Are Investors Moonstruck?
Lunar Phases and Stock Returns

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Abstract

Biological and psychological evidence suggests that lunar phases affect human behavior and mood. Do lunar phases affect investors' trading behavior and thus stock market returns? This paper investigates the relation between lunar phases and stock market returns in 48 countries. We find strong global evidence that stock returns are lower on days around a full moon than on days around a new moon. The magnitude of the return difference is 5.4 percent per annum based on our 15-day window analysis of the global portfolio. The return difference is not due to changes in stock market volatility. Moreover, the lunar effect is independent of other calendar-related anomalies such as the January effect, the day-of-week effect, the calendar month effect, the holiday effect. We also find that the lunar effect is not due to the returns around lunar holidays.

It is the very error of the moon,
She comes more near the earth than she was wont.
And makes men mad.
(Othello, Act V, Scene ii)

Introduction

Moon phases regulate mood and behavior; this belief dates back to ancient times. The lunar effect on human body and mind is supported anecdotally, as well as empirically through psychological and biological research. Do moon phases affect the asset market?

If investors make decisions strictly through rational maximization, then the answer is no. However, extensive evidence suggests that investors are subject to various psychological and behavioral biases when making investment decisions, such as loss-aversion, overconfidence, and mood fluctuation.[1] On a general level, numerous psychological studies suggest that mood can affect human judgment and behavior.[2] Behavioral finance literature also finds some evidence of the effect of mood on asset prices.[3] Since lunar phases affect mood, by extension, these phases may affect investor behavior and thus asset prices. If so, then asset returns during full moon phases may be different from those during new moon phases. More specifically, since psychological studies associate full moon phases with depressed mood, we hypothesize that stock returns are lower during the full moon periods.

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[1] Odean (1998) tests for the disposition effect and finds that investors demonstrate a strong preference for realizing winners rather than losers. Odean (1999) shows that investors trade excessively. Harlow and Brown (1990) offer a theoretical link between risk tolerance and behavioral traits.

[2] For example, Frijda (1988) argues that mood may affect human judgment through misattribution. Schwarz and Bless (1991) show that mood may influence people's ability to process information.

[3] Kamstra, Kramer, and Levi (2000) show that the Friday-Monday return is significantly lower on daylight-saving weekends than other weekends. Hirshleifer and Shumway (2001) also find that sunshine is positively correlated with stock returns. Coval and Shumway (2001) document that traders who experience morning losses are more likely to assume more risks in the afternoon than traders with morning gains. This behavior bias has short-term consequences for afternoon prices.

Similar to Hirshleifer and Shumway (2001), this study of the effect of lunar phases on stock market returns is motivated by a psychological hypothesis and therefore is not likely subject to the criticism of datasnooping. Moreover, in modern society, the lunar cycle has little tangible impact on people's economic and social activities, even less so than sunshine and seasonal changes. Consequently, it would be difficult to find rational explanations for any correlations between lunar phases and stock returns. Besides, the causality would be obvious if there were such a lunar effect on stock returns. Thus, investigating the lunar effect on stock returns is a strong test of whether investor mood affects asset prices.

To investigate the relation between lunar phases and stock returns, we first test the association of lunar phases with the returns of an equal-weighted global portfolio of 48 country stock indices. We find that global stock returns are significantly lower during the full moon periods than the new moon periods. The mean daily return difference between the new moon period and the full moon period is 4.34 basis points for the 15-day window specification and 5.51 basis points for the 7-day window specification. The above numbers translate into annualized return difference of 5.4 percent and 6.9 percent respectively, both significant at the 5 percent level.[4]

To test explicitly for the cyclical pattern of the lunar effect, we estimate a sinusoidal model. According to this model, the lunar effect reaches its peak at the time of full moon and declines to a trough at the time of new moon, following a cosine curve with a period of 29.53 days (the mean length of a lunar cycle). Our test results indicate a significant cyclical lunar pattern in stock returns.

We then test the association of lunar phases and daily stock returns for each of the 48 countries. The results of this investigation indicate that, for all 23 developed stock markets, stock returns are negatively correlated with 15-day full moon phases. For the remaining 25 emerging markets, stock market returns are negatively correlated with 15-day full moon phases in 20 of the markets. The statistical power of these country-by-country tests is low since there are more shocks in the stock return data at the country level.

In addition to a 15-day window, we also examine the relation between lunar phases and stock returns by looking at a 7-day window around the full moon and a 7-day window around the new moon. This test of the relation between lunar phases and daily stock returns yields similar results to the findings for the 15-day window for the emerging markets. For the developed markets, the 7-day window lunar effect is weaker, but still significant.

To fully utilize our panel data, we estimate a pooled regression with panel corrected standard errors (PCSE) for the following categories: G-7 countries, other developed countries, emerging-market countries, and all 48 countries. In all cases, we find a statistically significant relation between moon phases and stock returns for both the 7-day and the 15-day windows. For all countries, stock returns are, on average, 6.6 percent lower for the 15 days around the full moon than for the 15 days around the new moon on an annual basis. Using a 7-day window, stock returns are, on average, 8.3 percent lower on the full moon days than on the new moon days on an annual basis. Furthermore, the magnitude of this lunar effect is larger in the emerging market countries

[4] 5.4 percent per annum for the 15-day window is computed by multiplying 4.34 basis point difference in Table 2 by 125 days (which is number of full moon and new moon daily return differences in a year). 6.3

(a 7.09 basis points daily difference for the 15-day window and a 13.35 basis points daily difference for the 7-day window) than in the G-7 countries (a 3.47 basis points daily difference for the 15-day window and a 2.6 basis points daily difference for the 7-day window).

To relate the lunar effect to investor sentiment, we examine whether the lunar effect on stock returns is related to stock size, and thus individual vs. institutional decision-making, since institutional ownership is higher for large cap stocks. Indeed, we find evidence that the lunar effect is more pronounced for small (although not the smallest) cap stocks than for large cap stocks. Thus, the evidence suggests that the lunar effect is stronger for stocks that are held mostly by individuals. This finding is consistent with the idea that lunar phases affect individual moods, which in turn affect investment behavior.

To better understand the relation between lunar phases and stock markets, we investigate how lunar phases relate to stock trading volumes and return volatility. We find no significant evidence that the lunar effect observed in stock returns is associated with trading volumes or risk differentials between the full moon and the new moon periods.

Finally, we explore whether the lunar effect is related to other calendar-related anomalies, such as the January effect, the day-of-week effect, the calendar month effect, and the holiday effect. The findings indicate that the lunar effect remains the same after controlling for other calendar effects. Thus, we conclude that the lunar effect is unlikely a manifestation of these calendar anomalies.

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per cent per annum for the 7-day window is computed similarly.

The remainder of the paper is organized as follows. Section I discusses the literature on how lunar phases affect human mood and behavior. Section II describes the data. Section III reports the test results. Section IV concludes.

I. Literature

One difficulty in testing whether psychological biases and sentiments affect investor trading behavior and asset prices is to find a proxy variable for sentiment or mood that is observable and exogenous to economic variables. Nonetheless, there are several ingenious attempts. For example, in their respective studies of the relation between mood and stock returns, Saunders (1993) and Hirshleifer and Shumway (2001), drawing on psychological evidence that sunny weather is associated with an upbeat mood, find that sunshine is strongly positively correlated with stock returns. Likewise, in their study of the seasonal time-variation of risk premia in stock market returns, Kamsta, Kramer and Levi (2001) draw on a documented medical phenomenon, Seasonal Affective Disorder (SAD) to proxy investor mood and find a statistical significant relationship between SAD and stock market returns. Kamsta, Kramer and Levi (2001) relate yearly daylight fluctuations to stock market returns.

