The Impact of Jewish Holidays on US Market Volatility and Liquidity

By

Robert Aeder

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Professor Marti G. Subrahmanyam — **Faculty Advisor**

Professor Menachem Brenner — **Thesis Advisor**

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Abstract[1]

Deviations from the Efficient Markets Hypothesis have been researched for almost as long as the hypothesis has existed. This paper looks at the impacts of five major holidays on the Jewish calendar, which often coincide with open market days. In particular, market volatility, liquidity, and returns are investigated. It was expected that a non-participation effect for these days would cause a drop in market liquidity, a rise in market volatility, and a deviation from normal returns patterns. After conducting statistical analysis, it was discovered that the High Holidays of Rosh Hashana and Yom Kippur are impacted most, showing significant movement in both volatility and liquidity, while the effects seen on the three Pilgrimage Festivals are more mixed. There seems to be a trend indicating that holidays centered around synagogue attendance and family create a greater impact, but the true nature of this claim necessitates further research.

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[1] I would like to acknowledge the group of people without whom this paper wouldn't have been possible.

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Introduction and Rationale

Despite the evidence in favor of the Efficient Markets Hypothesis, the volume of trading and rates of return in world stock exchanges have been seen to fluctuate as a result of many factors. Some of these factors, such as the day of the week, day of the month, or season of the year, are more in consistent nature and are perhaps more easily understood. In these cases, general trader sentiment, attributed by some to the fatigue of the workweek or weather-related emotions, contributes to different trading patterns.

Among the suggested causes of these contributing factors is the non-participation effect, or volume shifts brought on by an absence of traders from the market. The most obvious place to look for situations of this type might be national holidays during which a substantial amount of people would take the day off from trading. In many of these cases, exchanges are closed to allow individuals time to celebrate. Although a significant effect on returns during the days preceding closed market holidays was found by Fields in 1934 and validated by several others since, there is no observed behavior of true open-market trading on the holiday itself.[2]

This leaves a small number of holidays that are not nationally observed as interesting examples of this potential effect. These holidays are predominantly of religious or cultural nature, creating a situation where the markets do not recognize these events as holidays affecting a specific group of traders. The holiday observers are forced to "sit out" as the rest of the trading population continues through what could be deemed an "open holiday." It is

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[2] Fields,M. 1934."Security Prices and Stock Exchange Holidays in Relation to Short Selling." *Journal of Business*, vol. 7 (January):328-338.

unknown whether a significant effect would be seen when looking at recent years, focusing on these “open market” holidays.

One cultural demographic that has consistently been a non-negligible proportion of the financial world, serving a wide array of different market roles, is that affiliated with the Jewish faith. Jewish market participants are quite diverse. While some may hold themselves to higher levels of ritual observance, others merely view their religion as a basis for familial traditions and values. Despite this wide spectrum, most members of the faith have at least some connection to any or all of the major dates on the Jewish calendar, namely the Jewish New Year (Rosh Hashana), the Day of Atonement (Yom Kippur), and the three major Pilgrimage Festivals. Based on these premises, this paper hopes to derive a conclusion about the potential impact of the Jewish segment of the market in the context of a non-participation effect on open market days, examining variations in returns, market liquidity, and market volatility.

If significant deviations from normal patterns were to be found, this could have implications for several different courses of research. First, it could change the way that future open-market holidays are treated by market participants in study and in practice. Second, it could open the door for future research of other cultures and religions that represent non-negligible proportions of the trading market and the potential impact of their holidays on open-market days. Last, a significant outcome could suggest a need to better understand the role of changing market demographics on market activity.

Overview of the Relevant Research

Positing Market Efficiency

In the 1950s and 1960s, the movements of the market were proposed by analysts to adhere to the "Random Walk Theory," a financial concept that proposes that the future prices of securities move in a random motion that hovers around the true value of the security.[3] Because these movements are "random" and independent of each other, one movement does not guarantee continuity of change or a countermovement.[4]

Random Walk Theory research was later expanded by Eugene Fama to form the more full-bodied Efficient Markets Hypothesis (EMH). Originally defended by Fama in 1969, the EMH states that the prices of securities fully reflect "all" information relevant to those prices.[5] While this hypothesis was understood by Fama to be quite extreme, he viewed that as an opportunity to understand not whether it was true, but instead to what extent it was true.[6] Accordingly, this validity of the hypothesis was assessed by Fama on several different levels:

- The *weak form hypothesis* relies on many of the same research points seen in the original Random Walk paper and claims that the current price of a stock reflects all information regarding past prices.[7]

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[3] Fama, Eugene F. "Random Walks in Stock Market Prices". *Financial Analysts Journal.* Vol. 21, No. 5 (Sept-Oct 1965). Pp 55-59. <http://www.jstor.org/stable/4469865>

[4] ibid.

[5] Fama, Eugene F. "Efficient Capital Markets: A Review of Theory and Empirical Work". *The Journal of Finance*. Vol. 25, No. 2 (May 1970). Pp. 383-417. <http://www.jstor.org/stable/2325486 >

[6] ibid.

[7] ibid.

- The *semi-strong form hypothesis* expands "all information" to include recent press announcements and annual report releases. The speed at which securities shift to include these components into their valuation lends to the validity of this claim.[8]
- The *strong form hypothesis* posits that security valuation may even move to reflect information not readily available to the public, such as the sentiment of the management of the company or unreleased metrics.[9]

Based on much of the data relating to the "Random Walk Theory," Fama found support for the weak form of the EMH. He also found support for the semi-strong form, based on research evaluating the proper valuation of stocks prior to stock split announcements and earnings calls. Fama did note that the strong form fell short in that both specialists on major securities exchanges and corporate management possess insider information. [10]

The extent to which Fama believed that the hypotheses withstood his tests translates into the extent to which it is theoretically impossible for a savvy investor to beat the market. Thus, he claimed that in most cases the only method of generating higher potential returns is by purchasing more risky securities.[11]

This opinion was shared by Malkiel, who wrote a book called *A Random Walk Down Wall Street*, which posited that securities moved up and down in a random fashion. His adamant belief in the "Random Walk Theory" led him to claim that, "a blindfolded

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[8] ibid.

