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Tell Me Why I Do Not Like Mondays

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Abstract: We conduct a strict and broad analysis of the 30-day expected volatility (VIX) of five very active individual US stocks, three US domestic indices, and that of 10-year US Treasury notes. We find prominent non-random movement patterns mainly on Mondays and Fridays. Furthermore, significant leaps in expected volatility on Monday occur primarily in the first two and the fifth Mondays of the month. We also document that higher values for the 30-day expected volatility on Mondays are more likely when there was a negative change in the volatility on the preceding Fridays. This pattern does not occur on other subsequent days of the week. The results are robust through time and different subsamples and are not triggered by outliers or the week during which the options on the underlying assets expire. Rational and irrational drivers are suggested to explain the findings. Given that, to date, no one has conducted such an examination, our findings are important for investors interested in buying or selling volatility instruments.

Keywords: Monday effect; Monday of the month; VIX; perceived volatility; weekend effect

MSC: 91-11

JEL Classification: G12; G13; G14; G32

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> "Tell me why
> I don't like Mondays
> I want to shoot the whole day down . . . "
> (The Boomtown Rats, The Fine Art of Surfacing, 1979)
> https://www.youtube.com/watch?v=-Kobdb37Cwc (accessed on 5 May 2022).

1. Introduction

The empirical finance research has documented the day-of-the-week effect not only in equities [1,2], but also in commodities (e.g., [3,4]), currencies (e.g., [5]), cryptocurrencies (e.g., [6,7]), Treasury bills (e.g., [8]), and corporate bonds (e.g., [9]). These studies maintain that Monday returns are significantly lower than those of other weekdays, and Friday returns are significantly positive or the highest.

In this study, we extend the literature by showing that the well-known Monday effect also occurs in the expected 30-day volatility (VIX) of five active individual stocks (Amazon, Apple, Goldman Sachs, Google, and IBM), three US domestic indices (the Dow Jones, Russell 2000, and NASDAQ), and the VIX of 10-year Treasury notes. As far as we know, the question of whether the perceived risk is higher on certain days of the week has not been addressed for these specific volatility vehicles.

Exploring cyclicality in the expected 30-day volatility of bonds and equities is important for the designing of volatility hedging strategies. Doing so is important to test the validity of the market efficiency hypothesis, particularly given that exchange volatility products have become a popular investment vehicle in recent years. In addition, the day-of-the-week anomaly has been under fire in the last two decades. Various studies have reported a lack of adequate support for this anomaly (e.g., [10,11]), inconsistencies in its

permanence (e.g., [12]) and even contradictory results (e.g., [13]). Given this debate and the lack of research on the seasonality of market expectations about the looking-forward volatility of individual stocks and bonds in the next 30 days, we seek to fill this gap in the literature and resolve some of these issues.

We subjected our findings to a battery of robustness checks and found, for example, that among the 319 Mondays in the VIX-style estimate of the expected 30-day volatility of Treasury notes (for May 2013 to February 2020), there were 224 Mondays (70.22%) associated with a positive change, and among the 342 sampled Fridays, there were 219 cases (64%) of a negative change.

As the expiration of options might be a factor inducing liquidity and price effects in the underlying assets (e.g., [14]), we control this possibility by removing the week on which the options on our securities of interest expired from consideration. Nevertheless, the regularity explored here was still evident. A more in-depth analysis of the volatility indices' levels indicates that the hike in the expected 30-day volatility of 10-year bonds, equity indices, and individual stocks is strongly evident on the first, second, and fifth Mondays of the month, but moderately so in the fourth week, leaving the third Monday of the month with no clear direction. Regardless of the sub-period analyzed, this result holds for the vast majority of volatility indices examined. For example, the first Monday of the month was positive in 75% of the cases for Amazon, and 80.56% for Google, whereas the fifth Monday was positive in 74.39% of the cases for Apple, 73.75% for Goldman Sachs, and 75.61% for the Russell 2000.

The results also indicate that the direction of the estimate of the expected 30-day volatility on Mondays is contingent on that of Fridays. The probability for a positive change in the VIX-style estimate on Monday is greater if the preceding Friday ended with a decline in the VIX. For example, a drop in the expected 30-day volatility on Fridays was followed by a positive change on Mondays for 74% of the cases in the Treasury notes (TYVIX), 61.5% of the cases in the Apple VIX (VXAPL), and 63.64% of the cases in the Russell 2000 VIX (RVX). Nevertheless, this Friday–Monday pattern does not occur on other subsequent days of the week.

Practically, none of the indices examined here are tradable. However, if we assume that these indices are tracked precisely by ETNs or ETFs, then investors could benefit substantially from constructing simple trading rules that take advantage of the patterns documented here. Figure 1 illustrates the *weekly* excess returns resulting from the difference between the returns of the volatility index on Mondays and Fridays ($R^V_{Monday} - R^V_{Friday}$). Pronounced returns can be obtained if investors short the volatility index on Thursday, buy it twice on Friday (the first acquisition is aimed at closing the short position, while the other is designed to take a new long position), and then sell it again on Monday. The average *weekly* profits are striking and range from 0.39% (for Apple) to 4.19% (for Google). These *theoretical* profits are still evident after accounting for reasonable levels of transaction costs and using different subsamples.

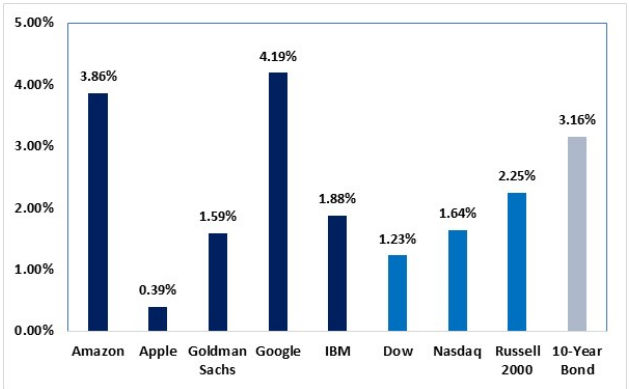

Figure 1. Average *weekly* returns resulting from the suggested trading strategy.

We suggest two different, if somewhat related, explanations for the results. The first is the variation in the type of economic news across the week. We observe that there is increased pessimism reflected in the press at the start of the week. Specifically, we find that the Economic Policy Uncertainty Index (EPU; [15]), an index developed using text analyses of US newspapers, is lower on Fridays but sharply higher on Sundays and Mondays. Figure 2 illustrates the average of the EPU index across weekdays.

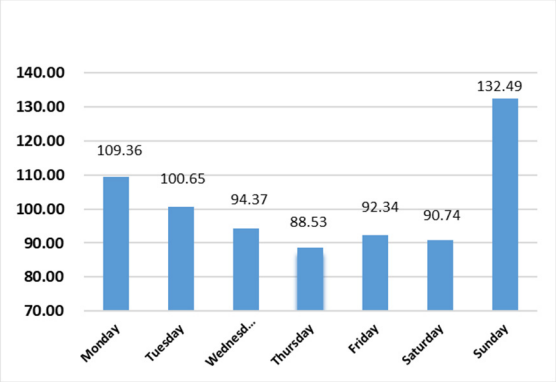

Figure 2. EPU across weekdays. The figure depicts the average of the Economic Uncertainty Policy (EPU) values across weekdays for 1985–2020. On Sundays and Mondays, the EPU is higher than on the rest of the weekdays. The difference between the EPU average on Mondays and Fridays is 17.02 (t-stat. = 7.92). The results are maintained when utilizing two equal subsamples: 1985–December 2002 and January 2003–February 2020.

In parallel, and as a complementary effect, there is a body of literature that relates the negative atmosphere on Monday to the timing of corporate news announcements. These studies, detailed in Section 2, maintain that companies tend to release good corporate news during trading hours and bad news on Friday after the market closes.

The second explanation (detailed in Section 2.2) relies on the irrational factor of investors' moods. Prior lab-based, survey-based, and social media-based works from psychology, decision-making, social media, sleep, and transportation have established that people's mood varies across weekdays, claiming that it improves on Fridays but sharply declines on Mondays (e.g., [16,17]). The psychology and decision-making literature have also established that mood affects people's judgment and decision-making significantly, and that psychological state influences their attitude toward risk (e.g., [18]). Hence, emotional states are potentially capable of affecting investors' risk assessments and preferences and, ultimately, their investment decisions. Indeed, many studies have documented that agents' financial decisions do vary with investor mood [19,20] and that market volatility reacts to investor sentiment [21].

Methodologically, we suggest decomposing the volatility into two components. The first component reflects all of the fundamental or rational economic variables derived from daily and intraday (5 min) data, while the second reflects irrational factors (captured by the residuals). We find that the irrational component exhibits a non-random discrepancy across weekdays, with a significant leap on Monday and a decline on Friday. This finding confirms our premise that irrational factors might explain part of this phenomenon.