In this paper, we appeal to a popular wisdom that lunar phases affect mood and behavior, and study the relation between lunar phases and stock returns. We argue that lunar effect is an exogenous proxy for mood since lunar phases do not have tangible effects on economic and social activities. Furthermore, unlike sunshine, lunar cycles are predictable. A relationship between lunar cycles and stock returns will indicate that stock prices are predictable and not correlated with economic fundamentals, which is a stronger violation of market efficiency hypothesis.

The idea that the moon affects individual moods has ancient roots. The moon has been associated with mental disorder since olden time, as reflected by the word "lunacy," which derives from Luna, the Roman goddess of the moon. Popular belief has linked the full moon to such disparate events as epilepsy, somnambulism, crime, suicide, mental illness, disasters, accidents, birthrates, and fertility.

Biological evidence suggests that lunar phases have an impact on human body and behavior. Research that concerns biological rhythms documents a circatrigintan cycle, a moon-related human cycle. The most common monthly cycle is menstruation. A woman's menstrual cycle is about the same length as a lunar cycle, which suggests the influence of the moon. Law (1986) finds a synchronous relationship between the menstrual cycle and the lunar cycle: a large and significant proportion of menstruation occurred around new moon. Studies also find a lunar effect on fertility, for example, Criss and Marcum (1981) document that births vary systematically over lunar cycles with a peak fertility at 3^{rd} quarter. Besides, lunar phases affect human nutrient intake: de Castro and Pearcey (1995) document an 8% increase in meal size and a 26% decrease in alcohol intake at the time of full moon relative to new moon.

Much attention has been paid to the lunar effect on human mood and behavior in psychology literature. A recent study, Neal and Colledge (2000), documents an increase in general practice consultations during the full moon. Lieber (1978) and Tasso and Miller (1976) all indicate a disproportionately high number of criminal offences occur during full moon. Weiskott (1974) reports evidence that number of crisis calls is higher during full moon and waning phases. Hicks-Caskey and Potter (1992) suggest an effect of the day of the full moon on the acting-out behavior of 20 developmentally delayed, institutionalized women. The study shows that on the day of the full moon there are significantly more misbehaviors than on any other day during the lunar period. Sands and Miller (1991) document that the full moon is associated with a significant but slight decrease in absenteeism after controlling for the effects of the day of the week, month, and proximity to a holiday. Overall, the effect of the moon has been studied informally and formally for years. However, we must note that, despite the attention this effect has received, psychological evidence for the lunar hypothesis in general is not conclusive even though biological evidence is strong. For example, in a review of empirical studies up to 1978 on the lunar effect, Campbell and Beets (1978) conclude that lunar phases have little effect on psychiatric hospital admissions, suicides, or homicides. On the other hand, researchers argue that this lack of relation does not preclude a lunar effect. It may simply mean that the effect has not been adequately tested due to small sample sizes and short sample time periods (Cyr and Kaplan 1987; Garzino 1982). Moreover, psychology literature has focused mostly on trying to link the moon to extreme behavioral problems in a few disturbed people, rather than less drastic lunar effect on human being in general. By studying the relationship between lunar phases and asset prices, this paper also extends psychological understanding of lunar effect on human behavior.

In addition, survey evidence suggests a wide belief in the lunar effect. A US survey finds that 49.4% of the respondents believe in lunar phenomena (Rotton and Kelly 1985a). Interestingly, among psychiatric nurses, this percentage rises to 74% (Agus 1973). Vance (1995) reports a similar result as the earlier surveys. Danzl (1987) finds survey evidence that eighty percent of the respondent emergency department nurses and 64% of the emergency physicians believe that the moon affects patients. Scientific explanations have been proposed to account for the moon's effect on the brain: sleep deprivation, heavy nocturnal dew, tidal effect, weather patterns, magnetism and polarization of the moon's light (Raison, et al 1999; Kelley 1942; Katzeff, 1981, Szpir 1996).

Given the extensive documentation of the correlation between lunar phases and human feelings, thoughts, and behaviors, more specifically, the correlation between full moon periods and sleep deprivation, depressed mood, suicidal events*,* we hypothesize that investors may value financial assets *less* during full moon periods than during new moon periods due to the changes in mood associated with lunar conditions.[5]

In this paper, we study the relation between lunar phases and stock market returns across countries. This study is not the first attempt to link lunar phases to stock returns. Rotton and Kelly (1985) cite a working paper by Rotton and Rosenberg (1984) that investigates the relation between lunar phases and Dow-Jones average closing prices. They find no relation when they difference Dow-Jones index prices and correct for first-order autocorrelations.[6] Our study differs from their research. First, we examine returns rather than prices. Second, we correct for heteroscedasticity and autocorrelations, thus providing a more precise test for the relation. Most importantly, we examine a sample of 48 countries, which increases the power of tests.

Dichev and Janes (2001) also examine the effect of lunar phases on stock returns. Their study is concurrent with, and independent of, our paper. Consistent with our findings, Dichev and Janes (2001) report a significant lunar effect on stock returns using a different sample of countries and a different time period. The findings of the two

[5] We follow the evidence and argument in Hirshleifer and Shumway (2001) that good mood is associated with high asset returns. Since we assume that investors' mood follows a sinusoidal model AND positive mood is associated with high asset returns, the hypothesis corresponds to a cycle in returns that meet its peak at new moon and its trough at the full moon. Following the same argument, the cycle in price levels (valuations) peaks one week after the new moon and bottoms out one week after the full moon.

papers complement each other. Dichev and Janes (2001) focus more on the US market and use a longer time series of US stock returns. Our paper provides more global evidence by including 48 countries with different levels of market development in the sample. In addition, we control for contemporaneous correlation and heteroscedasticity among country index returns and for autocorrelation within each country's stock index returns. Besides documenting return differences between the full moon and the new moon phases, we find *a cyclical pattern* in stock returns that corresponds to lunar phases. Beyond documenting the lunar effect, our paper examines other possible causes of such an effect. Additional tests lead us to conclude that the lunar effect is unrelated to the January effect, the day-of- week effect, the calendar month effect, and the holiday effect.

[6] We are unable to obtain the working paper by Rotton and Rosenberg (1984) through extensive research. Our comments on the difference between their work and ours are based on the discussion provided in Rotton and Kelly (1985).

II. Data

To examine whether stock returns are correlated with lunar phases, we need a lunar calendar and a sample of stock market returns. We obtain the lunar calendar from United Sates Naval Observatory (USNO) website.[7] This website provides a table that documents the date and time (Greenwich Mean Time) of four phases of the Moon for the period 1700 to 2015. The four phases are: new moon, first quarter, full moon and last quarter. For the year 2000, the length of the mean synodic month (New Moon to New Moon) is 29.53059 days.