[9] ibid.

[10] ibid.

[11] ibid.

chimpanzee throwing darts at the *Wall Street Journal* can select a portfolio that performs as well as those managed by the experts."[12] Because of the "Random Walk", he claimed, the most effective method of ensuring maximum rates of return was by investing in large index funds and riding the natural rise of the market. According to Malkiel, an actively managed portfolio was not only more labor intensive, but also generally less successful[13].

Anomalies in Market Behavior : Weekly, Monthly, and Yearly Effects

As seen through various earlier studies, however, there are definite trends in asset returns and volatility that deviate from the Efficient Market Hypothesis. Perhaps the most well known is the Day of The Week Effect, discussed by Cross in an 1973 article, "The Behavior of Stock Prices on Fridays and Mondays." In his paper, he noted that for Standard and Poor's Composite index on Mondays between 1953 and 1970 showed a positive return around ten percent less often than Tuesday through Thursday, while Fridays showed a ten percent greater chance of a positive return.[14] Cross also discovered that the chances of an "up Monday" were substantially lower after a "down Friday," while an "up Friday" resulted in relatively split odds of an increase or decrease the following Monday.[15] Those findings were supplemented by other research, such as that of Berument and Kiymaz, who found both higher returns and lower market volatility on Wednesdays along with higher market

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[12] Malkiel, Burton G. "A Random Walk Down Wall Street" W.M. Norton and Company, New York City. 1973.

[13] ibid.

[14] Cross, Frank. "The Behavior of Stock Prices on Fridays and Mondays" *Financial Analysts Journal,* Vol. 29, No. 6 (Nov-Dec 1973). Pp 67-69. <http://www.jstor.org/stable/4529641>

[15] ibid.

volatility on Fridays.[16] They suggested that the Friday effect stemmed from traders making moves on relatively smaller details compared to the rest of the week in anticipation of the break from trading.[17]

In addition to weekly effects, there are monthly and yearly effects also witnessed in the stock market. A study by Robert Ariel revealed that stocks have a tendency to show the overwhelming majority of their earnings in the last few days and first half of each month, with the remainder of calendar dates showing a zero average return.[18] Also studied heavily is the January Effect, which posits that securities have a tendency to show abnormal returns patterns, especially concerning stocks with small market capitalizations, right around the New Year.[19] Hypotheses for the reasons behind these effects vary from pressure due to tax-loss selling to the presence of mainstream pivot points for money managers readjusting portfolio composition at month's and year's end.[20]

Several other papers, such as that of Hong and Yu, suggest that different seasons may exhibit differing trading patterns. For instance, it was discovered that stock turnover in over fifty different stock markets was lower during the respective summer months, arguably due

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[16] Berument, Hakan, and Halil Kiymaz. "The Day of the Week Effect on Stock Market Volatility". *The Journal of Economics and Finance,* Vol. 25, No. 2 (Summer 2001). <http://www.bilkent.edu.tr/~berument/jef01.pdf>

[17] ibid.

[18] Ariel, Robert A. "A Monthly Effect in Stock Market Returns". *Journal of Financial Economics.* Vol 18, No. 1 (Mar 1987). Pp 161-174. <http://www.sciencedirect.com/science/article/B6VBX-45R2HV6-C/2/a98bd4b73df0bc46b3401541dabdab6d>

[19] M.S. Rozeff and W.R. Kinney, "Capital Market Seasonality: The Case of Stock Returns," J*ournal of Financial Economics*, vol. 3, no. 4 (October 1976) pp. 379-402.
Also see: Haugen, Robert A. And Philippe Jorion, "The January Effect : Still There after All These Years". *Financial Analysts Journal.* Vol 52, No. 1 (Jan - Feb 1996) pp 27-31. <http://www.jstor.org/stable/4479893>

[20] ibid.

to the larger proportion of their members going on vacation.[21] During this time, returns were also found to be lower and the bid-ask spread was larger, suggesting that a lack of trading creates a greater need for brokers to both hedge against significant movement in an unfavorable direction and magnify their transaction incomes.[22]

Anomalies in Market Behavior : Holiday Effects

Researchers have also begun to look into the effects of holidays, both open-market and closed-market, on returns patterns. The earliest studies in this area focused around the days preceding closed-market holidays and showed that markets advanced disproportionately on days before closed market holidays.[23] At times these days yielded returns anywhere from nine to fourteen times the average daily return for the year. Even after compensating for other potential coinciding effects, such as the day of the week or the January effect, significantly higher returns persist on these days. Suggestions as to why these effects have presented consistently indicate that investors look to exit short positions before the holiday weekend, creating a positive feeling leading into the long break from trading.[24]

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[21] Harrison Hong, Jialin Yu, Gone fishin': Seasonality in trading activity and asset prices, Journal of Financial Markets, Volume 12, Issue 4, November 2009, Pages 672-702, <http://www.sciencedirect.com/science/article/B6VHN-4WN2Y0J-1/2/8a503a3d4a81c0a10c8578d7f3d74cd8>

[22] ibid.

[23] Ryan Chong, Robert Hudson, Kevin Keasey, Kevin Littler, Pre-holiday effects: International evidence on the decline and reversal of a stock market anomaly, Journal of International Money and Finance, Vol. 24, No. 8, (Dec 2005), Pages 1226-1236,<http://www.sciencedirect.com/science/article/B6V9S-4H9YBX8-1/2/52794d90e71f5261fd86efcda2a9746b>

[24] ibid.