Our results confirm the claim that the 30-day expected volatility of bonds, equity indices, and individual stocks not only reflects the market participants' views about future market volatility as expressed through trade, but also mirrors investors' daily sentiment. Many studies have pointed to the VIX as an indicator of risk aversion and investors' mood or sentiment (e.g., [22,23]), where a rise (decrease) in the VIX reflects increased (deteriorating) perceptions about risk aversion or fears. Overall, both the rational and irrational explanations are in line with the global pictures explored here.

The paper is organized as follows. Section 2 reviews the relevant literature. Section 3 describes the data and the characteristics of the sample. Section 4 discusses the empirical findings and results, and Section 5 concludes the paper.

2. Literature Review

2.1. Explanations Based on Investors' Rational Considerations

The literature lists various possible rational explanations for the Monday anomaly: the high Friday return hypothesis (e.g., [24]), individual traders' decision-making processes following recommendations from brokerage houses (e.g., [25–29]), asymmetric risk between long and short positions around weekends [30], and the correlation structure (long memory) of the series [31].

One explanation that has attracted a great deal of attention in the literature is the timing of corporate announcements. Ref. [32] noted that positive corporate news is more likely to be announced during trading hours. Furthermore, companies are more likely to release negative news at the close of trading on Friday rather than on other days. Ref. [33] documented that unanticipated negative earnings announcements are more likely on Monday or over the weekend than on other weekdays. Consistent with [33,34] maintained that on Friday, investors' inattention is more likely. Hence, Fridays are associated with more delayed responses relative to other weekdays. Other studies corroborate this evidence (e.g., [35]). These studies maintain that managers strategically time their corporate announcements. Hence, bad news is more likely to be announced on Friday than on other weekdays, the day before a national holiday, when attention is limited, and after the market closes.

In addition to the tone of corporate announcements, previous papers have confirmed the role of the mass media and news coverage in affecting the price and volatility of asset prices and the formation of investors' expectations about future stock values (e.g., [36]). Many studies apply textual analysis techniques to provide comprehensive evidence about the significant relationship between information coverage and trading volume, returns, and volatility. For example, [37] observed that when the media express a high degree of pessimism, investors react, often leading to a decline in market prices. In addition, [38] found that variations in a firm's indicators of profitability and price efficiency are related to the percentage of negative words in the financial news.

In this spirit, [15] conducted textual analyses of newspaper texts to create a tool that would reflect economic and policy conditions. They reported that greater government policy uncertainty is associated with increased stock price volatility and less employment and investment in economic sectors such as defence, health care, finance, and infrastructure construction. In this spirit, recent studies confirm that fiscal pressure and financial solvency are capable of affecting the performance of public companies [39–41].

2.2. Explanations Based on Investors' Irrationality

The conventional framework of the finance theory implies that irrational factors do not play any role in influencing asset prices. However, the behavioural approach maintains that investor moods—reflected in optimistic or pessimistic expectations—can persist and affect asset prices for significant periods. Evidence in the behavioural finance literature shows that stock returns are associated with people's moods. In these studies, mood is captured using variations in natural conditions such as the weather (e.g., [42]) and amount of daylight (e.g., [43]). These studies are based on psychology and maintain that mood influences people's attitude toward risk. Consequently, returns on securities fluctuate with investors' moods.

Several works justify the lower returns on Mondays using the notion of mood. These studies maintain that people's mood does not randomly fluctuate across weekdays. Rather, it peaks on the weekend and slides sharply on Monday. For example, [44] explored the existence of the Blue Monday syndrome and maintained that when investors are feeling down, they are more pessimistic about the outlook for the securities they hold and more

apt to sell for less on Mondays than on other days. In this spirit, [4] utilized indirect proxies previously used in the literature to proxy for mood, including US closed-end fund discounts, returns on small stocks, consumer confidence and consumer attitudes towards buying a house. They argued that the Monday effect is more evident during periods of pessimism, implying that irrationality on the part of investors may explain the higher non-diversifiable risk on Mondays.

In many survey-based studies, Monday is viewed as the worst morning of the week (e.g., [16]). People who are asked why they do not like Mondays almost always point to the following themes. Generally, they talk about the difficulty of waking up on Monday after the weekend. Even those who say they had a full night's sleep often describe being tired on Monday [45]. Others cite the extra traffic on Mondays when commuting, noting that Mondays are the most congested mornings of the week [46,47]. The stress involved in arriving late to work also affects financial decision-making (e.g., [48] provide a comprehensive review). In addition, people claim that Monday marks the move from the leisure activities of the weekend to the beginning of five long workdays [44]. Studies on suicide document that Mondays are the peak days for suicides (e.g., [49]), with significantly fewer suicides on weekends [50]. All of these factors could play a role in fluctuations in investors' moods, which could affect their attitude toward risk.

Admittedly, it is hard to assess mood outside the lab using real-life data. However, ref. [51] suggested capturing the collective mood using data from social media. The authors examined data from about 509 million Twitter posts by 2.4 million users from numerous countries with differences in religion and culture. They documented that people tend to be more positive on weekends and early in the morning, and less on Mondays. Similar results are also reported in other studies (e.g., [52,53]). Ref. [54] showed that investors' moods, captured by Facebook status updates, deteriorate on Mondays, mainly for small capitalization indices and countries in which there is a greater desire to avoid uncertainty.

Finally, studies from the field of sleep observe that individuals tend to sleep-in later over the weekend. Disruptions in people's circadian rhythms often lead to a subsequent decline in mood and cognitive daytime functioning on Monday (e.g., [45,55,56]).

3. Data

To explore the role of these various factors in investors' decisions, we use daily data about the expected 30-day volatility of five very active individual stocks: Amazon, Apple, Goldman Sachs, Google, and IBM. Our data come from the Chicago Board Options Exchange (CBOE) website. At this stage, the only individual stocks for which the CBOE computes its VIX are those used here. We also used data about the VIX-style estimate of the expected 30-day volatility of the Dow Jones (VXD), NASDAQ (VXN), and Russell 2000 (RVX) and used data about the expected volatility of 10-year Treasury notes (TYVIX). Finally, we utilized 5 min data obtained from pitrading.com to construct estimates of realized variances for the assets explored here. Table 1 describes the sample periods considered, the number of observations, and the source of the data. The longest sample for equity market indexes is that of the VXN (October 2000 to February 2020), and the shortest one is that of the VXD (October 2013 to February 2020).

Table 1. Volatility indices—general description.

Security/Index	Ticker Symbol	Sample Period
Amazon	VXAZN	16 August 2011–28 February 2020
Apple	VXAPL	16 August 2011–28 February 2020
Goldman Sachs	VXGSCLS	6 October 2011–28 February 2020
Google	VXGOG	16 August 2011–28 February 2020
IBM	VXIBM	16 August 2011–28 February 2020
DOW	VXD	2 October 2013–28 February 2020
NASDAQ	VXN	10 October 2000–28 February 2020
Russell 2000	RVX	15 August 2011–28 February 2020
10-Year Treasury notes	TYVIX	30 May 2013–28 February 2020

Notes: The table reports the ticker symbol, source, and sample period for the data. The VXAZN is a VIX-style estimate of the expected 30-day volatility of Amazon stock returns. Similarly, VXAPL, VXGSCLS, VXGOG, VXIBM are the VIX-style estimates of Apple, Goldman Sachs, Google, and IBM stock returns, respectively. The VXD, VXN, and RVX are the VIX-style estimates of the expected 30-day volatility of the Dow Jones, NASDAQ-100, and Russell 2000 equity indices, respectively. Finally, TYVIX estimates the expected 30-day volatility of 10-year Treasury notes.

Table 2 presents the descriptive statistics of the VIX. Panel A of the table reports the statistics of the data in level, while Panel B reports the correlation between the volatility measures. For example, according to Panel A, the expected volatility of Amazon (VXAZN) spans August 2011 to February 2020, and the total number of observations was 2148. The average value of the level VIX was 31.69%, and its standard deviation was 8.63%. During the sample period, the VIX leapt to 66.06% during the subprime crisis, and the lowest value was 5.13%. Panel C of the table reports the average rate of return in the expected 30-day volatility across weekdays for the sampled securities. In this panel, we present the results of testing three different hypotheses:

(1) The first conjectures that the implied volatility is equal across weekdays. Based on the findings, we rejected this hypothesis for all of the sampled securities, as evident by the significant F-statistic values.
(2) The second hypothesis postulates that changes in the VIX are equal on Monday and Friday. Based on the findings, we rejected this hypothesis as well.
(3) Last, we checked whether the mean returns on the VIX are equal on Monday, Tuesday, Wednesday, and Thursday.

Based on the findings, we rejected this hypothesis, as evident by the F-statistic values in the right column of Panel C of Table 2. Therefore, there was no support for any of the hypotheses about equality across weekdays or equality between Mondays and Fridays.

Table 2. Descriptive statistics.