We obtain our stock market information on returns and trading volumes through Datastream. Our return sample consists of 48 countries listed in the Morgan Stanley Capital International (MSCI) as developed markets or emerging markets. We use the country indices calculated by Datastream (Datastream total market index) unless a country does not have this Datastream series for at least five years. In the case of an insufficient Datastream series, we collect other indices for the market from Datastream. All returns are measured as nominal returns in local currencies. We also collect trading volume data for 40 of the corresponding 48 stock indices. Eight of these 48 indices do not have trading volume data in Datastream. We report summary statistics for the sample in Table I.

[7] http://aa.usno.navy.mil/AA/

III. Test Results

This section describes the empirical results of testing the hypothesis that stock returns are associated with lunar phases. We first report test results using an equal-weighted global portfolio of the 48 country stock indices. This set of results indicates the significance of lunar effect on global stock returns.

We then report test results estimated country by country. It is not realistic to expect many countries to have statistically significant results due to the large amount of variation in daily stock returns and the relatively short time-series in our sample. To increase the power of the test, we estimate joint tests using stock returns for the entire panel of countries. We also report the joint test results for the following country categorizations: G-7 countries, other developed countries, and emerging market countries.

To better understand the lunar effect on stock returns, we further examine whether such an effect is related to stock sizes and whether lunar phases are associated with patterns in trading volumes and stock market volatility. We also investigate whether the lunar effect is related to other calendar-related anomalies, such as the January effect, the day-of-week effect, the calendar month effect and the holiday effect. We also check the robustness of the lunar effect to random 30-day cycles, lunar holiday effects and outliers.[8]

[8] Our test results are similar when we exclude the returns of the top and bottom 5 observations as outliers.

A. Lunar Effect on the Global Portfolio

Since lunar cycles are common everywhere across world, we estimate the coefficient of the following regression for an equally-weighted global portfolio of 48 countries:[9]

$$R_t = \alpha + \beta * \text{Lunardummy}_t + e_{t,} \qquad (1)$$

where Lunardummy is a dummy variable indicating the phase of a lunar cycle, specifically, the number of days around a full moon or a new moon. We define a full moon period as N days before the full moon day + the full moon day + N days after the full moon day (N = 3 or 7). Similarly, we define a new moon period as N days before the new moon day + the new moon day + N days after the new moon day (N = 3 or 7).[10] The Lunardummy variable takes on a value of one for a full moon period and zero otherwise. The coefficient on this dummy variable indicates the difference between the mean daily return during the full moon periods and that during the new moon periods.

In Table II, Panel A, we report the OLS estimates of β for the global portfolio using different specifications of a full moon period: N = 3 and 7. The estimated βs indicate the relation between lunar phases and stock returns. The mean daily return difference between the new moon period and the full moon period is 4.34 basis points for the 15-day window specification and 5.51 basis points for the 7-day window specification. The above numbers translate into annualized return difference of 5.4 percent and 6.9 percent respectively. Under both model specifications, the return difference is statistically significant at the 5 percent level.

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[9] At each point of time, we form the global portfolio using countries for which the return information is available.

[10] In the case of the 15-day window, a new moon period can be less than 15 days since a lunar month may be less than 30 days. In these cases, the new moon period is defined as the remaining days of the lunar month.

To test explicitly for the cyclical pattern of the lunar effect, we next estimate a sinusoidal model of continuous lunar impact. According to the model, the lunar effect reaches its peak at the time of the full moon and declines to the trough at the time of the new moon, following a cosine curve with a period of 29.53 days (the mean length of a lunar cycle). More specifically, we estimate the following regression for the global portfolio:

$$R_t = \alpha + \beta * \text{cosine}(2\pi d_t/29.53) + e_t \qquad (2)$$

where d is the number of days since the last full moon day and the β coefficient indicates the association between stock returns and lunar cycles. We report the test result in Table II, Panel A. Using this estimation, we find a negative relation (β = -2.97) between the global stock returns and lunar cycles. The test result is statistically significant at the 1 percent level. Figure 1 displays this pattern by plotting the average daily stock returns on the days of a lunar month for the global index and the estimated sinusoidal curve. Overall, the sinusoidal model suggests that the lunar effect is cyclical.

In Table II, Panel B, we report the average lunar month return difference between the full moon and the new moon periods based on the 15-day window. The annualized return difference is -4.2 percent for the sample period; this difference is statistically significant at the 5 percent level using the t-test and is significant at the 1 percent level using Wilcoxon signed rank test. Figure 2 plots the average stock returns of full moon periods versus new moon periods of the global portfolio.

In summary, we find global evidence on a significant correlation between stock returns and lunar phases. We document that on average returns are higher in the new moon periods than in the full moon periods.

B. Country-by-Country Tests

In this section, we report the regression results of model (1) and (2) for each country:

$$R_{it} = \alpha_i + \beta_i * \text{Lunardummy}_t + e_{it,} \qquad (3)$$

$$R_{it} = \alpha_i + \beta_i * \text{cosine}(2\pi d_t/29.53) + e_{it,} \qquad (4)$$

In Tables III, IV and V, we report the OLS estimates of β_i for each of the G-7 countries, other developed countries and emerging market countries, respectively. In each table, we also report the results of different specifications of a full moon period: N = 3 and 7.

For the 15-day window, *each* of the G-7 and other developed countries displays a negative β coefficient, suggesting that stock returns are, on average, lower around a full moon in all these countries. For the G-7 countries, 1 of the coefficients is statistically different from zero at the 5 percent significance level, and 4 of these coefficients are statistically significant at the 10 percent level. For the 16 other developed countries, 2 have statistically significant coefficients at the 5 percent level, and 3 have statistically significant coefficients at the 10 percent level. For the emerging market countries in Table V, 20 out of these 25 countries have negative β estimates, and 3 of these estimates are significantly different from zero at the 5 percent significance level. We find similar results using the 7-day window.

Estimating the sinusoidal model of continuous and cyclical lunar impact for each country, we find that all G-7 countries except Italy display a negative relation between stock returns and lunar cycles, with 1 estimate significantly different from zero at the 5 percent significance level. Furthermore, we find that 15 of the 16 other developed countries have negative signs, with 1 of these estimates significant at the 5 percent level. Among the 25 emerging market countries, 21 have negative β estimates, with 4 of these estimates significant at the 5 percent level.

It is not surprising to observe less statistically significant results using the country-by-country approach due to the large amount of variation in each country's daily stock returns and the relatively short time-series in our sample. To fully utilize our cross-sectional and time series data, we estimate a pooled regression with panel corrected standard errors (PCSE):

$$R_{it} = \alpha_i + \beta * \text{Lunardummy}_t + e_{it} \qquad (5)$$

$$R_{it} = \alpha_i + \beta * \text{cosine}(2\pi d_t/29.53) + e_{it} \qquad (6)$$

The above PCSE specification adjusts for the contemporaneous correlation and heteroscedasticity among country index returns as well as for the autocorrelation within each country's stock index return. Table VI presents regression results for G-7 countries, other developed countries, emerging market countries, and all markets, respectively, for the 15-day window specification, the 7-day window specification and the sinusoidal model. Regardless of model specifications, the coefficients on the lunar dummy variable are negative; 9 of the 12 coefficients are statistically significant at the 5 percent level. Interestingly, the magnitude of the lunar effect is larger in the emerging market countries (a 7.09 basis points daily difference for the 15-day window and a 13.35 basis points daily difference for the 7-day window) than in the G-7 countries (a 3.47 basis points daily difference for the 15-day window and a 2.6 basis points daily difference for the 7-day window). The cosine regressions also show a higher coefficient for the emerging markets than for the developed markets. Maturity of the stock market and the percentage of institutional investors may help explain the differences in the magnitude of lunar impact in these markets.[11]

In summary, we find that stock returns for the 48 countries are 6.6 percent lower during the 15-day full moon periods than those during new moon periods on an annual basis. The cosine regression for all markets also indicates a significant relation between stock returns and lunar cycles.