This idea of holiday sentiment leading into a holiday break has also been supported with research on open-market holidays. A study by Frieder and Subrahmanyam looked at the Jewish Holidays of Rosh Hashana and Yom Kippur along with the holiday of St. Patricks Day. It found that returns before the two festive holidays, Rosh Hashana and St. Patricks Day, were higher in the days preceding, while returns leading up to the more solemn day of Yom Kippur were actually lower than those not impacted by the holiday.[25] In addition, one other new study has focused on returns in predominantly Muslim financial markets during the Muslim holidays of Ramadan and Ashoura and found that returns also deviated from normal patterns in the direction of the emotion of the holiday.[26] This is particularly interesting, as the Muslim calendar moves in relation to the solar calendar and therefore rules out the potential statistical noise caused by seasonal effects over time.

Background on the Jewish Calendar and the Holidays under Observation[27]

The Jewish calendar is lunar based, meaning that the months run based on the cycles of the moon. However, the calendar also has a correction mechanism to keep the holidays in line with specific solar seasons. By adding in an extra month during specific years on a

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[25] Laura Frieder, Avanidhar Subrahmanyam, "Nonsecular Regularities in Returns and Volume". *Financial Analysts Journal*. Vol. 60, No. 4 (Jul - Aug 2004) pp 29-34. <http://www.jstor.org/stable/4480585>

[26] Al-Ississ, Mohammed. "The Impact of Religious Experience on Financial Markets". Working Paper. Mar 2010. Harvard University.

Also See: Fazal J. Seyyed, Abraham Abraham, Mohsen Al-Hajji, "Seasonality in stock returns and volatility: The Ramadan effect", *Research in International Business and Finance,* Volume 19, Issue 3, September 2005, Pages 374-383, <http://www.sciencedirect.com/science/article/B7CPK-4GHRC81-2/2/b1f358f6fce184ef2213b85fec4f2fe6>

[27] "Jewish Holidays". The Orthodox Union. <www.ou.org/holidays>

nineteen year cycle, the Jewish calendar is able to keep in line with the solar calendar. Holidays thereby occur in the same season, though on a different secular calendar date.

The Jewish holidays studied in this paper fall under two categories: High Holidays and Pilgrimage Festivals. The High Holidays of Rosh Hashana and Yom Kippur represent the holiest days on the calendar and are among the more widely celebrated days on the Jewish calendar. For these two fall holidays, there is usually some aspect of observance that spans across religious denominations, leading to a larger number of impacted individuals. The days are marked by spending generous amounts of time in prayer and meditation, usually in a synagogue or temple. Though they are both categorized as High Holidays, Rosh Hashana and Yom Kippur have very different focuses, as reflected in the nature of the prayers and practices for the respective purposes. Rosh Hashana is a two-day celebration of the Jewish new year. According to some authorities, it celebrates the anniversary of the creation of the world. Mornings are spent in lengthy prayer services, and the remainder of the day is spent having festive meals and eating foods symbolic for the holiday. In contrast, Yom Kippur is known in English as the "Day of Atonement," the day on which it is believed that all blessings and curses for the upcoming year are sealed. As the nature of this holiday is quite solemn, it is marked by a twenty-five hour period of fasting and a full day spent in prayer services.

The Pilgrimage festivals historically coincide with the ascension of Jews from areas throughout the Kingdom of Israel to the Holy Temple in Jerusalem to celebrate and bring their holiday offerings. While the Temple no longer exists, these three holidays have been continued in commemoration of this activity. Each, festival is accompanied by a two day

period of time during which work is prohibited, though each carries with it a unique story and set of observances. Sukkot, occurring in the fall just a few days after Yom Kippur, celebrates the fall harvest by eating meals outside in temporary dwellings. Passover is a springtime holiday that commemorates the exodus of the Jewish people from Egypt by holding two ceremonial dinners and refraining from eating unleavened bread. Shavuot celebrates the anniversary of the giving of the Ten Commandments at Mount Sinai.

Research Question and Hypotheses

After understanding the relevant research, the question is restated: To what extent does a non-participation effect of a religious group due to a holiday celebration cause changes in market behavior?

The several potential effects on the market led to the development of this paper's hypotheses. First, and perhaps most straightforward, is market liquidity. Theoretically, a group sitting out of the market for a day would cause the cumulative trade volume to decrease, creating a dip in market liquidity. However, it is unclear to what extent the rest of the market picks up the normal activity of this proportion of the market. In this case, it would be logical to expect that there will be a significant drop in market liquidity, most noticeable on the High Holidays.

The second effect to be considered is market volatility. A decline in liquidity causes a market to become more volatile, as there are fewer people in the market seeking to buy and sell securities at any given price. For this reason, it is logical to expect the market to be more volatile on holidays than on non-holidays.

Last is the issue of returns. As seen in the research, returns can be both positively and negatively affected by holidays. In many cases, the positive or negative sentiment felt by holiday observers has some impact on whether returns are significantly higher or lower as a result of the celebration. For this investigation, however, a more neutral stance will be taken, hypothesizing that returns will in some way deviate from normal patterns as a result of the holidays.

Data and Methodology

For this research, market data from 1980-present was assessed on several different exchanges and financial instruments. Initially, the returns on the Standard and Poor's (S&P) 500 were considered. This index gave a sampling of a diverse body of securities that would feel any effects that these holidays could potentially impose on the market. Next, data was collected on the historical rates of the VIX, a Chicago-based measure of S&P 500 volatility rooted in futures trading, historically calculated since 1990. The FTSE 100 was also examined, an index of the 100 most highly capitalized UK companies, traded since 1984.[28]

Since the Jewish holidays in question did not all fall during the week, several years during the observation period were not included. Table 1 shows the number of observations for each holiday for each index under consideration.