Panel A: Level Data in (%).									
	VXAZN	**VXAPL**	**VXGSCLS**	**VXGOG**	**VXIBM**	**VXD**	**VXN**	**RVX**	**TYVIX**
Mean	31.69 a	28.00 a	26.92 a	24.61 a	21.84 a	14.82 a	25.28 a	20.13 a	4.98 a
Med.	29.86	27.33	25.34	23.86	20.63	13.93	20.01	18.56	4.93
Max.	66.06	62.60	74.88	55.60	51.72	42.67	83.00	57.66	8.62
Min.	5.13	12.52	16.16	9.21	13.23	7.58	10.31	11.83	3.16
Stdev.	8.63	6.55	7.57	6.20	4.96	3.72	13.76	6.01	0.95
Skew.	0.66	0.84	2.13	0.89	1.23	1.68	1.83	2.53	0.66
Kurt.	3.19	4.15	9.63	4.13	5.29	7.76	5.85	10.96	3.42
#Obs	2148	2148	2112	2148	2148	1602	4825	2149	1697
Sample Period	2011:08 to 2020:02	2011:08 to 2020:02	2011:10 to 2020:02	2011:08 to 2020:02	2011:08 to 2020:02	2013:10 to 2020:02	2000:10 to 2020:02	2011:08 to 2020:02	2013:05 to 2020:02

Panel B: Correlation between the Volatility Measures.									
	VXD	**VXN**	**RVX**	**TYVIX**	**VXAZN**	**VXAPL**	**VXGSCLS**	**VXGOG**	**VXIBM**
VXN	0.95 *** [124.97]	1.00 ——							
RVX	0.96 *** [138.11]	0.90 *** [86.49]	1.00 ——						
TYVIX	0.53 *** [25.85]	0.46 *** [21.25]	0.60 *** [31.11]	1.00 ——					
VXAZN	0.62 *** [32.25]	0.65 *** [35.63]	0.61 *** [31.39]	0.33 *** [14.20]	1.00 ——				
VXAPL	0.84 *** [63.81]	0.83 *** [62.29]	0.81 *** [57.09]	0.51 *** [24.58]	0.75 *** [46.21]	1.00 ——			
VXGSCLS	0.92 *** [99.52]	0.90 *** [85.59]	0.93 *** [102.22]	0.58 *** [29.18]	0.56 *** [27.88]	0.80 *** [55.56]	1.00 ——		
VXGOG	0.81 *** [56.07]	0.83 *** [61.17]	0.78 *** [51.75]	0.41 *** [18.80]	0.85 *** [67.45]	0.86 *** [68.91]	0.77 *** [49.67]	1.00 ——	
VXIBM	0.86 *** [70.39]	0.86 *** [70.00]	0.84 *** [62.95]	0.43 *** [19.82]	0.61 *** [32.07]	0.80 *** [54.84]	0.89 *** [81.31]	0.80 *** [54.73]	1.00 ——

Panel C: Rate of Change in Volatility across Weekdays.								
	Mon (α_2)	**TUE (α_3)**	**WED (α_4)**	**THU (α_4)**	**FRI (α_6)**	H_0: $\alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = \alpha_6$	H_0: $\alpha_2 = \alpha_6$	H_0: $\alpha_2 = \alpha_3 = \alpha_4 = \alpha_5$
VXAZN	2.228 a (6.39)	0.619 c (1.85)	0.419 (1.25)	0.839 b (2.49)	−2.549 a (−7.59)	26.54 a	9.87 a	5.65 a
VXAPL	1.264 a (3.65)	−0.245 (−0.74)	−1.255 a (−3.79)	0.335 (1.01)	0.146 (0.44)	7.36 a	2.33 b	9.76 a
VXGSCLS	1.243 a (4.04)	−0.149 (−0.51)	−0.133 (−0.45)	−0.026 (−0.09)	−0.888 a (−2.99)	6.45 a	4.99 a	4.93 a
VXGOG	2.626 a (7.41)	0.345 (1.02)	0.158 (0.47)	0.66 c (1.94)	−2.167 a (−6.35)	24.18 a	9.75 a	10.55 a
VXIBM	1.599 a (4.46)	0.262 (0.76)	−0.832 b (−2.42)	0.049 (0.14)	−0.822 b (−2.38)	7.99 a	4.86 a	8.14 a
VXD	1.596 a (3.81)	0.657 (1.63)	−0.644 (−1.60)	0.589 (1.45)	−0.527 (−1.30)	5.13 a	3.64 a	5.03 a
VXN	1.678 a (8.36)	0.009 (0.05)	−0.243 (−1.26)	0.06 (0.31)	−0.571 a (−2.9)	19.18 a	8.06 a	19.57 a
RVX	1.944 a (6.32)	0.259 (0.88)	−0.143 (−0.49)	−0.118 (−0.39)	−0.855 a (−2.89)	11.85 a	6.56 a	10.59 a
TYVIX	2.039 a (7.80)	0.403 (1.61)	−0.740 a (−2.95)	−0.214 (−0.85)	−1.288 a (−5.10)	24.74 a	9.16 a	21.89 a

Notes: Panel A of the table reports the descriptive statistics of the looking-forward volatility variables. "a" denotes statistical significance at the level of 1%. The squared parentheses in Panel B report the T-Statistic values. "***" denotes statistical significance at the 1% level. Simple average values of the returns across weekdays. The values in parentheses are the t-stat. values, while "a," "b", and "c" denote statistical significance at the levels 1%, 5%, and 10%, respectively. The values reported on the right-hand side of the table are the F-statistic values for three different hypotheses. Overall, the hypothesis for equality across weekdays and equality between Monday and Friday are rejected. The model used is as follows. $\Delta V_t = \alpha_2 MON_t + \alpha_3 TUE_t + \alpha_4 WED_t + \alpha_5 THU_t + \alpha_6 FRI_t + \psi_t$; ΔV_t is the rate of change in the price of the volatility index. MON, TUE, WED, THU, and FRI are dummy variables that capture the day of the week. The T-Statistics are Newey–West [57] corrected.

4. Empirical Findings

Table 3 summarizes the distribution of the expected 30-day volatility indices on Fridays and Mondays. As outliers in the data could potentially yield biased inferences [58], we utilized the sign test. The test is free from the effect of outliers and validates whether the resulting ratio is statistically different from 0.5—the probability of a coin toss. The picture that emerges indicates that Fridays are associated with a decrease in the expected 30-day volatility, and that Mondays are associated with a positive increase in it. This finding holds true for the VIX of the individual stocks, indices, and Treasury notes. For example, regarding the VXAZN data, the table indicates that out of the 434 Fridays, there were 276 Fridays associated with a decrease in the VIX. In other words, 63.59% of the Fridays were associated with a negative change. In parallel, among the 402 Mondays, there were 261 cases of a positive change in the VIX—yielding 64.93% positive Mondays. The difference between the percentage of times there was a decline on Friday and an advance on Friday (63.59–35.94% = 27.65%) was strongly significant (t-stat. = 8.47). In addition, the difference between the percentage of times there was an increase on Monday and a decline on Monday (64.93–35.07% = 29.85%) was strongly significant as well (t-stat. = 8.86).

Table 3. Sign directions of Fridays and Mondays.

	VXAZN (2011:08–2020:02)		**VXAPL (2011:08–2020:02)**	
	Friday	**Monday**	**Friday**	**Monday**
Number of times the Index advanced	156	261	198	243
Number of times the Index declined	276	141	233	158
Number of times the Index was unchanged	2	0	3	1
Total	434	402	434	402
Percentage of times the Index advanced (1)	35.94% ***	64.93% ***	45.62% *	60.45% ***
(Sign Test t-stat.)	(5.66)	(5.99)	(1.54)	(4.19)
Percentage of times the Index declined (2)	63.59% ***	35.07% ***	53.69% *	39.30%***
	(5.66)	(5.99)	(1.54)	(4.19)
Difference (2)–(1)	27.65% ***	29.85% ***	8.06% **	21.14%***
(Sign Test t-stat.)	(8.47)	(8.86)	(2.38)	(6.13)
Mean percentage change (t-stat.)	−2.55 ***	2.23 ***	0.15	1.26 ***
	(−6.25)	(5.12)	(0.46)	(3.55)
Median percentage change	−1.59	2.21	−0.45	1.44

