the presence of a statistically significant anomaly. The regression analysis with dummy variables provides evidence of an anomaly if α1 (the dummy coefficient) is statistically significant ($p < 0.05$). The MCAR approach implies the existence of an anomaly if the trend model based on cumulative abnormal returns data has a high multiple R-squared, passes the F test, and the regression coefficients are statistically significant (*p-value* < 0.05). Authors' calculations.

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