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[28] Financial data all found on Yahoo! Finance <http://finance.yahoo.com>

Table 1 - Number of Open Market Coinciding Dates by Security, 1980 - 2010[29]

	Rosh Hashana	Yom Kippur	Sukkot	Passover	Shavuot
Possible Days of Holiday	62	31	62	62	62
Days Coinciding with Open Market - S&P 500	42	21	42	37	44
Days Coinciding with Open Market - VIX (since 1990)	28	16	28	23	30
Days Coinciding with Open Market - FTSE (since 1984)	36	19	36	31	37

Roughly two-thirds of the possible dates for any of the given indexes coincided with open market days. Given these results, it appears that the data yields a sufficient sample size to proceed with the research using this relatively recent time window of 1980-2010. Statistical tests were run to assess the validity of three different hypotheses.

1. First, the claim that Jewish open-market holidays show higher levels of volatility is checked. This is done using three different metrics:

[29] Source: <http://www.timeanddate.com>

•Standard F-test of variance on the standard deviation of returns on the S&P 500.[30]

•One-sided T-test comparison of the VIX values for holidays versus non-holidays.[31]

•Standard F-test analysis of the Parkinson hi-lo measure of volatility.[32]

2. The second hypothesis tested relates to the claim that these holidays saw lower levels of market liquidity. This was tested by investigating:

•One-sided T-test for differences in trading volume.

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[30] For the purposes of running all F-tests in this study, the following assumptions were made:

•The samples being compared are independent of one another
•The samples being compare follow a normal pattern of distribution

The null hypothesis $H_0=\frac{s_1^2}{s_2^2}=1$ was tested in each case against the alternate hypothesis $H_1=\frac{s_1^2}{s_2^2}>1$. As per the rules of conducting an F-test, the larger variance was place in the numerator of each test. The variances or standard deviations are always given with the results in order to differentiate numerator and denominator.

[31] For the purposes of running all 2 Sample T-tests in this study, the following assumptions were made:

•The samples being compared are independent of one another
•The samples being compare follow a normal pattern of distribution

[32] The Parkison measure of volatility was defined as:

$$P=\frac{.627}{n}\cdot\sum_{i=1}^{n}\ln\left(\frac{hi_i}{lo_i}\right)$$

With i being any given observation in the set, hi being the intra-day hi, lo being the intra-day low, and n being the number of observations in the set.

For more information, see:
Parkinson, Ryan. "The Extreme Value Method for Estimating the Variance of the Rate of Return". *The Journal of Business.* Vol. 53, No. 1 (Jan 1980) pp 61-65. <http://www.jstor.org/stable/2352357>

•One-sided T-test for the values of the Amihud Measure of Market Impact, a ratio factoring price and volume into one measure.[33]

3. Last, a two-sided T-Test is used to check for deviations from the normal patterns of rates of return on the holiday dates.

Comparisons are made against two different control values. For both the S&P 500 and the VIX indexes, comparisons are first made against the average of the values coming from the same day of the week from week prior and week following the holiday. By using the same day of the week, Day of the Week Effects are assumed to be avoided while still generating a strong picture of the market in context before and after the holiday. In addition, comparisons are made against the same-day values of the FTSE 100 when possible, in an attempt to see same day activity in a market with arguably less of a Jewish presence.

In addition to testing against control variables, testing is also conducted to compare the values of each of the holidays against the others. In this way, perhaps comparative significance could be found to exist in places where holidays fail to show significant deviations themselves.

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[33] The Amihud Measure of illiquidity was defined as:

$$A = 10^{9} \cdot \left(\frac{\Delta p}{vol \cdot p_{close}} \right)$$

Where p is the price of a security or index and vol is the daily trading volume.

For more information, see:

Yakov Amihud, "Illiquidity and stock returns: cross-section and time-series effects", *Journal of Financial Markets*, Vol 5, No 1, (Jan 2002), pp 31-56, <http://www.sciencedirect.com/science/article/B6VHN-44F8101-2/2/828ec403b0145e7e6995660eb03ca9c0>

Tests and Results

Summary Statistics

Table 2 shows the basic descriptive statistics for the S&P 500 and FTSE 100 daily rates of return for both holiday and control values. Notable here is that the average returns for the holiday values compared to the controls never differs by more than around two-thirds of a percent, giving reason to believe that when statistical tests are run differences in returns will be few and far between. Also to be noted are several strongly contrasting numbers within the standard deviations, leading to the conclusion that there may stand to be significant differences in variance. There is no clear result regarding whether the FTSE or S&P 500 control is more similar to the holiday values, as it depends on the holiday under consideration.

Table 2 - Summary Statistics for Rates of Return, Holiday and Control

	Daily ROR - Holiday		Daily ROR - S&P Control		Daily ROR - FTSE	
	Average	Std Dev	Average	Std Dev	Average	Std Dev
Rosh Hashana	0.008%	0.954%	-0.064%	0.784%	-0.165%	1.022%
Yom Kippur	-0.391%	1.963%	0.253%	0.707%	-0.040%	0.988%
Sukkot	-0.295%	1.654%	-0.061%	1.139%	0.108%	1.838%
Passover	0.350%	0.898%	0.107%	0.994%	0.075%	0.686%
Shavuot	0.116%	0.848%	0.003%	0.578%	-0.073%	0.844%

Another set of descriptive statistics to examine prior to starting statistical analysis is those of the daily trading volume. Table 3 shows the average and standard deviations of trading

volume for both the holiday and S&P 500 control data set.[34] As shown below, the largest differences seem to be found in the trading volumes for the High Holiday dates. Given their higher status within the Jewish faith, this outcome is fairly expected. All standard deviations appear to be quite large, but due to the upward trending nature of trade volume, these numbers might be skewed. Statistical tests will be run as a paired T-Test in order to normalize the data and allow it to pass the assumptions necessary for the statistical analysis.