	VXGSCLS (2011:10–2020:02)		**VXGOG (2011:08–2020:02)**		**VXIBM (2011:08–2020:02)**	
	Friday	**Monday**	**Friday**	**Monday**	**Friday**	**Monday**
Number of times the Index advanced	154	235	158	272	183	255
Number of times the Index declined	269	160	275	129	241	143
Number of times the Index was unchanged	4	1	1	1	10	4
Total	427	396	434	402	434	402
Percentage of times the Index advanced (1)	36.07% ***	59.34% ***	36.41% ***	67.66% ***	42.17% ***	63.43% ***
(Sign Test t-stat.)	(5.37)	(3.72)	(5.57)	(7.08)	(2.30)	(5.39)
Percentage of times the Index declined (2)	63.00% ***	40.40% ***	63.36% ***	32.09% ***	55.53% ***	35.57% ***
	(5.37)	(3.72)	(5.57)	(7.08)	(2.30)	(5.39)
Difference (2)–(1)	26.93% ***	18.94% ***	26.96% ***	35.57% ***	13.36% ***	27.86% ***
(Sign Test t-stat.)	(8.16)	(5.42)	(8.24)	(10.78)	(3.97)	(8.22)
Mean percentage change (t-stat.)	−0.89 ***	1.24 ***	−2.17 ***	2.63 ***	−0.82 **	1.60 ***
	(−2.95)	(3.84)	(−5.15)	(6.33)	(−2.37)	(4.98)
Median percentage change	−1.28	1.05	−1.20	2.43	−0.57	1.42

Table 3. *Cont.*

	VXD (2013:10–2020:02)		VXN (2000:10–2020:02)		RVX (2011:08–2020:02)	
	Friday	**Monday**	**Friday**	**Monday**	**Friday**	**Monday**
Number of times the Index advanced	126	174	363	536	170	242
Number of times the Index declined	196	128	600	366	260	159
Number of times the Index was unchanged	1	0	6	5	4	2
Total	323	302	969	907	434	403
Percentage of times the Index advanced (1)	39.01% ***	57.62% ***	37.46% ***	59.10% ***	39.17% ***	60.05% ***
(Sign Test t-stat.)	(3.84)	(2.65)	(7.42)	(5.48)	(4.13)	(4.04)
Percentage of times the Index declined (2)	60.68% ***	42.38% ***	61.92% ***	40.35% ***	59.91% ***	39.45% ***
	(3.84)	(2.65)	(7.42)	(2.65)	(4.13)	(4.04)
Difference (2)–(1)	21.67% ***	15.23% ***	24.46% ***	18.74% ***	20.74% ***	20.60% ***
(Sign Test t-stat.)	(3.04)	(2.25)	(11.09)	(8.12)	(6.24)	(5.98)
Mean percentage change (t-stat.)	−0.53	1.60 ***	−0.57 ***	1.68 ***	−0.85 ***	1.94 ***
	(−1.25)	(3.52)	(−2.92)	(7.50)	(−2.91)	(5.06)
Median percentage change	−1.51	1.13	−1.30	1.34	−1.25	1.32

	TYVIX (2013:05–2020:02)	
	Friday	**Monday**
Number of times the Index advanced	119	224
Number of times the Index declined	219	88
Number of times the Index was unchanged	4	7
Total	342	319
Percentage of times the Index advanced (1)	34.80% ***	70.22% ***
(Sign Test t-stat.)	(5.19)	(7.22)
Percentage of times the Index declined (2)	64.04% ***	27.59% ***
	(5.19)	(7.22)
Difference (2)–(1)	29.24% ***	42.63% ***
(Sign Test t-stat.)	(7.99)	(11.89)
Mean percentage change (t-stat.)	−1.29 ***	2.04 ***
	(−4.40)	(7.90)
Median percentage change	−1.65	1.86

Notes: The table illustrates the behaviour of the VIX-style estimator indices on Fridays and Mondays. The results support the premise that Fridays are associated with a decrease in the VIX (meaning an uptick in mood), and Mondays are associated with an increase in the VIX (meaning a deterioration in mood). "***", "**", and "*" indicate the statistical significance at the 1%, 5%, and 10% levels, respectively.

A similar picture emerges for the rest of the US single stocks. The percentages of negative Fridays in the rest of the domestic US indices were as follows: VXAPL (53.69%), VXGSCLS (63%), VXGOG (63.36%), VXIBM (55.53%). As the sign test indicates, all of these percentages are significantly and statistically different from 50%. In each panel of Table 3, we report the mean and median returns on Fridays and Mondays.

The percentage of negative Fridays in the VIX-style measure of other domestic US indices was 60.68% for the Dow's VXD, 61.92% for the NASDAQ's VXN, and 59.91% for the Russell 2000′s RVX. On the other hand, the percentage of positive Mondays exhibits a similar pattern for the Dow (57.62%), NASDAQ (59.10%) and Russell 2000 (60.05%). These results refute the hypothesis that the percentage equals 50%, indicating a high degree of systematic patterns. Lastly, the percentage of negative Fridays in the VIX of the Treasury notes (TYVIX) was 64.04%. On the other hand, the percentage of positive Mondays in the TYVIX was 70.22%.

The expiration of options might be a factor promoting liquidity and price effects in the underlying assets (e.g., [59]). To eliminate this possibility, we removed the week on which the options on our securities of interest expired from consideration. We repeated the tests that appear in Table 3 (According to the CBOE, the standard expiration date for equity indices, stocks, ETNs, and ETFs occurs on the third Friday each month). The results, reported in Table 4, are qualitatively unchanged. Indeed, we saw a tendency for the phenomenon to intensify.

Table 4. Sign directions of Fridays and Mondays after excluding the week on which options expire.

	VXAZN (2011:08–2020:02)		**VXAPL (2011:08–2020:02)**		**VXIBM (2011:08–2020:02)**	
	Friday	**Monday**	**Friday**	**Monday**	**Friday**	**Monday**
Number of times the Index advanced	118	208	149	207	143	213
Number of times the Index declined	213	102	181	102	181	94
Number of times the Index was unchanged	2	0	3	1	9	3
Total	**333**	**310**	**333**	**310**	**333**	**310**
Percentage of times the Index advanced (1)	35.44% ***	67.10% ***	44.74% *	66.77% ***	42.94% *	68.71% ***
(Sign Test t-stat.)	(5.09)	(6.20)	(1.59)	(5.91)	(1.59)	(6.59)
Percentage of times the Index declined (2)	63.96%	32.90%	54.35%	32.90%	54.35%	30.32%
Difference (2)–(1)	28.53% ***	34.19% ***	9.61% **	33.87% ***	11.41% ***	38.39% ***
(Sign Test t-stat.)	(7.67)	(9.05)	(2.49)	(8.95)	(2.96)	(10.34)
Mean percentage change (t-stat.)	−3.17 ***	2.10	−0.11	1.74 ***	−0.06	2.19 ***
	(−6.11)	(4.11)	(−0.31)	(4.29)	(−0.19)	(6.11)
Median percentage change	−1.62	2.82	−0.59	2.22	−0.45	2.18
	VXGSCLS (2011:10–2020:02)		**VXGOG (2011:08–2020:02)**		**TYVIX (2013:05–2020:02)**	
	Friday	**Monday**	**Friday**	**Monday**	**Friday**	**Monday**
Number of times the Index advanced	149	207	123	216	92	174
Number of times the Index declined	181	102	209	93	169	67
Number of times the Index was unchanged	3	1	1	1	2	5
Total	333	310	333	310	263	246
Percentage of times the Index advanced (1)	44.74% *	66.77% ***	36.94% ***	69.68% ***	34.98% ***	70.73% ***
(Sign Test t-stat.)	(1.59)	(5.91)	(4.66)	(6.93)	(4.63)	(6.50)
Percentage of times the Index declined (2)	54.35%	32.90%	62.76%	30.00%	64.26%	27.24%
Difference (2)–(1)	9.61% **	33.87% ***	25.83% ***	39.68% ***	29.28% ***	43.50% ***
(Sign Test t-stat.)	(2.49)	(9.06)	(6.89)	(10.75)	(7.01)	(10.70)
Mean percentage change (t-stat.)	−0.11	1.74 ***	−1.75 ***	2.39 ***	−1.38 ***	2.15 ***
	(−0.31)	(4.29)	(−3.95)	(5.62)	(−4.16)	(7.35)
Median percentage change	−0.59	2.22	−0.94	2.61	−1.61	1.88
	VXD (2013:10–2020:02)		**VXN (2000:10–2020:02)**		**RVX (2011:08–2020:02)**	
	Friday	**Monday**	**Friday**	**Monday**	**Friday**	**Monday**
Number of times the Index advanced	100	133	287	433	136	186
Number of times the Index declined	148	100	452	264	194	124
Number of times the Index was unchanged	1	0	4	4	3	1
Total	249	233	743	701	333	311
Percentage of times the Index advanced (1)	40.16% ***	57.08% **	38.63% ***	61.77% ***	40.84% ***	59.81% ***
(Sign Test t-stat.)	(2.98)	(2.16)	(5.91)	(6.23)	(3.01)	(3.46)
Percentage of times the Index declined (2)	59.44%	42.92%	60.83%	37.66%	58.26%	39.87%
Difference (2)–(1)	19.28% ***	14.16% ***	22.21% ***	24.11% ***	17.42% ***	19.94% ***
(Sign Test t-stat.)	(2.68)	(2.05)	(8.77)	(9.29)	(4.56)	(5.07)
Mean percentage change (t-stat.)	−0.38	1.78 ***	−0.40 *	2.02 ***	−0.53	1.94 ***
	(−0.79)	(3.46)	(−1.79)	(8.03)	(−1.57)	(4.33)
Median percentage change	−1.50	1.14	−1.09	1.63	−1.15	1.03

"***", "**", and "*" indicate the statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5 (and Table S1 in Supplementary Materials) provides a more detailed picture of the Monday effect, categorized by the week of the month. Given that some months include five Mondays, we followed [60] in defining the first week of the month as that containing the first trading day of the month. If Monday is the first trading day of the month, we consider it the start of the first week of the month. Otherwise, there is no Monday return for the first week of the month. "***", "**", and "*" indicate the statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5. Summary statistics for the Monday return categorized by week.