C. The Lunar Effect on Returns of Large Cap vs. Small Cap Stocks

In this section, we examine whether lunar effects are related to stock capitalization. This test is motivated by the empirical finding that institutional ownership is positively correlated with stock capitalization. Specifically, large capitalization stocks have a higher percentage of institutional ownership than small capitalization stocks. Since investment decisions of individual investors are more likely to be affected by sentiments and mood than those of institutional investors, we expect the lunar effect to be more pronounced in the pricing of small-cap stocks.

To assess the relation between lunar phases and stock capitalization, we form 10 stock portfolios based on market capitalization for stocks traded on NYSE +AMEX, NASDAQ, and NYSE+AMEX+NASDAQ, respectively. We estimate Equation (3) for each portfolio. The results in Table VII indicate that the lunar effect has the largest impact on the 9thdecile[12] (the second-smallest) with a coefficient of –4.22 and the

[11] Stock markets in emerging market countries in general are less mature, which may magnify the effect of behavioral biases on stock prices. For example, there is a smaller presence of institutional investors in these markets. Institutional investors tend to invest according to some mechanical rules rather than impulses; hence, their involvement should reduce the lunar effect on stock prices.

[12] Liquidity is likely to have a first-order effect in pricing extreme small stocks rather than mood, and hence, we expect a weaker lunar effect for stocks that are extremely small in capitalization.

smallest impact on the 1st decile (the largest) with a coefficient of –2.9. Tests of market-cap ranked portfolios using stocks traded on NYSE, AMEX and NASDAQ yield similar results. Overall, the test results are consistent with our hypothesis that stocks with more individual investor ownership display a stronger lunar effect and thus provide further evidence that mood or sentiment affects asset prices.

D. The Lunar Effect on Trading Volume

In this section, we investigate whether the observed lunar effect is related to trading volumes by estimating the coefficients of the following regressions for each country for the 15-day full moon window:

$$normvolume_{it} = \alpha_i + \lambda_i * Lunardummy_t + e_{it.} \qquad (7)$$

where normvolume is daily trading volume normalized by average daily volume in the month. Test results are reported in Table VIII. 20 out of 40 countries have higher trading volumes during full moon periods; 4 of the 20 positive coefficients are statistically significant at the 5 percent level; 3 of the 20 negative coefficients are statistically significant at the 5 percent level. The coefficient on the lunar dummy is positive but not significant for the global portfolio as well as the pooled regression of 48 countries. Thus, there is little evidence that trading volumes are related to lunar phases in a systematic manner. Therefore, it is unlikely that the lunar effect observed in stock returns is due to patterns in trading volume that are related to lunar phases.

E. Lunar Cycles and Stock Market Volatility

In this section, we examine whether the observed lunar effect is related to stock market volatility by estimating the coefficients of the following regressions for each country for the 15-day full moon window:

$$Volatility_{it} = \alpha_i + \lambda_i * Lunardummy_t + e_{it.} \qquad (8)$$

where volatility is the standard deviation of daily stock returns in each 15-day full moon period and each 15-day new moon period for a lunar month. We report the test results in Table IX. As we observe, the coefficient on the lunar dummy of the global portfolio and the pooled regression is positive but not significant. Moreover, none of the 48 country lunardummy coefficients is significant. Thus, we find little evidence that volatilities are related to lunar phases in a systematic manner. As a result, the lunar effect observed in stock returns is not due to risk differentials between the full moon and the new moon periods.

F. The Lunar Effect is not a Manifestation of Other Calendar Anomalies

The empirical results reported in Subsections A and B suggest that significantly different returns accrue to stocks during full moon vs. new moon periods. This section evaluates possible causes for these return differences other than lunar effects.

January Effect

The lunar effect found in this study is based on a measure of lunar phases using a lunar calendar. This effect is unlikely to be caused by the January effect[13], as lunar months do not correspond to calendar months. To test for the relation of our results and

[13] The January effect has been documented by Rozeff and Kinney (1976) and Reinganum (1983).

the January effect, we add a January dummy variable to our regression estimates of Equations (1) to (2). More specifically, we estimate the following equations for the global portfolio:

$$R_t = \alpha + \beta * \text{Lunardummy}_t + \delta * \text{Januarydummy}_t + e_t . \qquad (9)$$

$$R_t = \alpha + \beta * \text{cosine}(2\pi d/29.53) + \delta * \text{Januarydummy}_t + e_{t,} \qquad (10)$$

where Januarydummy is a dummy variable equal to one in the month of January and zero otherwise.

As shown in column two of Table X, the January effect is extremely strong across all regressions and so is the lunar effect. Comparing these results with the findings for equations that do not control for the January effect (column one), we find that the magnitude and the significance of the lunar effect remain remarkably unchanged for the different model specifications. The test result thus indicates that the January effect is not a driving force behind the observed lunar effect.

Day-of-Week Effect

If most full moon days fall on Monday, it is possible that the Monday effect may explain the observed lunar effect. We tabulate our sample to check on this possibility. Figure 3 shows that full moon days fall evenly on each day of the week in the sample. Hence, we conclude that the lunar effect on stock returns is not related to the Monday effect.

Calendar Month Effect

Ariel (1987) documents a calendar month effect on stock returns. More specifically, he shows that the mean US stock return for days during the first half of a calendar month is higher than the mean stock return during the second half of the month.

Thus, it is conceivable that the lunar effect shown in this paper may be a manifestation of this calendar month effect. To test for this possibility, we include a calendar dummy in Equations (1) and estimate the following regression using the global portfolio:

$$R_t = \alpha + \beta * \text{Lunardummy}_t + \delta * \text{calendardummy}_t + e_{t,} \quad (11)$$

where Calendardummy is a dummy variable equal to one for the first half of a calendar month and zero otherwise. As shown in the third column of Table X, the calendar month effect is not significant for the global portfolio during our sample period. Nevertheless, the magnitude and significance of the Lunardummy coefficient is highly consistent with our earlier finding. For all panels, the lunar effect is statistically significant at the 5 percent level. These test statistics suggest that the calendar month effect cannot explain the observed lunar effect.

Holiday Effect

Ariel (1990) documents that, on the trading day prior to holidays, stocks advance with disproportionate frequency and show high mean returns averaging nine to fourteen times the mean return for the remaining days of the year. To examine the relation between the observed lunar effect and the holiday effect, we exclude the day before holidays for each country when we construct our global portfolio. We estimate equation (1) using the holiday adjusted global index returns. As reported in column four of Table X, the lunar effect is unchanged and remains significant at one percent level. Thus, lunar effect does not appear to be related to holidays.