Table 3 - Summary Statistics for Daily Trade Volume, Holiday and Control

	Daily Volume - Holiday		Daily Volume - S&P Control	
	Average	**Std Dev**	**Average**	**Std Dev**
Rosh Hashana	957,661,667	1,398,054,739	1,030,853,324	1,631,648,172
Yom Kippur	1,068,015,714	1,622,976,612	1,226,990,000	1,742,955,406
Sukkot	1,112,725,486	1,788,713,956	1,124,814,981	1,882,722,402
Passover	1,110,015,416	1,615,282,480	1,159,536,205	1,662,876,557
Shavuot	1,274,097,491	1,963,426,567	1,101,324,318	1,492,353,042

In addition to the return and volume values for the larger indexes observed, it is also interesting to look at the descriptive statistics and values for the VIX index, Parkinson volatility, and the Amihud Measure of Market Impact.[35] There could be potentially significant differences in the Amihud measure of illiquidity, based on the data included in Table 4. However, the VIX values and Parkinson values appear similar when compared to

[34] Since reliable volume data for the FTSE was not found in the database used for data collection, comparisons of volume numbers will be made against the S&P 500 control values only.

[35] The Amihud measure of Market Impact is also reliant on volume figures; therefore there is no FTSE control value.

non-holiday controls. However, there could be room for comparison, though, when it comes to inter-holiday statistical analysis.

Table 4 - VIX Values, Amihud Measure, and Parkinson Volatility Measure, Holiday and Non Holiday

	Daily VIX - Holiday		Daily VIX - Control		Other Measures - Holiday		Other Measures - Control		
	Average	Std Dev	Average	Std Dev	Amihud	Parkinson	Amihud - S&P 500	Parkinson - S&P 500	Parkinson - FTSE
Rosh Hashana	22.48	10.11	22.47	10.62	0.0224	0.79%	0.034	0.83%	0.89%
Yom Kippur	25.24	13.78	24.51	13.21	0.0229	0.98%	0.030	1.02%	0.93%
Sukkot	23.48	13.77	23.32	11.75	0.0502	1.14%	0.036	0.92%	1.04%
Passover	18.91	6.11	19.82	7.31	0.0295	0.75%	0.047	0.85%	0.71%
Shavuot	19.20	7.48	18.73	5.55	0.0304	0.73%	0.033	0.76%	0.69%

Volatility

As previously discussed, the statistical tests run to test for changes in volatility include an F-test of variance for the S&P 500 rate of return versus the control variances, an F-test of Parkinson measures of variance, and a one-sided T-test of averages for the VIX holiday rates. Table 6 contains a summary of the test results for variance in rates of return, showing the F-statistics and p values for the tests run against both the S&P 500 and FTSE 100 controls.

Table 6 - F-Test of Variance Results for Rates of Return, Holiday Versus Control[36]

Holiday	Daily Return Variance vs. Same Day of week from Week Prior/ Follow (Averaged)			Daily Return Variance vs. Same Day FTSE ROR	
	Holiday	**Control**	**F-Stat (p val)**	**Control**	**F-Stat (p val)**
Rosh Hashana	**0.95%**	0.78%	1.33 (.368)	1.022%	1.15 (.668)
Yom Kippur	**1.96%**	0.71%	7.10*** (<.001)	0.988%	3.94*** (.005)
Sukkot	**1.65%**	1.14%	2.11** (.019)	1.838%	1.24 (.504)
Passover	**0.90%**	0.99%	1.23 (.545)	0.686%	1.72 (.131)
Shavuot	**0.85%**	0.58%	2.15** (.014)	0.844%	1.01 (.972)

There is a significant rise in daily return variance on three out of the five holidays (Yom Kippur, Sukkot, and Shavuot), as compared to the S&P 500 control. One holiday in particular, Yom Kippur, shows a significant rise on the 1 percent level against both the S&P 500 and the FTSE, a good strong sign that the volatility of the S&P 500 is higher on Yom Kippur. Interesting to note is that in the Shavuot F-tests, Variance is significantly higher at the 5% level when compared to the S&P 500 control, while producing a p-value of .972 when compared to the

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[36] As previously mentioned for all F-tests The null hypothesis $H_0 = \frac{s_1^2}{s_2^2} = 1$ was tested in each case against the alternate hypothesis $H_1 = \frac{s_1^2}{s_2^2} > 1$. *,**, and *** represent significance at the 10%, 5%, and 1% levels, respectively.

FTSE. In fact, all but one of the F-statistics for the FTSE are smaller than the S&P 500 control counterparts, perhaps an indicator that the same day European index is staying more in line with the American index than posited initially in the assumptions.

Also interesting to note is the significant differences between the variances of the five holidays. Shown in Table 7 below are the F-statistics and p values for these tests of variance. Both the significantly higher variances of Yom Kippur and Sukkot also proved to be larger than those of the other three holidays. Yom Kippur would be expected to have a higher variance than other days, as it is one of the High Holidays. Results from Sukkot are more surprising, indicating a phenomenon that warrants further investigation during the other tests of volatility.

Table 7 - Holiday to Holiday Rate of Return Variance Test F-Statistics and P-Values

	Rosh Hashana	Yom Kippur	Sukkot	Passover	Shavuot
Variances	**0.95%**	**1.96%**	**1.65%**	**0.90%**	**0.85%**
Rosh Hashana		4.24*** (<.001)	3.01*** (<.001)	1.13 (.716)	1.27 (.448)
Yom Kippur			1.40 (.346)	4.78*** (<.001)	5.36*** (<.001)
Sukkot				3.39*** (<.001)	3.81*** (<.001)
Passover					1.12 (.714)

Investigation of the VIX Averages shows less significance than the tests run on variances of rates of return. Table 8 lists the average values for both the holiday and control samples for each holiday, along with two different T-tests. The first test is a 2-sample T-test that compares the

two averages, while the second is a paired test that evaluates the samples with an extra check for independence.