Panel A: Amazon.									
	First Monday	**Second Monday**	**Third Monday**	**Fourth Monday**	**Fifth Monday**	**First Three Mondays**	**Last Two Mondays**	**Difference in the Two Periods**	**All Mondays**
1.08/2011–02/2020									
Mean	3.520 a	3.208 a	−0.939	2.713 a	3.626 a	1.529 b	3.144 a	1.614 c	2.228 a
T-Statistic	(3.52)	(5.71)	(−0.72)	(3.26)	(4.68)	(2.43)	(5.50)	(1.84)	(5.12)
Welch F-test								(3.61)	
Percentage positive	75.00%	78.35%	53.68%	57.61%	65.85%	67.54%	61.49%		64.93%
#Obs	36	97	95	92	82	228	174		402
2.08/2011−12/2015									
Mean	4.343 a	2.353 a	0.826	2.206 c	4.098 a	2.039 a	3.089 a	1.05	2.493 a
T-Statistic	(5.37)	(4.61)	(0.82)	(1.96)	(4.19)	(4.09)	(4.09)	(1.20)	(5.76)
Welch F-test								(1.34)	
Percentage positive	84.21%	76.00%	55.10%	56.25%	76.19%	68.64%	65.56%		67.31%
#Obs	19	50	49	48	42	118	90		208
3.01/2016–02/2020									
Mean	2.6	4.117 a	−2.819	3.267 b	3.131 b	0.982	3.202 a	2.22	1.943 b
T-Statistic	(1.35)	(4.06)	(−1.15)	(2.62)	(2.57)	(0.83)	(3.69)	(1.43)	(2.51)
Welch F-test								(2.28)	
Percentage positive	64.71%	80.85%	52.17%	59.09%	55.00%	66.36%	57.14%		62.37%
#Obs	17	47	46	44	40	110	84		194

Notes: The table reports the average daily return of the volatility index on each Monday of the month. Monday may appear five times in a certain month. If the first trading day of the month occurs on Monday, we will have five Mondays in that month. If the first trading day of the month is other than Monday, then no Monday is attributed to the first week of the month. The "first three weeks" column reports the average of returns on the first three Mondays combined. The "last two weeks" column reports the average returns of the fourth and fifth Mondays combined. "a", "b", and "c" indicate the statistical significance at the 1%, 5%, and 10% levels, respectively. Tests on the other measures are reported in Table S1 in Supplementary Materials.

The table tracks the 30-day volatility returns obtained on each Monday of the month, and reports the means, t-statistics, Welch F-statistics, ratio of positive returns, and number of observations. The "all weeks" column in the table reports the aggregated Monday returns. This column is positive in all cases regardless of the security and time period selected. Categorizing the Monday returns by the week of the month provides more finely grained distinctions in the returns. The first, second, and fifth Mondays of the month were associated with statistically significant positive returns, and the percentage of positive returns was quite high. For example, the first week Monday was positive in 75% of the cases for Amazon, 72.22% for Apple, 57.14% for Goldman Sachs, 80.56% for Google, and 72.22% for IBM. The fifth Monday was also positive in 65.85% of the cases for Amazon, 74.39% for Apple, 73.75% for Goldman Sachs, 73.17% for Google, and 78.05% for IBM. Very similar significant results were also evident for the equity and bond volatility indices: 69.35% for the VIX of the Dow Jones Index (VXD), 70.05% for the NASDAQ volatility index (VXN), 75.61% for the Russell 2000 (RVX), and 67.69% for the 10-year Treasury notes (TYVIX).

The Mondays of the fourth week were positive and statistically significant in five out of the nine indices considered. In contrast to the results obtained above, the Mondays of the third week had insignificant returns. Indeed, when considering the full sample, they even tended to be negative in five out of the nine volatility indices.

We combined the Monday returns of the first three weeks and compared the outcome (reported in the "first three weeks" column) with that resulting from combining the Monday returns of the last two weeks of the month (the fourth and fifth weeks reported in "last two weeks" column). The difference between these two Monday combinations was positive in eight out of the nine indices examined. However, only in three cases—Amazon, Google, and the RVX—was the difference statistically significant.

Overall, these findings indicate that the expected 30-day volatility of bonds, equity indices, and individual stocks is largely driven by the first, second, and fifth Mondays of the month and moderately by the fourth week. For robustness, we separated the sample into two relatively equal subsamples. The results remained essentially the same. These findings make the roots of this pattern difficult to explain based on rational factors, particularly given that the week on which the options expire is not the catalyst behind this anomaly.

In Table 6 (and Table S2 in Supplementary Materials), we conduct the same procedure and categorize Fridays by the week of the month in order to track the 30-day volatility returns obtained on each Friday of the month. Except for the VXD, the first, second, and third Fridays of the month are associated with negative returns, and the percentage of negative returns is quite high. For example, the first week Friday is negative in 68.3% of the cases for Amazon, 63.4% for Apple, 72.5% for Goldman Sachs, 68.3% for Google, and 63.4% for IBM. Similar significant results were also obtained in the equity and bond volatility indices: 67.7% for the NASDAQ volatility index (VXN), 68.3% for the Russell 2000 (RVX), and 76.7% for the 10-year Treasury notes (TYVIX).

We combined the Friday returns of the first three weeks and compared the outcome (reported in the "first three weeks" column) with that resulting from combining the Friday returns of the last two weeks of the month (the fourth and fifth weeks reported in "last two weeks" column). The difference between these two Friday combinations was negative in eight out of the nine indices examined, meaning that the expected 30-day volatility of bonds, equity indices, and individual stocks is largely driven by the first, second, and third Fridays of the month.

Table 6. Summary statistics for the Friday return categorized by week.

Panel A: Amazon.									
	First Friday	**Second Friday**	**Third Friday**	**Fourth Friday**	**Fifth Friday**	**First Three Fridays**	**Last Two Fridays**	**Difference in the Two Periods**	**All Fridays**
1.08/2011–02/2020									
Mean	−3.066 a	−0.913	−1.314 a	−1.471	−6.684 a	−1.445 a	−3.942 a		−2.549
T-Statistic	(−3.13)	(−1.64)	(−2.88)	(−1.64)	(−5.06)	(−4.21)	(−4.90)	−2.497 a	(−6.25)
Welch F-test								(−2.84)	
Percentage negative	68.29%	72.00%	64.36%	55.45%	60.44%	68.18%	57.81%	(−2.70)	63.59%
#Obs	41	100	101	101	91	242	192		434
2.08/2011–12/2015									
Mean	−1.704 c	−1.458 a	−0.827	−3.096 b	−6.127 a	−1.225 a	−4.551 a		−2.730 a
T-Statistic	(−1.89)	(−2.92)	(−1.34)	(−2.05)	(−3.52)	(−3.38)	(−3.95)	−3.326 a	(−4.81)
Welch F-test								(−2.89)	
Percentage negative	68.42%	74.00%	61.54%	61.54%	60.42%	67.77%	61.00%	(−2.75)	64.71%
#Obs	19	50	52	52	48	121	100		221
3.01/2016–02/2020									
Mean	−4.243 b	−0.367	−1.830 a	0.254	−7.306 a	−1.664 a	−3.279 a		1.943 b
T-Statistic	(−2.59)	(−0.37)	(−2.73)	-0.29	(−3.60)	(−2.85)	(−2.93)	−1.615	−2.51
Welch F-test								(−1.18)	
Percentage negative	68.18%	70.00%	67.35%	48.98%	60.47%	68.60%	54.35%	(−1.07)	62.44%
#Obs	22	50	49	49	43	121	92		213

Notes: The table reports the average daily return of the volatility index on each Friday of the month. Friday may appear five times in a certain month. If the first trading day of the month occurs on Friday, we will have five Fridays in that month. If the first trading day of the month is other than Friday, then no Friday is attributed to the first week of the month. The "first three weeks" column reports the average of returns on the first three Fridays combined. The "last two weeks" column reports the average returns of the fourth and fifth Fridays combined. "a," "b", and "c" indicate the regular levels of statistical significance. Table S2 reports the test results for the rest of the volatility measures.

We also examined the performance of the 30-day expected volatility using year-by-year snapshots and computed the ratios of the positive Fridays and Mondays for each of the sampled securities. Table S3 in Supplementary Materials summarizes the results for the sampled indices. In addition, further robustness checks regarding the sign direction of Fridays and Mondays (with two equal subsamples) appear in Table S4 in Supplementary Materials.