Lunar Holidays

Frieder and Subrahmanyam (2002) document that Jewish holidays have a significant impact on U.S. equity market. Specifically, they find that returns are significantly positive around Rosh HaShanah and significantly negative around Yom Kippur. We check the robustness of our lunar cycle effect by including a lunar holiday dummy because many Jewish, Islamic, Hindu, Chinese and Korean holidays fall on the fixed days of a lunar based calendar.

We present the test results in Table XI. First, we report the country level regressions where we include the relevant country lunar holiday dummy. Interestingly, we find that the Jewish holiday dummies are statistically significant for the U.S. and the Israeli markets while the lunar holiday dummies for other countries are not significantly different from zero. Our results are consistent with the findings for the U.S. stock market in Frieder and Subrahmanyam (2002). For both the U.S. and Israeli market, we find that returns are lower around Yom Kippur and higher around Rosh HaShanah. However, the coefficients on the lunar dummies do not change much when we include the lunar holiday dummies, indicating that the Jewish holiday effect is probably independent of the lunar cycle effect. The test results are similar when we include the holiday (non-lunar) dummies.

In the last column, we examine the impact of Jewish holidays on the global portfolio by including the Jewish holiday dummies in Equation (1). We find that the coefficient on Yom Kippur is significant and the coefficient on Rosh HaShanah is close to zero. Similar to our earlier results, the coefficient on the lunar dummy is 0.413 and significant at the one percent level. Our results suggest that Yom Kippur seems to have a negative impact on the returns of the global portfolio. Nevertheless, the lunar cycle effect is independent of the Jewish holiday effect.

30-day Cycle Effect

To test whether the observed lunar effect in this study reflects a general pattern in stock returns, rather than a lunar-driven cycle, we shift the lunar phase by 1 to 29 days (as the average length of a lunar month is 29.53 days). That is, we start a 30-day cycle 1 to 29 days after the first full moon, and estimate the 30-day cycle effect for each specification, using the following PCSE regression with a 15-day window:

$$R_{it} = \alpha_i + \beta * 30daydummy_t + e_{it} \qquad (12)$$

where 30daydummy is a dummy variable indicating the phase of a 30-day cycle. 30daydummy takes on a value of one for 7 days before the starting day + the starting day + 7 days after the starting day, and a value of zero otherwise.

The results in Table XII suggest that the 30-day cycle effects for the cycles starting 1 to 7 days after the full moon and the cycles starting 24 to 29 days after the full moon have negative signs. Moreover, the statistical significance of the estimated 30-day cycle effect declines as these 30-day cycles deviate more from the lunar cycle. In fact, for the cycles starting 11 to 20 days after the full moon, the pattern is reversed. Figure 4 graphs the estimates of the 30-day cycle effect and shows that the documented lunar effect cannot arise from any 30-day cycles except for the ones that closely track the lunar cycle.

After evaluating possible explanations for our results, we conclude that the lunar effect on stock returns is independent of other calendar-related anomalies, such as the January effect, the day-of-week effect, the calendar month effect, and the holiday effect. Our results are also robust to the lunar holiday and the non-lunar 30-day cycle explanations.

IV. Conclusion

This paper investigates the relation between lunar phases and stock returns for a sample of 48 countries. We find strong global evidence that stock returns are lower on days around a full moon than on days around a new moon. Constructing a lunar trading strategy, we find that the magnitude of this return difference is roughly 4.2 percent per annum. Since lunar phases are likely to be related to investor mood and are not related to economic activities, our findings are thus not consistent with the predictions of traditional asset pricing theories that assume fully rational investors. The positive association we find between lunar phases and stock returns suggests that it might be valuable to go beyond a rational asset pricing framework to explore the psychological effects of investor behavior on stock returns.

Psychology literature has provided numerous theories on how mood affects perceptions and preferences. One theory is that mood affects perception through misattribution: attributing feelings to wrong sources leads to incorrect judgements (Frijda 1988; Schwarz and Clore 1983). Alternatively, mood may affect people's ability to process information. In particular, investors may react to salient or irrelevant information when feeling good (Schwarz 1990; Schwarz and Bless 1991). Finally, mood may affect preferences (Loewenstein 1996; Mehra and Sah 2000). This paper is only a first step towards confirming the effect of mood on asset prices. It would be interesting to better understand *how* mood affects asset prices. In his survey paper, Hirshleifer (2001) pointed out that one area of future research is to conduct experimental testing of behavioral hypotheses. In a related vein, future work can examine asset market experiments that manipulate mood. For example, is trading behavior in experimental markets different when the markets are staged at different parts of the lunar cycle?

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Table I
Summary Statistics

This table reports the summary statistics for the 48 country stock indices. All sample periods end on July 31, 2001.

Country	Code	Starting Date	Number of Observations	Mean Daily Return	StdDev of Daily Return
ARGENTINA	TOTMKAR	1/88	3510	0.00350	0.03672
AUSTRALIA	TOTMKAU	1/73	7213	0.00040	0.01104
AUSTRIA	TOTMKOE	1/74	6355	0.00029	0.00859
BELGIUM	TOTMKBG	1/73	7124	0.00033	0.00821
BRAZIL	BRBOVES	1/72	2475	0.00790	0.07093
CANADA	TOTMKCN	1/73	7226	0.00033	0.00839
CHILE	TOTMKCL	7/89	3013	0.00087	0.01034
CHINA	TOTMKCH	1/91	2443	0.00157	0.02994
CZECH	CZPX50I	4/94	1750	-0.00047	0.01270
DENMARK	TOTMKDK	1/74	6377	0.00059	0.01089
FINLAND	TOTMKFN	1/88	3339	0.00071	0.01834
FRANCE	TOTMKFR	1/73	7264	0.00048	0.01111
GERMANY	TOTMKBD	1/73	7192	0.00032	0.00950
GREECE	TOTMKGR	1/88	3385	0.00097	0.01919
HONG KONG	TOTMKHK	1/73	7103	0.00058	0.01895
HUNGARY	BUXINDX	2/91	2629	0.00087	0.01761
INDIA	IBOMBSE	4/84	2903	0.00081	0.01894
INDONESIA	TOTMKID	4/84	2761	0.00020	0.02598
IRELAND	TOTMKIR	1/73	7103	0.00053	0.01087
ISRAEL	ISTGNRL	1/84	4179	0.00153	0.01438
ITALY	TOTMKIT	1/73	7445	0.00052	0.01341
JAPAN	TOTMKJP	1/73	7145	0.00023	0.01013
JORDAN	AMMANFM	11/88	2176	0.00031	0.00863
KOREA	TOTMKKO	1/75	3322	0.00032	0.02083
LUXEMBURG	TOTMKLX	1/92	2370	0.00062	0.01005
MALAYSIA	TOTMKMY	1/88	3349	0.00049	0.01652
MEXICO	TOTMKMX	1/88	3436	0.00132	0.01715
MOROCCO	MDCFG25	12/87	1820	0.00124	0.00930
NETHERLAND	TOTMKNL	1/73	7219	0.00040	0.00957
NEW ZEALAN	TOTMKNZ	1/88	3409	0.00024	0.01147
NORWAY	TOTMKNW	1/80	5419	0.00050	0.01419
PAKISTAN	PKSE100	12/88	2795	0.00040	0.01628
PERU	PEGENRL	1/91	2597	0.00165	0.01591
PHILIPPINES	TOTMKPH	9/87	3464	0.00061	0.01553
POLAND	TOTMKPO	1/94	1803	0.00006	0.02317
PORTUGAL	TOTMKPT	1/90	2858	0.00022	0.00932
RUSSIA	RSMTIND	9/94	1676	0.00257	0.03684
SINGAPORE	TOTMKSG	1/73	7128	0.00022	0.01443
SOUTH AFRICA	TOTMKSA	1/73	7170	0.00065	0.01353
SPAIN	TOTMKES	1/88	3623	0.00040	0.01158
SWEDEN	TOTMKSD	1/82	4903	0.00070	0.01348
SWITZ	TOTMKSW	1/73	7174	0.00032	0.00848
TAIWAN	TOTMKTA	9/87	3371	0.00044	0.02235
THAILAND	TOTMKTH	1/88	3349	0.00041	0.02012
TURKEY	TOTMKTK	1/88	3467	0.00258	0.02995
UNITED KINGDOM	TOTMKUK	1/65	8503	0.00048	0.01029
UNITED STATES	TOTMKUS	1/73	7216	0.00037	0.00982
VENEZUELA	TOTMKVE	1/90	2829	0.00159	0.02525