Table 8 - VIX Averages, Holiday and Control, and 2 Sample/Paired T-test results[37]

	Average Holiday VIX	Average Control VIX	2 Sample T-Stat (p val)	Paired Test T-Stat (p val)
Rosh Hashana	22.48	22.47	.003 (.499)	.04 (.485)
Yom Kippur	25.24	24.51	.153 (.440)	1.06 (.154)
Sukkot	23.48	23.32	.047 (.481)	.24 (.406)
Passover	18.91	19.82	-.458 (.675)	-1.87 (.963)
Shavuot	19.20	18.73	.276 (.391)	.71 (.240)

[37] As previously mentioned, for the purposes of running all 2 Sample T-tests in this study, the following assumptions were made:

- The samples being compared are independent of one another
- The samples being compare follow a normal pattern of distribution

When the independence of the samples cannot be known for sure, a Paired t-test of differences may be used.

Null and alternate hypotheses for the VIX tests are as follows:

2 Tailed T-test $H_0: \mu_1 \leq \mu_2$, $H_1: \mu_1 > \mu_2$

Paired T-test of differences $H_0: \frac{1}{n}\sum_{i=1}^{n}(i_{hol}-i_{ctrl}) \leq 0$, $H_1: \frac{1}{n}\sum_{i=1}^{n}(i_{hol}-i_{ctrl}) > 0$

Looking at the results of both tests, there appear to be no significant findings based on the VIX figures for either T-test. Even Yom Kippur, the one holiday that showed significant findings against both controls for its high level of rate of return variance, failed in both cases to present a significantly higher VIX value.

Both Yom Kippur and Sukkot present the highest volatility measures relative to the other holidays. Rosh Hashana also presents a significantly higher VIX average than the least volatile holiday, Passover.[38] The new discovery of the presence of a significantly higher volatility for Rosh Hashana helps make the case for a higher level of volatility for the High Holidays, when compared to the Pilgrimage Festivals. Sukkot, however, continues to be an exception to this rule, showing much higher levels of volatility than Passover and Shavuot.

Table 9 illustrates that the F-statistics for the tests of the Parkinson Measure of Variance show no significant differences in variance from either control value. In addition, there is no significantly higher variance in this case for any holiday when compared to the others. The highest values once again, though, are seen on Yom Kippur and Sukkot.

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[38] Yom Kippur and Sukkot show significantly higher VIX values than Passover and Shavuot at the 10% level of significance. Rosh Hashana also shows significantly higher VIX values than Passover at the 10% level, but falls just short of showing significance in its relationship with Shavuot.

Table 9 - Parkinson Variance Measure F-Test results

Holiday	Parkinson Variance Measure vs. Same Day of week from Week Prior/Follow (Averaged)			Parkinson Variance Measure vs. Same Day of week from Week Prior/Follow (Averaged)	
	Holiday	**Random**	**F-Stat (p val)**	**Parkinson - FTSE**	**F-Stat (p val)**
Rosh Hashana	**0.79%**	0.83%	1.05 (.888)	0.89%	1.11 (.732)
Yom Kippur	**0.98%**	1.02%	1.04 (.926)	0.93%	1.06 (.903)
Sukkot	**1.14%**	0.92%	1.24 (.491)	1.04%	1.09 (.790)
Passover	**0.75%**	0.85%	1.13 (.718)	0.71%	1.05 (.892)
Shavuot	**0.73%**	0.76%	1.03 (.922)	0.69%	1.06 (.865)

Liquidity Tests

As noted in the methodology section, liquidity was evaluated using a one-tailed T-test of means for both trade volume and the Amihud measure of market impact, the results that can be found in Table 10.

The circumstance concerning liquidity is similar in many ways to that of volatility, which is logical. Both Rosh Hashana and Yom Kippur show significantly lower daily volumes than non-holiday dates. In addition, Passover also shows a significantly lower volume on its holiday dates. In contrast, Shavuot shows higher volume on the holiday than the control dates, an interesting, unexpected finding.

In terms of expanding the liquidity impact into the more broad Amihud measure, only Rosh Hashana continues to be significantly lower than the control values, with Yom Kippur and Passover now falling short of even the ten percent level of significance. In the case of this measure, it is Sukkot that contradicts expectation, in reality showing a higher level of market impact.

Understanding why Rosh Hashana and Yom Kippur have significantly lower volumes is more simple to understand, as they are both holidays that require large amounts of time to be spent in synagogue and are observed by the largest proportion of the Jewish population. Passover, however, is slightly more nuanced. One possible reasoning behind its lower volume may have to do with the family-centric nature of the ceremonial dinners held on the holiday. More than the other two pilgrimage festivals, Passover is usually associated with more travel to visit extended family and communal celebration. Though this is more of a qualitative explanation and would need more research to be supported, it fits well with the results observed in the statistical tests conducted.

Table 10 - Daily Volume and Amihud Measure T-Test Results, Holiday vs. Control[39]

Holiday	Trade Volume (In Thousands) vs. S&P 500 Control			Amihud Measure of Market Impact vs. S&P 500 Control		
	Holiday	Random	T-Statistic	Holiday	Random	T-Statistic
Rosh Hashana	957,612	1,030,853	-1.52* (.069)	0.0224	0.0337	-1.79** (.040)
Yom Kippur	1,068,016	1,226,990	-3.99*** (<.001)	0.0229	0.0299	-1.01 (.162)
Sukkot	1,112,725	1,124,815	-.19 (.427)	0.0502	0.0360	3.73 (.997)
Passover	1,110,015	1,152,705	-2.08** (.044)	0.0295	0.0465	-1.50 (.142)
Shavuot	1,274,097	1,101,324	2.04 (.976)	0.0304	0.0326	-.33 (.372)

Returns Tests

Lastly, tests are run to establish whether there was a significant deviation from normal returns patterns over the holiday. This is done by comparing returns to both control sets. The results of those 2-sided T-tests are shown in Table 11. There are nearly no significant deviations from normal return patterns, a notable result. The only holiday that shows significance against one control, Shavuot, falls far short of showing any level of significance against the other control measure. Even when compared against each other, only one holiday has a significant deviation from another, with Passover showing significantly higher returns than Sukkot.[40]

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[39] The Null and Alternate Hypotheses for these T-tests $H_0 = \mu_1 \geq \mu_2$, $H_1 = \mu_1 < \mu_2$

[40] Using a 2-sided T-Test, this relationship was found be significant at the 5% level.

