

## Monthly Anomaly in U.S. Treasury Bills Market

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### Abstract

We explore monthly anomaly in total monthly returns of U.S. Treasury bills from January 1926 to December 2013. The mean of monthly returns for the entire period as well as the mean of monthly returns of all the months were significantly greater than zero. No monthly seasonality was detected either in terms of mean or variance. When we slice the data into four sub-periods, we find results similar to what we find for the entire data set. The non-existence of significant differences in the means or the volatilities of the returns of a month compared to the other eleven months stacked shows that the T-bills market is largely free from monthly anomalies. This is contrary to what we found with similar studies on monthly returns of long-term Treasury bonds and corporate bonds. The mean of total monthly returns during Republican presidencies was higher than during Democratic presidencies.

**Keywords:** Anomaly, seasonality, month effect, volatility.

### I. Introduction

The U.S. federal government finances its multi-trillion dollar budget deficit by issuing Treasury securities. U.S. Treasury securities markets – Treasury bills, notes, and bonds – are among the most active in the world. T-bills are issued with maturities of one-month, three-month, six-month, and one-year.

T-bills market is highly active and market participants include corporations and many foreign governments. These are highly sophisticated investors. The huge volume of trading and the sophistication of the traders should make the market highly efficient. We would not expect to find seasonality in the monthly total returns of T-bills. This paper explores seasonality in the monthly returns of T-bills from January 1926 to December 2013. The behavior of T-bills market has implications for investors and policy makers. The next section presents literature survey on the behavior of U.S. T-bills returns, followed by research methodology, data and descriptive statistics, analysis of results, and finally summary and conclusion.

### II. Literature Survey

The behavior and efficiency stock markets have been extensively researched. The examination of the behavior of the fixed income markets has not received such scrutiny. There have been even fewer studies on the T-bills market. Gibbons and Hess (1981) found some day-of-the-week effects in the trading of thirty-day T-bills between 1963 and 1968. Ferri, Goldstein, and Oberhelman (1984) also look at the day-of-the-week effect in T-bills return. The result of this study show for the data tested that the day-of-the-week effect in the returns of the bills market are occasional but irregular features of the market. Eiseman and Timme (1984) explore intraweek seasonality in the federal funds market using data from January 1966 to June 1982, and found seasonality to vary over time in intensity and relative size. Park and Reinganum (1986) find unusual price behavior of T-bills that mature at the turn of calendar months. Flannery and Protopapadakis (1988) find intraweek seasonality continue to be significant but not uniform. Chen and Chan (1997) found using monthly returns from 1926 to 1990 T-bills return showed

strong October effect during economic expansion and strong November effect during contraction.

### III. Research Methodology

This study looks at seasonality over 88-year period. We explore if month effect was exhibited in U.S. T-bills total monthly returns over the period 1926-2013, and if so, was it more pronounced during Democratic presidencies or Republican presidencies. In exploring monthly seasonality in securities returns, many studies have used the dummy variable methodology. Chien, Lee and Wang (2002) provide statistical analysis and empirical evidence that the methodology may lead to misleading results. We avoid this apparent problem by following the methodology used in Hamid and Dhakar (2005) through which the authors analyze seasonality in the monthly changes of the Dow Jones Industrial Average.

We study the month effect in three different ways:

1. If the mean of T-bills total monthly returns was different from zero. The mean of monthly total returns for a given month  $i$  is subjected to the following hypothesis test:  $H_0: \mu_i = 0$  vs.  $H_a: \mu_i \neq 0$ .
2. If the mean of T-bills total monthly returns of a given month was different from the mean of the other eleven months stacked. We conduct the following hypothesis test for a given month  $i$ :  $H_0: \mu_i = \mu_j$  vs.  $H_a: \mu_i \neq \mu_j$ , where  $j$  represents the remaining 11 months other than  $i$ . Since the variances for many  $(i, j)$  periods and the sample sizes were unequal, we use the more conservative t-test assuming unequal variances.
3. If the variance of the T-bills total monthly returns for a given month was different from the variance for the other months. We conduct the following hypothesis test for a given month  $i$ :  $H_0: \sigma_i^2 = \sigma_j^2$  vs.  $H_a: \sigma_i^2 \neq \sigma_j^2$ , where  $j$  represents the remaining 11 months other than  $i$ . We use the standard F-test for testing this hypothesis.

