Daylight Savings Time Change Market Impacts Executive Summary

Erdos Data Science Bootcamp - Fall 2024

Github: https://github.com/ghuckabe/DSTMarketAnalysis/tree/main

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Objective and Overview

Daylight savings time (DST) was first implemented in Canada in 1908 and then in the US in 1918 primarily to conserve resources during wartime. DST has been demonstrated to have an impact on sleep and health, and some evidence has been presented by Kramer, Kamstra, and Levi (2000) that suggests measurable impacts from DST change on the American stock market. Other statisticians such as Berument, Dogan, and Onar (2010) refute this notion, so the issue is certainly controversial. This project aims to contribute to this discourse by answering the question of if DST changes impact stock market behaviors and how to characterize this impact if such exists.

DST shifts occur two weekends per year, once in the Fall and once in the Spring. In a phenomenon known as the weekend effect, stocks typically depreciate between Friday and the following Monday. To distinguish impacts from DST changes from normal weekend effects, comparisons are made between time change weekends and regular weekends in search of statistically significant differences. DST is also not implemented universally, and comparisons are also made with Japan, where DST is not in use.

Datasets and Data Processing

Kaggle Datasets

- Daily stock markers for an expansive selection of individual American stocks from 1970 through 2018, annotated by sector and index https://www.kaggle.com/datasets/ehallmar/daily-historical-stock-prices-1970-2018
- Similar daily markers for individual Japanese stocks https://www.kaggle.com/datasets/cryptrader/huge-japanese-stock-market-dataset-all-in-one/data

Available markers include daily open, close, high, and low prices, and trade volumes. Fridays and Mondays are picked out from the daily series and paired. Weekends with holidays or where Friday or Monday data points are missing are omitted. To make fair comparisons between different stocks or across different years, these stock markers are taken in difference and normalized. For example, fractional weekend return (Monday opening price minus Friday closing price divided by the Friday closing price) would be considered rather than raw return.

Statistical Evaluations

Comparing means in weekend returns and volatility markers for DST change weekends and typical weekends, statistical t tests were performed to evaluate the significance of any observed differences. It was observed that DST changes' effect on weekend returns is more pronounced in the fall (hour gained) than in the spring (hour lost). NASDAQ shows differences in weekend return between DST change and typical weekends around the 90% confidence level, and NYSE shows results around the 70% confidence level. The DST effect on 'volatility weekend effect' (the percent change from Friday to Monday of the percent change in the daily high and low) is more pronounced in the spring, at least for NYSE. NASDAQ shows differences in stock volatility between DST change and typical weekends at the 64% confidence level, and NYSE shows results at the 97% confidence level.

In addition to comparing behaviors of these indices, t tests were performed on individual stocks

across all sectors. Individual stocks which show strongest DST effects can be picked out to build money-making strategies. Power tests were also performed to assess if these individual stocks provided enough statistics to support confidence in their demonstrated DST change impacts. A number of such stocks which demonstrate a low p-value for similarity in behavior between weekend returns during DST shifts and possess enough statistics to achieve a reasonable power can be further studied to recommend a strategy to take advantage of the observed DST change effects.

Demonstrating Distinguishability via Classification

Statistical tests serve as one method of demonstrating that stock behavior on DST-change weekends is distinct from average weekends. An alternative strategy is to train a classifier to distinguish between DST-change weekends and non-DST change weekends. High classification accuracy on test data not seen in training gives evidence that these weekend classes are distinguishable. This strategy has the benefit of making a multidimensional comparison, taking into account multiple features of the weekend stock data simultaneously.

Quite a few classification models were considered, including logistic regression, support vector machine, and decision tree. The best classification performance was achieved with a collection of 100 decision trees combined using sci-kit learn's ADABoost algorithm. Each tree was given a maximum depth of 5 layers. Due to the disparity between the number of weekends or data points for the DST change and non-change weekend classes, the most impactful hyperparameter was to set the weights of each class to be balanced, since without this parameter, the optimization tends to favor classifying all weekends as non-DST change weekends.

When evaluated on a test set of stock data never before seen in training, this boosted decision tree classifier achieved over 95% accuracy in classifying DST change weekends as such, with only a 15% false positive rate for miscategorizing non-DST change weekends. The BDT takes advantage of low differences between high and low stock prices on Monday and Friday along with high differences between Monday opening and Friday closing prices. The achieved success in classification demonstrates that there is indeed distinguishability in American market behaviors over time change weekends compared to average weekends.

Despite Japan not participating in daylight savings, evaluation of the BDT classifier on Japanese stocks demonstrates that the American time changes correlate with similarly identifiable features in the Japanese stock behavior. The classifier accurately tagged 91% of weekend stock entries that correspond with the date of the American time change, with an extremely small false-tag rate of 1% for weekends not corresponding with the American time change. This result suggests that, though countries like Japan do not directly undergo any time change, international markets are impacted by American DST change and exhibit corresponding stock behaviors.

Conclusions:

According to this research, daylight savings time changes do impact market return and volatility and even international markets such as Japan's are not entirely independent of DST effects. Fall DST shifts show higher average return and Spring DST shifts show an increase in volatility, both relative to other weekends. Lastly, individual stocks are affected differently and this may allow for strategies to be developed around those stocks with higher DST effects.

Future Directions:

- Recommendations for market strategy utilizing stocks with significant DST effects; some preliminary attempts were made but this merits further investigation. A successful strategy that leverages DST will likely need to be a modification of a strategy that already leverages the Weekend Effect.
- CRSP dataset (need institutional access) has intraday data
- Time series analysis and forecasting with Prophet; some preliminary attempts were made but this also merits further investigation. This may help with distinguishing seasonality and trends.