Table 11 - T-test Results for Rates of Return, Holidays vs. S&P 500 and FTSE 100 Controls

	Daily ROR - Holiday		Daily ROR - S&P 500 Control			Daily ROR - FTSE 100 Control		
	Average	**Std Dev**	**Average**	**Std Dev**	**T-Stat (p val)**	**Average**	**Std Dev**	**T-Stat (p val)**
Rosh Hashana	**0.008%**	**0.954%**	-0.064%	0.784%	.307 (.761)	-0.165%	1.022%	1.05 (.299)
Yom Kippur	**-0.391%**	**1.963%**	0.253%	0.707%	1.40 (.176)	-0.040%	0.988%	-.724 (.480)
Sukkot	**-0.295%**	**1.654%**	-0.061%	1.139%	-.743 (.460)	0.108%	1.838%	-1.00 (.319)
Passover	**0.350%**	**0.898%**	0.107%	0.994%	1.64 (.110)	0.075%	0.686%	1.40 (.167)
Shavuot	**0.116%**	**0.848%**	0.003%	0.578%	.682 (.499)	-0.073%	0.844%	1.794* (.081)

The lack of significance of returns deviations requires some thought, as it breaks from the trends seen in research of other holidays. Several possibilities exist that would explain these results. First, there is always the chance that the presence of a shift in market sentiment is not felt by the Jewish population. This, however, seems unlikely, as there is no clear reason why the presence of market sentiment would be dependent on religion. The more likely explanation appears to be that the non-participation effect actually creates a situation where those who would be most impacted by sentiment effects are not trading on the days on which they would be affected. For that reason, the individuals remaining in the trading population are those who are not swayed by the holiday's presence and therefore have no reason to act in a way that causes a shift in market patterns. If this is the case, it could have interesting implications for the way that non-participatory effects are studied in the future with regard to anticipated deviations in returns.

Summary of Findings

High Holidays

As expected, the High Holidays were found to have the largest impacts on volatility and liquidity.

Rosh Hashana, while showing lower volatility levels than Yom Kippur and not quite significant on its own, is still higher in volatility levels than the other Pilgrimage Festivals. In addition, it shows lower levels of liquidity in terms of both trade volume and market impact, good indicators that the market is behaving differently as a result of the holiday.

Yom Kippur shows both the highest volatility shift as a result of the holiday as well as the largest drop in volume. As the holiest day on the Jewish calendar, it is understandable that the effects of the most significant magnitude would be seen on this day. Other measures that fall short of showing significance look to be trending in that direction in many cases, a sign that the holiday may suffer from small sample size. For future research, perhaps a larger window should be used in order to give the holiday a better chance of showing significant results.

Pilgrimage Festivals

Two out of the three Pilgrimage Festivals show results that require some thought and reflection. Sukkot shows unexpected results with its unusually high level of volatility in its rates of return. It was hypothesized that some movement would be seen, but its movement relative to the other festivals creates the need to understand why these results are found. One suggestion for this deviation from its fairly comparable pilgrimage counterparts is the lasting impact of the High Holidays, which fall only shortly before Sukkot. Perhaps there is an effect beyond the one day for the more major holidays, a possibility that opens up an interesting topic for further research.

Passover is the other holiday that showed interesting results, deviating from normal liquidity figures along with only the High Holidays. Understanding why this happens led to a search for the difference between Passover and the other Pilgrimage Festivals. Two theories seem to be likely. First is the family-centric nature of Passover tends to lead people to travel to be with relatives for the holiday. This could cause a rise in the non-participation effect, lowering trade volume further. The other theory is the coinciding holiday of Good Friday, a closed-market holiday that has a tendency to fall out during the weeks around Passover. The combination of two holidays, one open-market and the other closed-market, could be intensifying any observed changes.

Conclusion

The concepts of the "Random Walk Theory" and "Efficient Markets Hypothesis" are long standing and well researched. Over the years, many papers have been written about market anomalies, such as the Day of the Week Effect, the Day of The Month Effect, and the January Effect. Each illustrated that the "Efficient Markets Hypothesis" does not necessarily hold in its strongest form. More recently, this line of research has expanded to include the impacts of closed-market and open-market holidays on returns and market volatility. This paper attempted to better understand the specific impacts of the Jewish High Holidays and Pilgrimage Festivals on market returns, volatility, and liquidity. Based on past research, the hypothesized results pointed to an expected decline in liquidity due to non-participation, resulting in increased volatility. For returns, it was unclear which directional movement was expected, as research on

holidays had shown results in both directions. For that reason, the hypothesis was that some deviation in returns would be seen.

The data set for the study included the S&P 500, VIX volatility index, and FTSE 100, along with several ratios and measures of volatility developed by prior researchers. Comparisons were made between holiday results of the S&P 500 and control values calculated by both the FTSE 100 and dates from the weeks prior to and following the holiday.

Statistical analysis provided several findings, most surrounding the more heavily observed High Holidays. In particular, Yom Kippur showed significantly higher volatility and lower liquidity than the control values against which it was compared. Rosh Hashana also showed lower trading volume levels and lower market impact than non-holiday dates. Both of these impacts were fairly expected, as the impact on the non-negligible Jewish population was anticipated to be heaviest on these holidays.