Overall, the results are consistent over time and across the different sampled securities. They indicate that the VIX-style volatility indices performed better on Mondays (column "+Monday") than on Fridays (column "+Friday") in terms of the percentage of times the index advanced, the mean percentage change (fifth column vs. fourth column), and the median percentage change in each year of this period (the last two columns). Generally, the results contradict the conclusions drawn by prior works maintaining that, according to the efficient market hypothesis, once a pricing inefficiency becomes known to the public, it will vanish [61]. Specifically, [62] claimed that the seasonal effects documented in the finance literature often seem to reverse, diminish, or simply disappear post-academic publication.

4.1. Do Monday's Price Changes Depend on Friday's Price Changes?

Table 7 depicts the performance of the expected 30-day volatility measure (the VIX) on Monday, contingent on the change in the VIX on the preceding Friday. For example, the picture obtained for the VIX-style estimate for Apple (VXAPL) indicates that of the 183 times in which there was a positive change in the VIX on Friday, there was a subsequent positive change on Monday in 56.28% of the times (103 Mondays). However, of the 205 in which Fridays witnessed a negative change in the VIX, there were 126 subsequent Mondays with a positive change in the VIX, meaning 61.46% of the time. The largest ratio occurs for the VIX-style measure of the 10-year Treasury notes. As Table 7 indicates, of the 197 in which Fridays witnessed a negative change in the price of the volatility index, there were 146 subsequent Mondays with a positive change in the price, meaning 74.11% of the time. The collective picture indicates that the probability of the volatility index returns being positive on Mondays (R^{VP}_{Monday}) is greater when the preceding Fridays are associated with a negative change in the price. In other words, $Prob\left(R^{VP}_{\text{Monday}} > 0 \,|\, R^{VP}_{\text{Friday}} < 0\right) > Prob\left(R^{VP}_{\text{Monday}} > 0 \,|\, R^{VP}_{\text{Friday}} > 0\right)$.

Table 7. Changes in the VIX on Monday contingent on its direction of change on Friday.

Performance of the Index on Monday	VXAZN		VXAPL	
	After an Advance on Friday	After a Decline on Friday	After an Advance on Friday	After a Decline on Friday
Number of times the Index advanced	97	152	103	126
Number of times the Index declined	47	94	79	79
Number of times the Index was unchanged	0	0	1	0
Total	144	246	183	205
Percentage of times the Index advanced	67.36% ***	61.79% ***	56.28% **	61.46% ***
(t-stat.)	(4.17)	(3.69)	(1.70)	(3.28)
Percentage of times the Index declined	32.64% ***	38.21% ***	43.17% **	38.54% ***
(t-stat.)	(4.17)	(3.69)	(1.70)	(3.28)
Difference (2)–(1)	34.72% ***	23.58% ***	13.11% **	22.93% ***
(t-stat.)	(5.98)	(5.07)	(2.43)	(4.49)
Mean percentage change	3.00 ***	1.39 ***	1.02 *	1.06 **
(t-stat.)	(3.85)	(2.59)	(1.74)	(2.23)
Median percentage change	2.66	1.91	1.33	1.31

Table 7. *Cont.*

Performance of the Index on Monday	**VXGSCLS**		**VXGOG**		**VXIBM**	
	After an Advance on Friday	**After a Decline on Friday**	**After an Advance on Friday**	**After a Decline on Friday**	**After an Advance on Friday**	**After a Decline on Friday**
Number of times the Index advanced	72	149	90	170	99	143
Number of times the Index declined	69	90	51	78	64	75
Number of times the Index was unchanged	1	0	0	1	1	0
Total	142	239	141	249	164	218
Percentage of times the Index advanced (t-stat.)	50.70% (0.17)	62.34% *** (3.82)	63.83% *** (3.28)	68.27% *** (5.77)	60.37% *** (2.66)	65.60% *** (4.61)
Percentage of times the Index declined (t-stat.)	48.59%	37.66%	36.17% *** (3.28)	31.33% *** (5.77)	39.02% *** (2.66)	34.40% *** (4.61)
Difference (2)–(1) (t-stat.)	2.11% (0.34)	24.69% *** (5.24)	27.66% *** (4.54)	36.95% *** (8.37)	21.34% *** (3.74)	31.19% *** (6.48)
Mean percentage change (t-stat.)	0.47 (0.67)	1.40 *** (3.87)	2.39 *** (3.58)	2.64 *** (4.81)	1.52 *** (2.77)	1.49 *** (3.67)
Median percentage change	0.33	1.27	2.66	2.29	1.22	1.56
Performance of the Index on Monday	**VXD**		**VXN**		**RVX**	
	After an Advance on Friday	**After a Decline on Friday**	**After an Advance on Friday**	**After a Decline on Friday**	**After an Advance on Friday**	**After a Decline on Friday**
Number of times the Index advanced	56	108	186	323	85	147
Number of times the Index declined	58	67	144	212	70	84
Number of times the Index was unchanged	0	0	1	4	1	0
Total	114	175	331	539	156	231
Percentage of times the Index advanced (t-stat.)	49.12% (0.43)	61.71% *** (3.10)	56.19% ** (2.25)	59.93% *** (4.61)	54.49% (1.12)	63.64% *** (4.15)
Percentage of times the Index declined	50.88% (0.38)	38.29% *** (3.00)	43.50%	39.33%	44.87%	36.36%
Difference (2)–(1) (t-stat.)	1.75% (0.47)	23.43% *** (2.66)	12.69% *** (3.15)	20.59% *** (6.56)	9.62% (1.63)	27.27% *** (5.74)
Mean percentage change (t-stat.)	1.39 (1.56)	1.47 *** (2.94)	1.94 *** (4.32)	1.30 *** (5.24)	2.17 *** (2.74)	1.52 *** (3.80)
Median percentage change	−0.09	1.26	0.96	1.17	0.46	1.60

Performance of the Index on Monday	**TYVIX**	
	After an Advance on Friday	**After a Decline on Friday**
Number of times the Index advanced	68	146
Number of times the Index declined	38	47
Number of times the Index was unchanged	2	4
Total	108	197
Percentage of times the Index advanced (t-stat.)	62.96% *** (2.69)	74.11% *** (6.77)
Percentage of times the Index declined	35.19%	23.86%
Difference (2)–(1) (t-stat.)	27.78% *** (4.04)	50.25% *** (10.92)
Mean percentage change (t-stat.)	1.67 *** (3.27)	2.27 *** (7.48)
Median percentage change	1.48	1.97

Notes: A description of the changes in the VIX indices on Monday contingent on its direction of change on Friday. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. The values in parentheses are the T-Statistics.

Regarding the VIX-style measure for Apple (VXAPL), the difference between the percentage of times there was an advance in the VIX on Monday after a decline on Friday and the percentage of times there was a decline in the VIX on Monday after a decline on Friday (61.46–38.54% = 22.93%) was strongly significant (t-stat. = 4.49). In parallel, the difference between the percentage of times there was an advance in the VIX on Monday

after an advance on Friday and the percentage of times there was a decline in the VIX on Monday after an advance on Friday (56.28–43.17% = 13.11%) was significant as well (t-stat. = 2.43). Similar results were obtained with respect to other individual stocks. For example, for the VXGOG, if Fridays are associated with a decline in the VIX, they are followed by a positive leap in the VIX in 68.27% of the cases.

In order to ensure that our findings above are free of outliers, we re-ran the test on a yearly basis. In Table S5 in Supplementary Materials, we summarize the results of this strict examination. Once again, we find that the percentage of Mondays on which there was an advance in the VIX was greater after a decline on Friday than after an advance on Friday. For example, this pattern was evident in the VXAPL in six out of the nine years. The mean change in the VIX on those Mondays preceded by a rise on Friday was 0.67%, whereas the mean change on those Mondays preceded by a decline on Friday was 0.90%. The corresponding median values were 1.12% and 1.03%, respectively. Overall, the probability of having an increase in the VIX on Monday is contingent on what happened on Friday.

4.2. A Comparison of Monday and Other Days of the Week

The relationship between changes in the VIX-style indices on Monday and on Friday is significantly different from the relationship between price changes on other successive business days. Table 8 shows how the VIX of the sampled securities performed on Monday and on days other than Monday, contingent on the direction of change the previous day.

Table 8. A Comparison of changes in the VIX on Monday and on other days of the week contingent on the direction of change the previous day.