Unless otherwise stated, significance in all cases is tested at the 5% level. In addition to the t-test and F-test, we use three nonparametric tests which do not depend on the assumption of normal distribution of the data series. Kruskal-Wallis nonparametric test is a test of differences in population medians. Mood Median test is like Kruskal-Wallis test but is more robust against outliers. Mann-Whitney test is a 2-sample rank test (also called the two-sample Wilcoxon rank sum test) of the equality of two population medians.

To gain deeper insight into the month effect, we divide the data period (January 1926 to December 2013) into four sub-periods:

- 1926 to 1945: the 20-year period which includes the Great Depression years, and the Second World War;
- 1946 to 1972: the 27-year period which includes the Breton Woods fixed exchange rate era, and the breakdown of that era in 1972;
- 1973 to 1992: the 20-year period after the onset of a volatile world following breakdown of Breton Woods system.
- 1993 to 2013: the 21-year period that has exhibited increasing volatility.

We analyze the behavior of T-bills total monthly returns for (a) the entire data, (b) the four sub-periods, (c) the Republican presidencies, and (d) the Democratic presidencies.

**IV. Data and Descriptive Statistics**

Our data consists of 1,056 monthly returns of U.S. T-bills from January 1926 to December 2013. The data is obtained from Stocks, Bonds, Bills, and Inflation Yearbook 2014. The data contains 518 months which saw Republican presidents, and 538 months which saw Democratic presidents.

The descriptive statistics for the monthly T-bills total monthly returns are shown in Table 1. The mean monthly return for the entire period was 0.287% (3.444% annualized) and the median is 0.250%. The distribution of monthly means was positively skewed. The maximum monthly return was 1.35% in June 1981 and the minimum was -0.06% in November 1938.

**Table 1: Descriptive Statistics for T-bills Total Monthly Returns: January 1926 to December 2013**

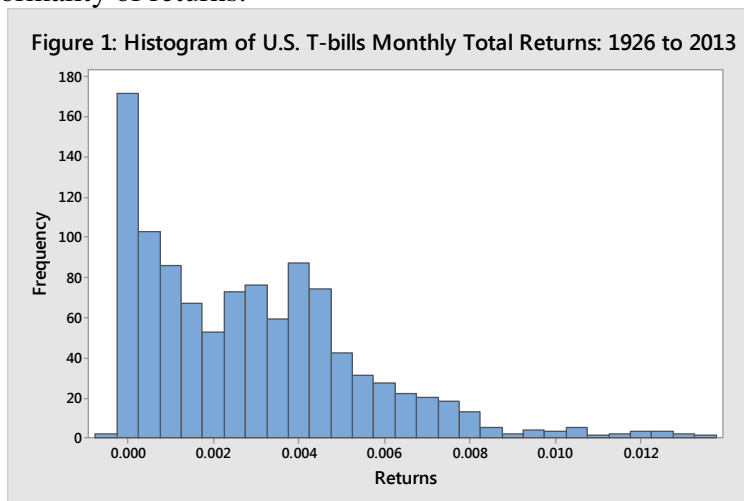
T-Bills Total Monthly Returns	
Mean	0.287%
Median	0.25%
Mode	0.300%
Std Deviation	0.253%
Kurtosis	1.2732
Skewness	1.0448
Minimum	-0.06%
Maximum	1.35%
Count	1,056

The frequency distribution of T-bills monthly returns is not normally or log-normally distributed. The Kurtosis (1.2732) is much less than it would be under normal distribution (3). The distribution is presented below. Only 12 (a little over 1%) of the monthly returns were negative (between -0.06% and -0.01%). As Table 2 shows, nearly half of the returns (46%) were between 0% and 0.24%. A little over one-third of the returns (35%) were between 0.25% and 0.49%. That means a little over four-fifths of the returns (82%) were less than 0.49%. So less than one-fifth of the returns were 0.50% or higher (highest return was 1.35%). During 82 of 84 months between January 1930 to December 1935, monthly returns were between 0.00% and 0,24%. Of the 60 months between January 2009 and December 2013, 59 of the monthly returns were 0% (32) or 0.01% (27). The very high Jarque-Berra statistic of 323.32 that we got also shows non-normality of the data series.