Table II
Lunar Phases and Stock Returns: A Global Portfolio

Panel A reports regression results from estimating the relation between daily stock returns and lunar phases. We estimate the following regression for the global portfolio: $R_t = \alpha + \beta * Lunardummy_t + e_t$. Lunardummy is a dummy variable indicating the phase of a lunar cycle, specifically, the days around a full moon. We define a full moon period as N days before the full moon day + the full moon day + N days after the full moon day (N = 3 or 7). Lunardummy is equal to one during a full moon period and zero otherwise. In column 3, we report the β coefficient for the following regression: $R_t = \alpha + \beta * cosine(2\pi d_t/29.53) + e_t$, where d is the number of days since the last full moon. Panel B reports the average lunar month return difference between the full moon and the new moon periods. T-statistics are reported in the parentheses. The daily returns are in basis points.

Panel A: Regression Analysis

15-day Window	7-day Window	Cosine
-4.34*** (-3.19)	-5.51*** (-2.70)	-2.97*** (-3.09)

Panel B: Average Monthly Return Difference between the Full Moon and the New Moon Periods based on the 15-day Window

Mean Lunar Month Return Difference	-35.09** (-2.32)
Signed-Rank Test (P-value)	0.0009
Number of Lunar Month with Positive Return Difference	258
Number of Lunar Month with Negative Return Difference	144

***indicates a 1% significance level using a two-tailed test
** indicates a 5% significance level using a two-tailed test
* indicates a 10% significance level using a two-tailed test

Table III
Lunar Phases and Stock Returns: G-7 Countries

This table reports country-by-country results from estimating regressions of daily stock returns on lunar phases. We first estimate the following regression for each country: $R_{it} = \alpha_i + \beta_i * Lunardummy_t + e_{it.}$ Lunardummy is a dummy variable indicating the phase of a lunar cycle, specifically, the days around a full moon or a new moon. We define a full moon period as N days before the full moon day + the full moon day + N days after the full moon day (N = 3 or 7). Accordingly, we define a new moon period as N days before the new moon day + the new moon day + N days after the new moon day (N = 3 or 7). Lunardummy is equal to one during a full moon period and zero otherwise. We display the country β's for N =3 and N = 7 in columns 2 and 3, respectively. In column 4, we report the β coefficient for the following regression: $R_{it} = \alpha_i + \beta_i * \text{cosine}(2\pi d/29.53) + e_{it,}$ where d is the number of days since the last full moon. T-statistics are reported in the parentheses. The daily returns are in basis points.

	7-Day Window N = 3	15-Day Window N = 7	Cosine Regression
CANADA	-3.58 (-1.22)	-3.87** (-1.96)	-1.70 (-1.22)
FRANCE	-1.24 (-0.33)	-3.46 (-1.33)	-1.46 (-0.79)
GERMANY	-4.43 (-1.34)	-3.77* (-1.68)	-2.50 (-1.57)
ITALY	3.23 (0.70)	-1.38 (-0.45)	0.00 (0.00)
JAPAN	-7.92** (-2.22)	-4.60 (-1.92)*	-3.43** (-2.02)
UK	-0.01 (0.00)	-3.85 (-1.72)*	-1.80 (-1.10)
US (1973-2001)	-4.52 (-1.32)	-2.70 (-1.18)	-1.07 (-0.62)

***indicates a 1% significance level using a two-tailed test
** indicates a 5% significance level using a two-tailed test
* indicates a 10% significance level using a two-tailed test

Table IV
Lunar Phases and Stock Returns: Other Developed Countries

This table reports country-by-country results from estimating a regression of daily stock returns on lunar phases. We estimate the following regression for each country: $R_{it} = \alpha_i + \beta_i * \text{Lunardummy}_t + e_{it.}$ Lunardummy is a dummy variable indicating the phase of a lunar cycle, specifically, the days around a full moon. We define a full moon period as N days before the full moon day + the full moon day + N days after the full moon day (N = 3 or 7). Lunardummy is equal to one during a full moon period and zero otherwise. We display the country β's for N =3 and N = 7 in columns 2 and 3, respectively. In column 4, we report the β coefficient for the following regression: $R_{it} = \alpha_i + \beta_i * \text{cosine}(2\pi d_t/29.53) + e_{it,}$ where d is the number of days since the last full moon. T-statistics are reported in the parentheses. The daily returns are in basis points.

	7-Day Window N = 3	15-Day Window N = 7	Cosine Regression
AUSTRALIA	-1.20 (-0.48)	-1.67 (-0.64)	-0.24 (-0.13)
AUSTRIA	-3.68 (-1.16)	-2.81 (-1.30)	-1.74 (-1.14)
BELGIUM	-1.02 (-0.35)	-2.34 (-1.20)	-0.74 (-0.54)
DENMARK	-5.34 (-1.22)	-2.79 (-1.02)	-2.42 (-1.25)
HONG KONG	-9.15 (-1.40)	-6.46 (-1.43)	-4.84 (-1.52)
IRELAND	-1.39 (-0.36)	-4.86* (-1.88)	-2.78 (-1.52)
NETHERLANDS	0.21 (0.08)	-4.43** (-1.96)	-1.93 (-1.21)
NORWAY	-3.20 (-0.95)	-1.70 (-0.44)	0.50 (0.18)
SINGAPORE	2.52 (0.44)	-8.51** (-2.49)	-5.39** (-2.21)
SPAIN	-8.18 (-1.57)	-3.18 (-0.83)	-2.15 (-0.79)
SWEDEN	-5.07 (-0.90)	-5.63 (-1.46)	-2.90 (-1.06)
SWITZERLAND	-2.63 (-0.47)	-2.87 (-1.43)	-1.60 (-1.12)
FINLAND	-2.72 (-0.92)	-2.11 (-0.33)	-4.37 (-0.97)
GREECE	-9.04 (-0.92)	-8.62 (-1.31)	-6.87 (-1.47)
LUXEMBURG	-7.04 (-1.07)	-5.76 (-1.39)	-3.57 (-1.22)
NEW ZEALAND	-3.22 (-0.54)	-5.01 (-1.29)	-2.64 (-0.94)

***indicates a 1% significance level using a two-tailed test
** indicates a 5% significance level using a two-tailed test
* indicates a 10% significance level using a two-tailed test

Table V
Lunar Phases and Stock Returns: Emerging Market Countries

This table reports country-by-country results from estimating a regression of daily stock returns on lunar phases. We estimate the following regression for each country: $R_{it} = \alpha_i + \beta_i * Lunardummy_t + e_{it.}$ Lunardummy is a dummy variable indicating the phase of a lunar cycle, specifically, the days around a full moon. We define a full moon period as N days before the full moon day + the full moon day + N days after the full moon day (N = 3 or 7). Lunardummy is equal to one during a full moon period and zero otherwise. We display the country β's for N =3 and N = 7 in columns 2 and 3, respectively. In column 4, we report the β coefficient for the following regression: $R_{it} = \alpha_i + \beta_i * cosine(2\pi d_t/29.53) + e_{it}$ where d is the number of days since the last full moon. T-statistics are reported in the parentheses. The daily returns are in basis points.