Percentage of Times the Index Advanced	**VXAZN**		**VXAPL**	
	On Monday	**On Other Days**	**On Monday**	**On Other Days**
After an Advance the previous day	67.36% ***	47.52%	56.28% **	47.61%
(t-stat.)	(4.17)	(1.14)	(1.70)	(1.19)
After a decline the previous day	61.79% ***	48.66%	61.46% ***	54.33% ***
(t-stat.)	(3.69)	(0.39)	(3.28)	(2.57)
Mean Percentage Change				
After an Advance the previous day	3.00 ***	−0.38 *	1.02 *	−0.35
(t-stat.)	(3.85)	(−1.82)	(1.74)	(−1.43)
After a decline the previous day	1.39 ***	0.10	1.06 **	−0.16
(t-stat.)	(2.59)	(0.41)	(2.23)	(−0.72)

Percentage of Times the Index Advanced	**VXGSCLS**		**VXGOG**		**VXIBM**	
	On Monday	**On Other Days**	**On Monday**	**On Other Days**	**On Monday**	**On Other Days**
After an Advance the previous day	50.70%	43.82% ***	63.83% ***	48.75%	60.37% ***	48.42%
(t-stat.)	(0.17)	(3.36)	(3.28)	(0.45)	(2.66)	(0.56)
After a decline the previous day	62.34% ***	56.46% ***	68.27% ***	52.52%	65.60% ***	51.07%
(t-stat.)	(3.82)	(3.82)	(3.58)	(1.40)	(4.61)	(0.60)
Mean Percentage Change						
After an Advance the previous day	0.47	−0.44 **	2.39 ***	−0.31	1.52 ***	−0.57 **
(t-stat.)	(0.67)	(−2.09)	(3.58)	(−1.54)	(2.77)	(−2.14)
After a decline the previous day	1.40 ***	−0.16	2.64 ***	−0.18	1.49 ***	−0.09
(t-stat.)	(3.87)	(−0.79)	(4.81)	(−0.67)	(3.67)	(−0.38)

Table 8. *Cont.*

Percentage of Times the Index Advanced	**VXD**		**VXN**		**RVX**	
	On Monday	**On Other Days**	**On Monday**	**On Other Days**	**On Monday**	**On Other Days**
After an Advance the previous day	49.12%	45.09% ***	56.19% ***	43.19% ***	54.49%	42.51% ***
(t-stat.)	(0.43)	(2.47)	(2.25)	(5.56)	(1.12)	(3.99)
After a decline the previous day	61.71% ***	43.63% ***	59.93% ***	42.45% ***	63.64% ***	46.28% **
(t-stat.)	(3.10)	(3.29)	(4.61)	(6.27)	(4.15)	(1.73)
Mean Percentage Change						
After an Advance the previous day	1.39	−0.16	1.94 ***	−0.25 *	2.17 ***	−0.48 **
(t-stat.)	(1.56)	(−0.57)	(4.32)	(−1.90)	(2.74)	(−2.45)
After a decline the previous day	1.47 ***	00.19	1.30 ***	−0.11	1.52 ***	0.01
(t-stat.)	(2.94)	(0.61)	(5.24)	(0.83)	(3.80)	(0.07)

Percentage of Times the Index Advanced	**TYVIX**	
	On Monday	**On Other Days**
After an Advance the previous day	62.96% ***	43.40% **
(t-stat.)	(2.69)	(2.25)
After a decline the previous day	74.11% ***	40.18% ***
(t-stat.)	(6.77)	(3.92)
Mean Percentage Change		
After an Advance the previous day	1.67 ***	−0.38 **
(t-stat.)	(3.27)	(−2.03)
After a decline the previous day	2.27 ***	−0.57 ***
(t-stat.)	(7.48)	(−3.21)

Notes: A comparison of changes in VIX on Monday and on other days of the week contingent on the direction of change the previous day. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. The values in parentheses are the T-statistics.

As the table indicates, the percentage of time the VIX advanced after an increase on the previous day is greater on Monday than on days other than Monday. For example, after a positive change in the VXAZN on the previous day, there was a further positive change in the VIX on days other than Monday 47.52% of the time, in contrast to 67.36% on Mondays. The mean change in the VIX on days other than Mondays preceded by a rise on the previous day was −0.38%, whereas the mean change on those days preceded by a decline on the previous day was 0.10%.

Table 8 also summarizes the percentage of time the index advanced after a decline on the previous day, on Monday and on days other than Monday. The picture that emerges indicates that for days other than Monday, a decline in the VIX on day "t" is followed by an advance in the VIX in 48.66% of the cases. However, a decline in the VIX on Friday was followed by an advance in the index in 61.79% of the cases. Overall, the percentage of time the index advanced on Monday was higher than on days other than Monday for all indices in the sample.

The seasonality explored here accords with prior works assuming, implicitly, that seasonality effects are relatively stable across time. Not surprisingly, calendar effects are generally labelled using the relevant season: "Sell in May and go away", the "holiday" effect, or the "Monday" effect. However, our findings contradict those of [63]. The authors used data for 11 equity markets and rejected the classic argument regarding the stability of the day-of-the-week effect.

4.3. Potential Drivers

4.3.1. Investors' Irrationality

Level of mood or emotion is difficult to assess. Social science studies often use questionnaires or surveys for this purpose. However, given that we are interested in exploring the variation in investor mood across weekdays, we followed the literature and utilized the Twitter Happiness Index. The Twitter index is widely used in recent behavioural studies to reflect mood (e.g., [64]). Data about the Twitter Happiness Index are available from September 9, 2008. Table 9 reports the average daily values of the Twitter Happiness Index for the entire sample as follows: 6.011 (Monday), 6.009 (Tuesday), 6.010 (Wednesday), 6.015 (Thursday), 6.031 (Friday), 6.034 (Saturday–the highest) and 6.024 (Sunday). Statistical tests examining equality between the happiness values on Friday and Monday led us to reject this hypothesis (t-statistic = 7.51). In parallel, we do not reject the hypothesis that the happiness values on Monday equal those on Tuesday. These observations are in line with [52,65]. Both studies maintain that participants' mood on Monday is not significantly different from that observed on Tuesday. Overall, our results accord with previous studies that evaluated individuals' moods using questionnaires and surveys; the weekend is often associated with high values of happiness relative to Mondays, confirming that mood varies across weekdays.

Table 9. Twitter Happiness Index across weekdays (2008–2020).

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
Mean	6.011 ***	6.009 ***	6.010 ***	6.015 ***	6.031 ***	6.034 ***	6.024 ***
Med.	6.010	6.010	6.010	6.010	6.030	6.030	6.020
Max.	6.250	6.210	6.250	6.360	6.340	6.290	6.260
Min.	5.770	5.880	5.870	5.890	5.780	5.870	5.840
Stdev.	0.043	0.042	0.044	0.050	0.049	0.046	0.049
Skew.	−0.039	0.309	0.841	1.556	0.545	0.247	0.352
Kurt.	5.289	3.783	6.434	9.794	7.947	4.292	4.628
#Obs	598	599	599	599	599	596	598

Notes: The table presents the descriptive statistics of the Twitter Happiness Index across the weekdays. Data come from http://hedonometer.org/index.html and are available from 9 September 2008 to the present. "***" indicates statistical significance at the 1% levels. The values in parentheses are the T-statistics.

Another way to explore non-rationality in pricing volatility is to examine whether they are rationally priced across weekdays. The level of a volatility index, which is an observed variable, is assumed to track the expected volatility of the underlying security, which can be an individual stock, a bond, or a market index. Recall that the level of any volatility index is calculated by the same procedure used in evaluating the VIX of the S&P 500 index.

We suggest decomposing the price of the volatility index (V_t) into two components. The first component reflects all of the fundamental or rational economic variables (V_R), while the second reflects irrational factors (V_{IR}). In other words,

$$V_t = V_{R,t} + V_{IR,t} \quad (1)$$

This separation allows us to better understand the dynamic factors affecting the level of the volatility index. Thus, if irrational disturbances are absent, the observed price is said to completely reflect the economic value of the index. In other words,

$$V_{R,t} = f(X) \quad (2)$$

where X is a matrix of potential rational fundamentals that are revealed in the underlying index. For the sake of robustness, we use the following stationary model that utilizes the first difference (i.e., rate of change).

$$\Delta V_{i,t} = \underbrace{\mu_{i,0} + \sum_{h=1}^{H} b_{ih} R_{i,t-h+1} + \sum_{k=1}^{K} c_{ik} \Delta V_{i,t-k} + d_i \Delta RV_{i,t}}_{Rational\ Part} + U_{i,t} \quad (3)$$

$\Delta V_{i,t}$ denotes the rate of change in the volatility index. $R_{i,t}$ denotes the rate of change in the price of the underlying index for security "i." Similar to [66], we use contemporaneous as well as lagged returns of the underlying asset price and additional lagged changes in volatility to explain the current changes in the index price. H and K are set according to the Akaike and Hannan–Quinn information criteria and range between 1 and 3. *RV* is the actual (ex-post) realization of return variation for each security computed using 5 min data over the next 22 days, as suggested in [67]. We validated the stationarity of the variables using the augmented Dickey–Fuller test [68].