**Table 2: Frequency Distribution of T-bills Monthly Returns: January 1926 to December 2013**

Range of Returns	Frequency	Frequency( as % of total)
-0.06% to -0.01%	12	1.16%
0.00% to 0.24%	498	45.93%
0.25% to 0.49%	360	34.88%
0.50% to 0.74%	130	12.60%
0.75% to 0.99%	38	3.68%
1.00% to 1.35%	18	1.74
Total	1056	100%

The histogram of the monthly returns (Figure 1) shows what we find from frequency distribution: non-normality of returns.



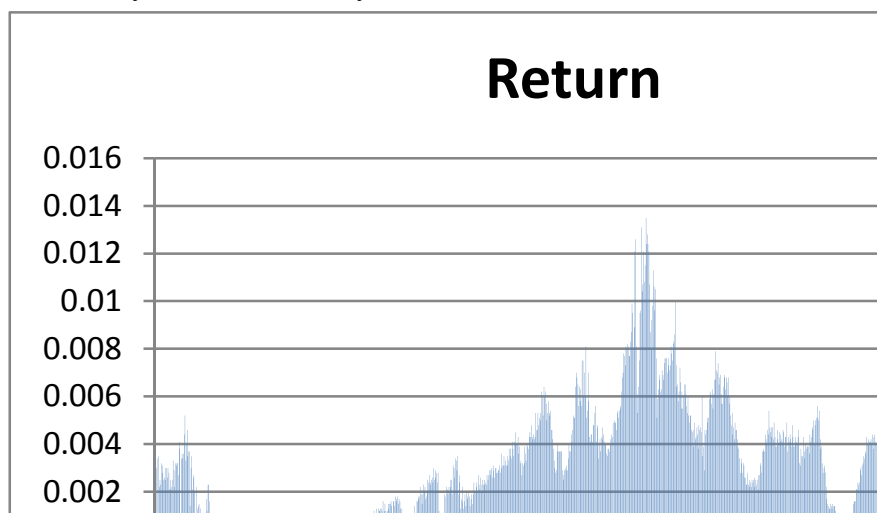
Though the mean of monthly returns was 0.287% (3.444% annualized), it varied widely over the decades. The average monthly and annualized returns for various periods (Table 3) shows the returns were the lowest in the 1940s possibly largely because of borrowing needs on account of World War II and subsequent reconstruction. Then we see a rising trend every decade until the 1980s (0.713% average monthly return or 8.551% annualized). After that we see a falling trend. The rising trend matches with ever-increasing GDP growth after World War II and until the 1980s. Very high inflation in the late 1970s and early 1980s also may have contributed to higher overall average returns in these two decades. After World War II and until 1981 interest rates in general have increased in the U.S. and have decreased thereafter. The average returns in periods shown below roughly mirror the increase and decrease of interest rates.

Table 3: Average monthly returns and average annualized returns for various periods

Period	Average monthly return (%)	Average annualized return (%)
1926-1929	0.301	3.608
1930-1939	0.046	0.549
1940-1949	0.034	0.409
1950-1959	0.155	1.857
1960-1969	0.317	3.809
1970-1979	0.511	6.126
1980-1989	0.713	8.551
1990-1999	0.402	4.819
2000-2009	0.227	2.720
2010-2013	0.127	1.527
<b>Average:</b>	<b>0.283</b>	<b>3.397</b>
1926-2013	0.287	3.444

Figure 2 shows the trend of monthly returns for the entire data set. The peak period was from January 1978 to December 1982 – the mostly Carter years during which the first and second oil shocks and the aftermath of the inflationary pressures of the Vietnam War led to double digit inflation rates and corresponding high T-bills monthly returns. During these five years the average return was 0.86% (0.29% for the entire data period) or 10.32% annualized.