	7 Day Window N = 3	15 Day Window N = 7	Cosine Regression
ARGENTINA	-24.93 (-1.31)	-20.37 (-1.64)	-12.4 (-1.41)
BRAZIL	-92.60* (-1.86)	-29.85 (-1.46)	-27.3 (-1.35)
CHILE	-19.06*** (-3.48)	-6.48* (-1.72)	-6.71** (-2.52)
CHINA	-14.70 (-0.82)	-9.61 (-0.79)	-10.22 (-1.19)
CZECH	2.70 (0.31)	3.96 (0.65)	2.28 (0.53)
HUNGARY	-1.97 (-0.19)	10.22 (1.49)	3.03 (0.62)
INDIA	-9.12 (-0.91)	-8.41 (-1.20)	-7.03 (-1.40)
INDONESIA	-33.32*** (-2.80)	-19.60** (-1.98)	-16.8** (-2.38)
ISRAEL	-10.82 (-1.62)	-17.98 (-1.60)	-6.78** (-2.16)
JORDAN	2.32 (0.45)	-1.25 (-0.34)	0.06 (0.21)
MALAYSIA	0.90 (0.10)	-7.43 (-1.30)	-1.16 (-0.28)
MEXICO	0.90 (0.10)	-14.27** (-2.44)	-9.98** (-2.41)
MOROCCO	-0.10 (-0.02)	-1.40 (-0.32)	-0.85 (-0.27)
PAKISTAN	-6.99 (-0.82)	-1.25 (-0.20)	-2.27 (-0.52)
PERU	8.99 (1.02)	-4.88 (-0.78)	-1.73 (-0.39)
PHILIPPINES	-6.39 (-0.82)	-1.80 (-0.34)	-1.63 (-0.43)
POLAND	-15.91 (-1.04)	0.99 (0.09)	-3.39 (-0.44)
PORTUGAL	-3.89 (-0.76)	-7.74** (-2.22)	-4.71* (-1.91)
RUSSIA	-53.16** (-2.13)	-19.33 (-1.07)	-22.00* (-1.73)
SOUTH AFRICA	-0.56 (-0.12)	-1.84 (-0.57)	-1.70 (-0.75)
SOUTH KOREA	-14.63 (-1.40)	1.92 (0.27)	-4.56 (-0.89)
TAIWAN	-3.12 (-0.28)	-5.43 (-0.71)	-1.98 (-0.36)
THAILAND	-5.19 (-0.52)	-2.45 (-0.35)	-2.13 (-0.43)
TURKEY	-29.36** (-2.02)	-13.05 (-1.28)	-13.89* (-1.92)
VENEZUELA	-4.97 (-0.38)	2.22 (0.23)	2.89 (0.43)

***, **, * indicate 1%, 5%, 10% significance levels using a two-tailed test

Table VI
Lunar Phases and Stock Returns: Joint Tests

Panels A and B report the estimates of a pooled regression with panel corrected standard errors (PCSE): $R_{it} = \alpha_i + \beta * Lunardummy_t + e_{it}$ for the 7-day window and 15-day window, respectively. The PCSE specification adjusts for the contemporaneous correlation and heteroscedasticity among country indices and for the autocorrelation within each country's stock index[14]. Panel C reports the β coefficient for the following regression: $R_{it} = \alpha_i + \beta_i * cosine(2\pi d_t/29.53) + e_{it,}$ where d is the number of days since the last full moon. T-statistics are reported in the parentheses. The daily returns are in basis points.

Panel A: 7-day window	
	Panel (PCSE)
G7	-2.60 (-1.14)
Other Developed Markets	-3.75 (-1.47)
Emerging Markets	-13.35*** (-3.55)
All Markets	-6.80*** (-2.61)
Panel B: 15-day window	
	Panel (PCSE)
G7	-3.47** (-2.2)
Other Developed Markets	-4.38** (-2.38)
Emerging Markets	-7.09** (-2.42)
All Markets	-5.18*** (-2.63)
Panel C: Cosine regressions	
	Panel (PCSE)
G7	-1.75* (-1.56)
Other Developed Markets	-2.69** (-2.05)
Emerging Markets	-6.24*** (-3.08)
All Markets	-3.69*** (-2.76)

***indicates a 1% significance level using a two-tailed test
** indicates a 5% significance level using a two-tailed test
* indicates a 10% significance level using a two-tailed test

[14] We do not adjust for autocorrelation in stock returns in the 7-day window case.

Table VII
Lunar Effect and Stock Sizes

This table reports results from estimating a regression of daily returns of market-cap ranked portfolios on lunar phases. The portfolios are constructed using stocks traded in all US markets, NYSE and AMEX, NASDAQ, respectively. Decile 1 corresponds to the largest market-cap stocks. We estimate the following regression for each portfolio: $R_{it} = \alpha_i + \beta_i * Lunardummy_t + e_{it.}$ Lunardummy is a dummy variable indicating the phase of a lunar cycle, specifically, the days around a full moon. We define a full moon period as N days before the full moon day + the full moon day + N days after the full moon day (N = 7). Lunardummy is equal to one during a full moon period and zero otherwise. We display each portfolio's β for N = 7 in columns 2, 3, and 4. T-statistics are reported in the parentheses. The daily returns are in basis points.

Decile Number	All US Markets	NYSE and AMEX	NASDAQ
1	-2.90* (-1.71)	-0.66 (-0.20)	-3.3* (-1.94)
2	-3.26** (-1.99)	-2.7 (-1.18)	-3.5** (-2.16)
3	-3.52** (-1.99)	-2.1 (-0.97)	-4.0** (-2.32)
4	-3.70** (-2.08)	-2.90 (-1.51)	-4.2** (-2.31)
5	-3.09* (-1.67)	-2.70 (-1.41)	-3.4* (-1.77)
6	-3.65* (-1.90)	-3.00 (-1.59)	-4.2** (-2.06)
7	-3.49* (-1.73)	-2.80 (-1.48)	-3.9* (-1.77)
8	-3.51* (-1.74)	-2.90 (-1.51)	-4.0* (-1.75)
9	-4.22** (-2.03)	-3.40* (-1.73)	-5.6** (-2.14)
10	-2.75 (-1.20)	-3.00 (-1.36)	-2.2 (-0.70)

***indicates a 1% significance level using a two-tailed test
** indicates a 5% significance level using a two-tailed test
* indicates a 10% significance level using a two-tailed test

Table VIII
Lunar Phases and Trading Volumes

This table reports test results from estimating a regression of daily trading volume on lunar phases. Panel A displays the test results from the global portfolio and the pooled regression, and Panel B presents the country-by-country results. We estimate the following regression : $normvolume_{it} = \alpha_i + \lambda_i * Lunardummy_t + e_{it.}$ Normvolume is daily trading volume normalized by average monthly volume. Lunardummy is a dummy variable equal to one during a full moon period and zero otherwise. We define a full moon period as N days before the full moon day + the full moon day + N days after the full moon day (N = 7). T-statistics are reported in the parentheses.