More interesting and difficult to understand was the impact of the three Jewish pilgrimage festivals. Sukkot showed higher levels of volatility than both non-holidays and the other two festival celebrations, while Passover showed a significant drop in trading volume. Ascertaining why each of these holidays impacted the market in the way they did leads to several unique suggested causes, such as the proximity of Sukkot to the other fall holidays or the more travel and family-oriented nature of Passover. Also interesting to note about Passover is that it has a tendency to fall out close to Easter weekend, preceded by the market holiday of Good Friday. Perhaps this drop in liquidity is caused by a joint impact of two religious observances. Whatever the true cause, this could be an interesting topic of further investigation.

Deviations in returns for the holidays were not discovered during this study, running counter to the claims of many that the sentiment of the day can lead to deviations from normal patterns. This may be explainable, however, by reasoning that those impacted by the holiday on some emotional level are most likely those not participating, creating a situation where the trader sentiment is not impacted.

Based on the findings of this paper, there are several other areas of research that could be interesting to explore. First, it would be interesting to see if in recent years the advent of automated trading programs have mitigated any of the impact of the more major holidays. Second, the impact of the shift in market demographics also warrants investigation. Especially with the opening of Asian markets to the Western world, the cultural and racial makeup of market makers and participants has changed, and this could possibly have a significant reverse effect on prior trends. Last, a theoretical alternate effect on the opening of other world markets to U.S. market participants could be the recognition of Jewish holiday effects in geographic areas without significant Jewish populations. Research could be done for Eastern markets, looking at volatility and liquidity, to see if a similar impact could now be witnessed elsewhere. Each of these topics could, given the results found here, further the collective understanding of the role of triggers for financial activity found outside the normal realm of finance research.

Works Referenced and Bibliography

Al-Ississ, Mohammed. “The Impact of Religious Experience on Financial Markets”. Working Paper. Mar 2010. Harvard University.

Amihud, Yaakov, “Illiquidity and stock returns: cross-section and time-series effects”, *Journal of Financial Markets*, Vol 5, No 1, (Jan 2002), pp 31-56, <http://www.sciencedirect.com/science/article/B6VHN-44F8101-2/2/828ec403b0145e7e6995660eb03ca9c0>

Ariel, Robert A. “A Monthly Effect in Stock Market Returns”. *Journal of Financial Economics.* Vol 18, No. 1 (Mar 1987). Pp 161-174. <http://www.sciencedirect.com/science/article/B6VBX-45R2HV6-C/2/a98bd4b73df0bc46b3401541dabdab6d>

Berument, Hakan, and Halil Kiymaz. “The Day of the Week Effect on Stock Market Volatility”. *The Journal of Economics and Finance,* Vol. 25, No. 2 (Summer 2001). <http://www.bilkent.edu.tr/~berument/jef01.pdf>

Chong, Ryan, Robert Hudson, Kevin Keasey, Kevin Littler, Pre-holiday effects: International evidence on the decline and reversal of a stock market anomaly, Journal of International Money and Finance, Vol. 24, No. 8, (Dec 2005), Pages 1226-1236,<http://www.sciencedirect.com/science/article/B6V9S-4H9YBX8-1/2/52794d90e71f5261fd86efcda2a9746b>

Cross, Frank. “The Behavior of Stock Prices on Fridays and Mondays” *Financial Analysts Journal,* Vol. 29, No. 6 (Nov-Dec 1973). Pp 67-69. <http://www.jstor.org/stable/4529641>

Fama, Eugene F. “Efficient Capital Markets: A Review of Theory and Empirical Work”. *The Journal of Finance*. Vol. 25, No. 2 (May 1970). Pp. 383-417. <http://www.jstor.org/stable/2325486 >

Fama, Eugene F. “Random Walks in Stock Market Prices”. *Financial Analysts Journal.* Vol. 21, No. 5 (Sept-Oct 1965). Pp 55-59. <http://www.jstor.org/stable/4469865>

Fields,M. 1934."Security Prices and Stock Exchange Holidays in Relation to Short Selling." *Journal of Business*, vol. 7 (January):328-338.

Frieder, Laura, Avanidhar Subrahmanyam, “Nonsecular Regularities in Returns and Volume”. *Financial Analysts Journal*. Vol. 60, No. 4 (Jul - Aug 2004) pp 29-34. <http://www.jstor.org/stable/4480585>

Haugen, Robert A. And Philippe Jorion, “The January Effect : Still There after All These Years”. *Financial Analysts Journal.* Vol 52, No. 1 (Jan - Feb 1996) pp 27-31. <http://www.jstor.org/stable/4479893>

Hong, Harrison, Jialin Yu, Gone fishin': Seasonality in trading activity and asset prices, Journal of Financial Markets, Volume 12, Issue 4, November 2009, Pages 672-702, <http://www.sciencedirect.com/science/article/B6VHN-4WN2Y0J-1/2/8a503a3d4a81c0a10c8578d7f3d74cd8>

“Jewish Holidays”. The Orthodox Union. <www.ou.org/holidays>

Malkiel, Burton G. “A Random Walk Down Wall Street” W.M. Norton and Company, New York City. 1973.

Parkinson, Ryan. “The Extreme Value Method for Estimating the Variance of the Rate of Return”. *The Journal of Business.* Vol. 53, No. 1 (Jan 1980) pp 61-65. <http://www.jstor.org/stable/2352357>

Rozeff, M.S. and W.R. Kinney, "Capital Market Seasonality: The Case of Stock Returns," J*ournal of Financial Economics*, vol. 3, no. 4 (October 1976) pp. 379-402.

Seyyed, Fazal J., Abraham Abraham, Mohsen Al-Hajji, “Seasonality in stock returns and volatility: The Ramadan effect”, *Research in International Business and Finance,* Volume 19, Issue 3, September 2005, Pages 374-383, <http://www.sciencedirect.com/science/article/B7CPK-4GHRC81-2/2/b1f358f6fce184ef2213b85fec4f2fe6>

“Time and Date” Timeanddate.com. <http://www.timeanddate.com>

“Yahoo! Finance” . Yahoo. <http://finance.yahoo.com>