Figure 2: T-bills Monthly Returns: January 1926 to December 2013



## V. Results and Analysis

### V.1 Entire Period (1926 – 2013)

Firstly, we explore monthly anomaly for the entire monthly returns data set. We test for the three types of month effects. Table 4 summarizes the statistical outputs and results of the tests.

Table 4: Month Effect in T-bills Total Returns: January 1926 to December 2013

	All	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Count	1056	88	88	88	88	88	88	88	88	88	88	88	88
Mean	0.287	0.286	0.268	0.291	0.293	0.289	0.284	0.289	0.286	0.291	0.300	0.277	0.290
Median	0.25	0.25	0.245	0.27	0.245	0.26	0.255	0.27	0.25	0.26	0.265	0.255	0.24
Minimum	-0.06	-0.01	-0.03	-0.01	-0.01	-0.02	0	-0.01	-0.01	0	0	-0.06	0
Maximum	1.35	1.04	1.07	1.21	1.26	1.15	1.35	1.24	1.28	1.24	1.21	1.07	1.31
Std Dev	0.25	0.24	0.24	0.26	0.27	0.26	0.25	0.26	0.25	0.25	0.26	0.25	0.26
p-value (m=0)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
p-value (t test)		0.95	0.43	0.87	0.82	0.94	0.92	0.93	0.97	0.88	0.63	0.68	0.91
p-value (F test)		0.17	0.17	0.39	0.20	0.42	0.49	0.43	0.50	0.51	0.29	0.41	0.32
Mean % Change	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Pos
Mo. Effect (Mean)													
Mo. Effect (Var)													

Note 1. “Positive” implies that the mean percentage change was significantly greater than zero. “Negative” implies that the mean percentage change was significantly less than zero.

Note 2. “Higher” implies that the mean percentage change was significantly greater than the rest of the months. “Lower” implies that the mean percentage change was significant smaller than the rest of the months.

Note 3: All returns in all tables are in percentage.

The mean of monthly returns for the entire data set (0.287%) was significantly greater than zero (p value=0.00). The means of monthly returns of all the individual months were significantly greater than zero. The mean of monthly returns in October was the highest (0.300%) followed by April (0.293%) and in turn followed by March and September (both 0.291%). February had the lowest mean (0.268%). The mean return of none of the months was significantly different from the mean return of the other eleven months stacked. Thus, taking the entire period into account, the means of monthly returns did not exhibit any anomaly. The standard deviation of the monthly

returns of none of the months was significantly different from the standard deviation of the monthly returns of the other eleven months stacked. The non-existence of significant differences in the means or the volatilities of the returns of a month compared to the other eleven months stacked shows that T-bills prices were largely efficient. This stands contrary to what we found with similar studies on monthly returns of long-term Treasury and corporate bonds as well as monthly returns of large and small stocks.

Nonparametric Kruskal-Wallis test result (not reported for brevity) shows no significant difference in the medians of the returns of the twelve months (H statistic = 0.83; p value=1.00). Mood Median test also shows no difference in the medians of the monthly returns (Chi-Square statistic = 0.95; p value=1.00).

### **V.2 First Sub-Period (1926-1945)**

In spite of the Great Depression leading to deflation and the pegging of interest rates during World War II, the mean of monthly returns of this sub-period (0.088%) was significantly greater than zero (p value=0.00). The means of monthly returns of all the individual months were significantly greater than zero (p values ranged between 0.00 and 0.01). The returns of none of the months were significantly different from the mean returns of the other eleven months stacked. The standard deviation of monthly returns of none of the months was significantly different from the standard deviation of the returns of the other eleven months stacked. The absence of monthly seasonality in returns shows the efficiency of T-bills prices in the first sub-period. (The tables showing output for the four sub-periods are not presented for brevity.)

### **V.3 Second Sub-Period (1946-1972)**

This was an era of fixed-exchange rates and relative domestic progress and prosperity. This was an era in which America helped Europe to rise up from the ashes of the Second World War under the Marshall Plan and also helped Japan to get back on its feet. (The Marshall Plan itself was worth over \$120 billion in today's dollars.) Compared to the previous sub-period, the mean of T-bills monthly total returns more than doubled (0.228% vs. 0.088%) and this was significantly greater than zero (p = 0.00). The mean of monthly returns of all the individual months were positive and significantly greater than zero. The mean of monthly returns of none of the months was significantly different from the mean returns of the other eleven months stacked. The standard deviation of the monthly returns of none of the months was significantly different from the standard deviation of the returns of the other eleven months stacked. We do not detect monthly seasonality for the second sub-period as well.