Once Equation (3) is estimated, we can compute the residuals of the model using $\hat{U}_t = \Delta V_{t,i} - \Delta \hat{V}_{t,i}$. The residuals are designed to capture what rational factors cannot explain. Thus, they reflect the irrational component in the volatility price. The underlying assumption is that if the volatility index is rationally priced, the residuals should be the same for each trading day across the week. However, if the residuals originated in the spread between the VIX estimate and the ex-post realized volatility, and other related variables follow day-of-the-week patterns, then this would suggest that investors are making systematic pricing errors when predicting future volatility. Formally, the following regression model tests this proposition.

$$\hat{U}_{it} = \sum_{d=2}^{6} \gamma_{id} Day_{d,t} + \eta_{it}, \quad (4)$$

where Day_d is a dummy variable that captures the day of the week on which the return on the volatility index is observed. γ_d captures the expected residual on Day_d where d = 2, . . . , 6.

The estimation results of this model are presented in Table 10. A quick glance at the table shows that γ_2 (average of residuals on Monday) was positive and statistically significant in all cases. In parallel, γ_6 (average of residuals on Friday) was negative and statistically significant in the vast majority of cases. While the reported estimates for γ_2 and γ_6 were significantly different from zero, the rest of the coefficient estimates for γ_3 through γ_5 were very close to zero in most cases. The F-tests hypothesizing equality in these coefficients are jointly strongly rejected, indicating that the residuals behave in a non-random way across weekdays. Finally, the inclusion of other explanatory variables in Equation (3), such as the Treasury yield spread, corporate default spread, changes in gold prices, and inflation, did not change the results qualitatively. To save space, we do not present the estimation results, but they are available upon request. Overall, these findings support the premise that one of the driving forces in pricing volatility is the irrationality of investors, as evident in the positive and negative residuals on Monday and Friday, respectively.

Table 10. Testing the residuals of Equation (3).

	MON γ_2	**TUE** γ_3	**WED** γ_4	**THU** γ_5	**FRI** γ_6	γ_2=γ_3=γ_4=γ_5=γ_6	γ_2=γ_6	γ_3=γ_4=γ_5=γ_6
VXAZN	1.93 a	0.34	0.21	0.45	−2.81 a	26.26 a	9.85 a	22.23 a
	(5.58)	(1.03)	(0.63)	(1.36)	(−8.40)			
VXAPL	−1.39 a	−0.24	−1.27 a	0.17	0.07	8.27 a	2.81 a	4.11 a
	(4.10)	(−0.75)	(−3.92)	(0.52)	(0.21)			
VXGSCLS	1.29 a	−0.12	−0.04	−0.06	−0.988 a	7.36 a	5.38 a	2.44 c
	(4.24)	(−0.41)	(−0.13)	(−0.20)	(−3.35)			
VXGOG	2.36 a	0.12	−0.02	0.26	−2.57 a	26.48 a	10.22 a	16.29 a
	(6.81)	(0.36)	(−0.05)	(0.79)	(−7.67)			
VXIBM	1.55 a	0.27	−0.81 b	0.01	−0.90 a	7.97 a	4.94 a	2.90 b
	(4.34)	(0.78)	(−2.37)	(0.03)	(−2.61)			
VXD	−0.14	0.73 c	0.77 b	−1.05 a	−0.34	3.86 a	0.37	5.09 a
	(−0,34)	(1.87)	(1.98)	(−2.67)	(−0.88)			
VXN	1.50 a	−0.13	−0.36 c	−0.14	−0.77 a	19.39 a	8.21 a	2.47 c
	(7.55)	(−0.67)	(−1.89)	(−0.71)	(−4.01)			
RVX	1.75 a	0.08	−0.23	−0.38	−1.11 a	12.55 a	6.79 a	3.00 b
	(5.78)	(0.29)	(−0.77)	(−1.30)	(−3.79)			
TYVIX	2.03 a	0.47 c	−0.69 a	−0.20	−1.49 a	27.03 a	9.73 a	10.86 a
	(7.83)	(1.89)	(−2.77)	(−0.80)	(−5.91)			

Notes: The residuals resulting from Equation (3) were regressed against dummies for the weekdays. $\hat{U}_{it} = \sum_{d=2}^{6} \gamma_d Day_{d,t} + \eta_{it}$. The overall picture that emerges indicates that residuals are higher on Mondays and lower on Fridays. Residuals are assumed to reflect the irrational part in the pricing of the volatility index. "a," "b", and "c" denote statistical significance at the 1%, 5%, and 10% levels, respectively. The hypothesis about joint equality for the coefficients is rejected. The hypothesis about equality in the coefficients of Monday and Friday is also rejected. Finally, the hypothesis about equality in the coefficients of Tuesday, Wednesday, Thursday, and Friday is also rejected. By Equation (3), $\Delta V_{i,t} = \mu_{i,0} + b_1 R_{i,t} + b_2 R_{i,t-1} + c_i \Delta V_{i,t-1} + d_i \Delta RV_{i,t} + u_{i,t}$. The T-Statistics were Newey–West (HAC, 1987) corrected in all estimations.

4.3.2. Investors' Rational Considerations

To assess investors' rational concerns, we utilized the Economic Policy Uncertainty (EPU) Index. As Table 11 illustrates, across weekdays for 1985–2020, the average levels of uncertainty are: (the information has been available on a daily basis since January 1985) 109.36 (Monday), 100.65 (Tuesday), 94.37 (Wednesday), 88.53 (Thursday), 92.34 (Friday), 90.74 (Saturday), and 132.49 (Sunday). The picture that emerges indicates that the EPU on Sundays and Mondays is higher than on the rest of the weekdays. The difference between the EPU average on Mondays and Fridays is 17.02 (t-stat. = 7.92). The difference between Sundays and Fridays is 40.15 (t-stat. = 18.16).

Table 11. Economic Uncertainty Policy across weekdays (Level).

Panel A. Full Sample.							
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**
Mean	109.36 ***	100.65 ***	94.37 ***	88.53 ***	92.34 ***	90.74 ***	132.49 ***
Med.	92.74	83.69	76.74	71.27	75.88	74.25	118.11
Max.	623.45	719.07	690.81	515.61	560.12	586.55	496.43
Min.	5.80	5.93	3.38	4.75	3.32	4.15	4.05
Stdev.	67.65	69.96	67.18	62.39	62.16	64.78	69.97
Skew.	1.81	2.32	2.22	1.96	1.78	2.01	1.29
Kurt.	8.85	13.44	11.79	8.65	7.95	9.94	5.23
#Obs	1834	1835	1835	1835	1835	1834	1834

Notes: The table reports the descriptive statistics of the Economic Policy Uncertainty Index developed by [15]. The overall picture indicates that uncertainty, as reflected in US newspapers, is greater on Sunday and Monday. "***" indicates statistical significance at the 1% levels.

Overall, uncertainty, as reflected in the media and press, is greater on Sundays and Mondays. Our findings are in line with many works arguing that the information content of the news has a sizable effect on the price movements of equity markets (e.g., [38]). Generally, pessimistic or negative news drives investors to react, and security prices slide. In addition, studies examining the empirical properties of the VIX observe a strong negative and asymmetric relationship between news sentiment (for the constituents of the S&P 500 Index) and changes in the VIX [69].

5. Conclusions

We studied the daily behaviour of numerous volatility indices designed to track the expected 30-day volatility for five very active individual US stocks, three US domestic indices, and 10-year Treasury notes and found evidence that returns on these volatility indices are far from being a coin toss. Our findings, which were not affected by extreme events or outliers that can skew the results, held true using different subsamples and statistical methods. They indicated that the expected 30-day volatility of these securities and market indices is systematically higher on Mondays, but lower on Fridays. More specifically, the hike in the looking-forward volatility of 10-year bonds, equity indices, and individual stocks is strongly evident in the first, second, and fifth Mondays of the month. On the other hand, the Friday effect primarily occurs on the first three Fridays of the month. Lastly, the direction of the expected 30-day volatility on Mondays is contingent on Fridays.

Using evidence from psychology, social media, decision-making, transportation studies, and investigations into sleep patterns, we documented that the public tends to dislike Mondays, supporting the premise that individuals' moods vary across weekdays. In parallel, we found that the mass media tend to express a more pessimistic tone on Sundays and Mondays, as reflected in the Economic Uncertainty Index (EPU). In addition, the tendency to announce negative corporate news on Friday after the markets have closed may also contribute to the patterns we detected. For investors interested in buying or selling volatility products, our findings might help in timing the transaction. Future research may be able to provide further evidence of the deterioration in mood on Monday and its consequences for investors' risk aversion and asset pricing.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/math10111850/s1, Table S1. Summary statistics for the Monday returns categorized by week (continuation of Table 5). Table S2. Summary statistics for the Friday returns categorized by week (continuation of Table 6). Table S3. Changes in the VXAZN on Mondays and Fridays by Year (2011–2020). Table S4. Sign direction of Fridays and Mondays in the Sampled Volatility Indices (two equal subsamples). Table S5. Changes in the VIX on Monday contingent on its direction of change on Friday.

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