### **V.4 Third Sub-Period (1973-1992)**

From a mean monthly return of 0.088% in the first sub-period and 0.228% in the second sub-period, the mean monthly return increased to 0.621% in the third sub-period. It was significantly greater than zero. All months experienced mean returns significantly greater than zero. The mean of monthly returns of none of the months were significantly different from the returns of the other eleven months stacked. The standard deviations of monthly returns of none of the months were significantly different from the standard deviation of monthly returns of the other eleven months stacked.

### V.5 Fourth Sub-Period (1993-2013)

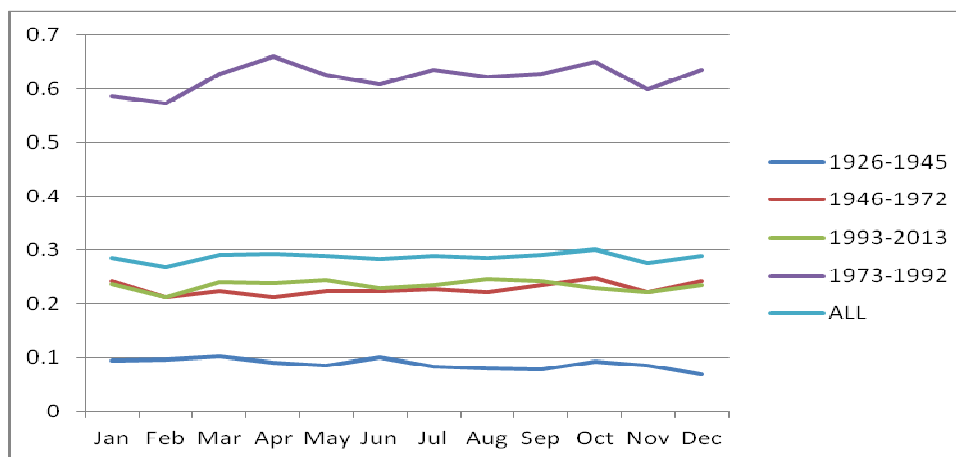
From a mean monthly return of 0.088% in the first sub-period, 0.228% in the second sub-period, and 0.621% in the third sub-period, the mean of monthly returns in the last 21 years fell to 0.235%. It was largely the result of the Great Recession. It was higher than the mean return of the first sub-period and significantly greater than zero. All months experienced mean returns significantly greater than zero. The mean of monthly returns of none of the months was significantly different from the mean returns of the other eleven months stacked. The standard deviation of monthly returns of none of the months was significantly different from the standard deviation of the returns of the other eleven months stacked.

So we find no month effect in terms of either the mean return of a month being significantly different from the mean of the other eleven months stacked, or the volatility of a month being significantly different from the volatility of the other eleven months stacked – either for the entire period or for any of the four sub-periods.

### V.6 Comparison of Four Sub Periods

Figure 3 shows the means of the various months for the three sub-periods. As we saw for the entire data set, we see a similar pattern for each of the three sub-periods.

**Figure 3: Comparison of Four Sub-periods Contrasted With Entire Data Set**



From 0.088% in the first sub-period, to 0.228% in the second sub-period, and 0.621% in the third sub-period, the mean of monthly returns in the last 21 years fell to 0.235%. The medians also show similar trend (0.030%, 0.205%, 0.595%, and 0.245%) and so do the standard deviations of the monthly changes (0.125%, 0.142%, 0.222%, and 0.176%). The means of the first three sub-periods are significantly different: the means of the second and third sub-periods are significantly higher than the mean of the first sub-period, and the mean of the second sub-period is significantly higher than the mean of the first sub-period – all for p values of 0.00. The mean of the fourth sub-period is significantly higher than that of the first sub-period, and significantly lower than that of the fourth sub-period, but is not significantly different compared to that of the second sub-period.



Nonparametric Kruskal-Wallis test result (not reported for brevity) shows significant difference in the medians of the returns of the four sub-periods (H statistic = 558.89; p value=0.00). Mood Median test also shows significant difference in the medians of the monthly returns (Chi-Square statistic= 355.26; p value=0.00).

While the means and medians increased, the standard deviations also increased significantly based on F-test. The standard deviation of the returns of the second sub-period is significantly higher than that of the first sub-period for a p-value of 0.04. The standard deviation of the third sub-period is significantly higher than that of the first for a p-value of 0.00. The standard deviation of the third sub-period is significantly higher than that of the second sub-period for a p-value of 0.00. The standard deviation of the fourth sub-period is also significantly higher than that of the first and second sub-periods. But it went down significantly compared to the third sub-period. So though volatility of returns have decreased significantly in the last two decades largely because of the Federal Reserve System keeping rates very low, it is higher compared to earlier times.

The stable period during Breton Woods fixed exchange rate system did not lower the standard deviation of the second sub-period possibly as a result of the effects of the Korean War and the Vietnam War. The even higher standard deviation during the third sub-period (0.222%) is attributable to the volatile world after the break-up of the Breton Woods system and the effects of globalization and technological innovations causing wide-spread dissemination of news and the need for market participants to react faster to such news.

## **VI. Month Effect: Republican and Democratic Presidential Periods**

Given the important impact presidencies have on the economy, we explored the three types of month-effects in T-bills total monthly returns during the Republican and Democratic presidencies.

### **VI.1 Republican Presidencies**

Table 4 shows the statistical output for T-bills total monthly returns during Republican presidencies over the entire period. The mean of T-bills total monthly returns (0.372%) over the 518 Republican months was significantly greater than zero. The median of T-bills total monthly returns during Republican periods was 0.335%. The means of T-bills total monthly returns for all the individual months were significantly greater than zero. We do not see a month effect in terms of mean: the mean return of none of the months was significantly different from the mean returns of the other eleven months stacked. The mean of monthly returns for the twelve months were within 0.34% and 0.39%. However, we see a month effect in terms of variance: the standard deviation of the returns of December was significantly lower than that of the other eleven months stacked. We would not expect to see such an anomaly in a highly efficient market; the volatility of no month should be significantly different from that of the other eleven months.



Table 4: Month effect in T-bills Total Monthly Return: Republican presidencies

	All	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Count	518	44	44	43	43	43	43	43	43	43	43	43	43
Mean	0.37	0.34	0.35	0.38	0.39	0.38	0.38	0.39	0.38	0.38	0.39	0.35	0.35
Median	0.34	0.31	0.33	0.35	0.34	0.32	0.35	0.32	0.32	0.32	0.37	0.35	0.34
Minimum	-0.03	0.00	-0.03	0.08	0.08	0.01	0.02	0.03	0.03	0.03	0.02	0.02	0.00
Maximum	1.35	0.80	1.07	1.21	1.13	1.15	1.35	1.24	1.28	1.24	1.21	1.07	0.87
Std Dev	0.25	0.20	0.23	0.24	0.26	0.26	0.26	0.27	0.27	0.26	0.26	0.23	0.23
p-value (m=0)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
p-value (t test)		0.30	0.53	0.80	0.74	0.80	0.78	0.67	0.85	0.79	0.65	0.51	0.32
p-value (F test)		0.05	0.31	0.45	0.31	0.28	0.29	0.19	0.26	0.39	0.35	0.24	0.00
Mean % Change	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Pos
Month Effect (Mean)													
Month Effect (Var)													Lower

### VI.2 Democratic Presidencies

Table 5 shows the statistical output for T-bills total monthly returns during Democratic presidencies over 1926-2013. The mean of T-bills total monthly returns (0.205%) over the 538 Democratic months is significantly greater than zero. The overall median of T-bills total monthly returns during Democratic presidencies was 0.10% compared to 0.335% during Republican presidencies. The mean of monthly returns of all the months were significantly greater than zero. We do not see a month effect in terms of mean: as in the case of Republican presidencies. The mean of monthly returns of none of the months was significantly different from the mean returns of the other eleven months stacked. The mean of monthly returns for the twelve months were within 0.19% and 0.24%. As in the case of the Republican presidencies, we see a month effect in terms of variance, but of the opposite type: the standard deviation of the monthly returns of December was significantly higher than that of the other eleven months stacked. We would not expect to see such an anomaly in a highly efficient market; no month should exhibit volatility significantly different from that of the other eleven months.

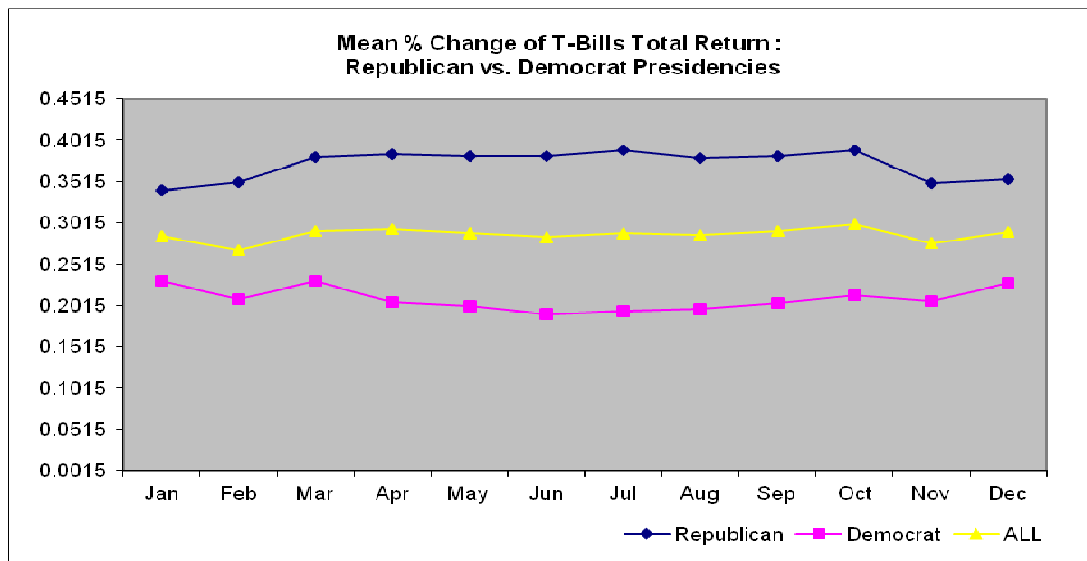
Table 5: Month effects in T-bills Total Monthly Returns: Democratic presidencies

	All	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Count	538	44	39	40	45	45	45	45	45	45	45	45	45
Mean	0.21	0.23	0.21	0.23	0.21	0.20	0.19	0.19	0.20	0.20	0.21	0.21	0.23
Median	0.10	0.14	0.14	0.155	0.1	0.10	0.10	0.10	0.10	0.10	0.12	0.10	0.11
Minimum	-0.06	-0.01	-0.01	-0.01	-0.01	-0.02	0	-0.01	-0.01	0	0	-0.06	0
Maximum	1.31	1.04	0.89	1.21	1.26	0.82	0.81	0.77	0.77	0.83	0.95	0.99	1.31
Std Dev	0.23	0.25	0.21	0.25	0.25	0.22	0.20	0.20	0.21	0.22	0.24	0.25	0.28
p-value (m=0)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
p-value (t test)		0.50	0.92	0.52	0.98	0.88	0.62	0.71	0.78	0.98	0.79	0.97	0.56
p-value (F test)		0.23	0.22	0.24	0.24	0.34	0.12	0.11	0.17	0.35	0.35	0.26	0.04
Mean % Change	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Pos	Pos
Month Effect (Mean)													
Month Effect (Var)													Higher

**VI.3 Comparison between Republican and Democratic Presidencies: 1926-2013**

Figure 4 below shows the mean monthly T-bills total returns for the entire period, as well as the mean monthly returns under Republican and Democratic presidencies. The pattern is pretty similar for all three trend lines from February onwards. The high point is October for the entire data period and the Republican presidencies; it is January during Democratic presidencies.

Figure 4: Monthly Mean Returns Contrasted: Republican vs. Democratic Presidencies



Two-sample t-test assuming equal variances shows a significant difference (p value=0.00) between the mean monthly returns during Republican presidencies (0.372%) and Democratic presidencies (0.205%). However, F-test (p value=0.22) shows no significant difference in the standard deviations of mean monthly returns during Republican presidencies (0.246%) and during Democratic presidencies (0.233%).

Nonparametric Kruskal-Wallis test result (not reported for brevity) shows significant difference in the medians of the monthly returns during Republican and Democratic presidencies (H statistic = 153.87; p value=0.00). Mood Median test also shows significant difference in the medians under the two types of presidencies (Chi-square = 71.10, p value=0.00). Two-sample Mann-Whitney test of the equality of two population medians also shows significant difference in the medians of the returns under the two types of presidencies (W statistic = 222874.0; p value=0.00).

It would be interesting to see if the difference in the means and medians were related to a higher borrowing during the Republican presidencies compared to Democratic presidencies to warrant the higher average returns achieved by investors during Republican presidencies. However, we have to note that such results are not just the action of the presidents in power but also caused by actions of the Congress and the Federal Reserve System. It will be very hard, if not impossible, to isolate the relative impact of the actions of the three parties.

If war periods cause higher prices, Democrats have had more than their share of war presidents: Woodrow Wilson was the war president during First World War, Franklin Delano Roosevelt during Second World War, Harry Truman during Korean War, and Kennedy and Johnson presided over the major part of the Vietnam War. The Depression Years, which depressed prices greatly, were presided over by Republican President Herbert Hoover. These factors could well have accounted for the lower monthly returns during Democratic presidencies.

#### **VI.4 Mean Returns during Expansions and Recessions**

The mean of monthly returns for the 853 months that saw economic expansion was 0.28% (median: 0.27%). The mean of monthly returns for the 203 months that saw economic recession was 0.30% (median: 0.19%). Based on standard t-test, there is no significant difference between the two means ( $p$  value=0.47). Based on two non-parametric tests there is no significant difference. The standard deviations of the monthly returns in the two periods are respectively 0.24% and 0.31% - and the difference is significant based on F-test for a  $p$ -value of 0.00. Recessions bring greater uncertainty and hence we would expect to see greater variance of returns in such periods. But we do not see a significant difference in the means of the two economic conditions.

### **VII. Summary and Conclusion**

This paper explores the behavior and efficiency of the U.S. T-bills total monthly returns over the period January 1926 to December 2013. We looked at efficiency via monthly seasonality in T-bills total monthly returns. We looked at three types of month effects: if the means of monthly T-bills total monthly returns of the entire data set and of each of the twelve months were significantly different from zero; if the mean of total monthly returns for each month was different from the means of the other months stacked; if the variance of the total monthly returns for each month was different from the variance of the other eleven months stacked.

The means of T-bills total monthly returns for the entire data set as well as for each month were significantly greater than zero ( $p = 0.00$ ). We find that there is some semblance of symmetrical distribution in the monthly returns with July as the mid-point. The means of monthly returns as well as the standard deviations of the returns of none of the months were significantly different from that of the other eleven months.

We sliced the data into four sub-periods to gain greater insight on monthly seasonality. We find significant increase in the means and medians of monthly returns for each of the first three successive sub-periods and also an increase in the standard deviations of the monthly returns for the first three successive sub-periods – and a fall in the last sub-period. The mean of monthly returns for each sub-period and for each month in each sub-period were significantly greater than zero. As in the case of the entire data set, the means of monthly returns as well as the standard deviations of the returns of none of the months in any of the sub-periods were significantly different from that of the other eleven months stacked. The absence of seasonality in monthly returns for the entire data set as well as for the four sub-periods is a testament to the efficiency of the T-bill market to a high degree.

The mean of T-bills total monthly returns for the 518 months with a Republican president (0.372%) was significantly higher than the mean of the 538 months with a Democratic president (0.205%) and so were the medians. There was no significant difference in the variances of

returns of the two types of presidencies. However, the variance of the monthly returns in December during Republican presidencies was significantly lower compared to the other eleven months stacked; the variance of monthly returns of December was higher compared to the other eleven months during Democratic presidencies.

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