Panel A: Global Evidence	
	λ
Global Portfolio	36.27339 (0.71)
Pooled Regression of 48 countries	48.802 (1.01)

Panel B: Country by Country Evidence			
Country	λ	Country	λ
Canada	5.00 (0.06)	Indonesia	691.50*** (2.91)
Germany	-65.60 (-0.41)	India	-83.20 (-0.66)
France	105.00 (0.81)	Philippines	854.20*** (2.84)
Italy	107.10 (0.96)	Taiwan	-330.70*** (-2.60)
Japan	-10.70 (-0.08)	Argentina	-174.90 (-1.14)
United States	8.50 (0.15)	Malaysia	102.70 (0.79)
United Kingdom	124.50 (1.56)	Mexico	-581.20*** (-3.08)
South Africa	392.60 (1.47)	Thailand	-62.90 (-0.36)
Australia	-115.50 (-0.81)	Turkey	-142.70 (-1.17)
Belgium	24.70 (0.17)	Spain	-261.60** (-2.19)
Hong Kong	67.60 (0.53)	Finland	-18.90 (-0.08)
Ireland	1629.70*** (2.87)	Greece	-197.50 (-1.09)
Netherlands	174.70* (1.72)	New Zealand	247.30 (1.19)
Singapore	135.20 (0.98)	Pakistan	254.40* (1.76)
Switzerland	154.10 (1.23)	Chile	-208.00 (-1.05)
Austria	-155.40	Portugal	-366.80

	(-1.03)		(-1.05)
Denmark	733.00*** (2.62)	Venezuela	-36.70 (-0.12)
Korea	-69.70 (-0.46)	China	-232.00 (-1.07)
Norway	-143.20 (-0.74)	Luxembourg	98.40 (0.18)
Sweden	201.30 (1.48)	Poland	0.60 (0.00)

***indicates a 1% significance level using a two-tailed test
** indicates a 5% significance level using a two-tailed test
* indicates a 10% significance level using a two-tailed test

Table IX
Lunar Phases and Volatility

This table reports test results from estimating a regression of daily trading volume on lunar phases. Panel A displays the test results for the global portfolio and the pooled regression, and Panel B presents the country-by-country results. We estimate the following regression : $normvolume_{it} = \alpha_i + \lambda_i * Lunardummy_t + e_{it.}$ Normvolume is daily trading volume normalized by average monthly volume. In this table, we report the following regression estimates for the global portfolio and each of the 48 countries: $volatility_{it} = \alpha_i + \lambda_i * Lunardummy_t + e_{it.}$ Volatility is the standard deviation of daily stock returns in each 15-day full moon period and each 15-day new moon period for each lunar month. Lunardummy is a dummy variable equal to one during a full moon period and zero otherwise. We define a full moon period as N days before the full moon day + the full moon day + N days after the full moon day (N = 7). T-statistics are reported in the parentheses.

Panel A: Global Evidence	
	λ
Global Portfolio	1.14 (0.47)
Pooled Regression of 48 countries	0.8 (0.76)

Panel B: Country by Country Evidence			
Country	λ	Country	λ
Canada	-0.18 (-0.05)	Indonesia	16.07 (0.65)
Germany	1.14 (0.34)	India	-9.41 (-0.77)
France	1.36 (0.38)	Philippines	0.85 (0.10)
Italy	6.68 (1.47)	Taiwan	6.23 (0.57)
Japan	2.18 (0.52)	Argentina	11.05 (0.43)
United States	2.04 (0.57)	Malaysia	5.42 (0.43)
United Kingdom	-1.44 (-0.40)	Mexico	3.58 (0.39)
South Africa	4.79 (0.94)	Thailand	12.61 (1.11)
Australia	2.18 (0.52)	Turkey	-0.07 (-0.00)
Belgium	1.32 (0.42)	Spain	0.06 (0.01)
Hong Kong	2.47 (0.30)	Finland	1.45 (0.12)
Ireland	0.04 (0.01)	Greece	12.93 (1.09)
Netherlands	-2.10 (-0.59)	New Zealand	-4.81 (-0.72)
Singapore	-2.03 (-0.32)	Pakistan	-6.19 (-0.63)
Switzerland	3.70 (1.02)	Chile	4.66 (0.92)
Austria	-2.90 (-0.77)	Portugal	-4.34 (-0.72)
Denmark	-0.37	Venezuela	6.85

	(-0.05)		(0.44)
Korea	-0.84 (-0.07)	China	-6.12 (-0.26)
Norway	-4.61 (-0.74)	Luxembourg	1.66 (0.23)
Sweden	-0.95 (-0.16)	Poland	-0.34 (-0.02)
Brazil	-179.39 (-1.16)	Israel	5.23 (0.75)
Morocco	-5.30 (-0.61)	Czech	7.43 (0.78)
Hungary	11.37 (0.87)	Jordan	-0.87 (-0.14)
Russia	-15.68 (-0.48)	Peru	6.22 (0.63)

***indicates a 1% significance level using a two-tailed test
** indicates a 5% significance level using a two-tailed test
* indicates a 10% significance level using a two-tailed test

Table X
Lunar Phases, Stock Returns and Other Calendar Anomalies

This table reports regression results of daily stock returns on lunar phases controlling for other calendar anomalies. Model 1 is our basic regression as described in equation (1) and (2). Model 2 controls for the January effect. Model 3 controls for the calendar month effect. Model 4 controls for the holiday effect. T-statistics are reported in the parentheses. The daily returns are in basis points. P-values for the non-parametric tests are reported in the last row.

Panel A: 15-day Window				
	Model 1	Model 2	Model3	Model 4[15]
Lunardummy	-4.34*** (-3.19)	-4.32*** (-3.19)	-4.35*** (-3.20)	-4.28*** (-3.15)
Januarydummy		14.14*** (5.85)		
Calendardummy			0.78 (0.57)	
Panel B: 7-day Window				
	Model 1	Model 2	Model3	Model 4
Lunardummy	-5.51*** (-2.70)	-5.48*** (-2.69)	-5.48*** (-2.68)	-4.92** (-2.41)
Januarydummy		17.67*** (2.86)		
Calendardummy			-1.57 (-0.77)	
Panel C: Cosine Regression				
	Model 1	Model 2	Model3	Model 4
Cosine	-2.97*** (-3.09)	-2.95*** (-3.08)	-2.98*** (-3.10)	-2.80 *** (-2.91)
Januarydummy		14.14*** (5.85)		
Calendardummy			-0.78 (-0.58)	

***indicates a 1% significance level using a two-tailed test
** indicates a 5% significance level using a two-tailed test
* indicates a 10% significance level using a two-tailed test

[15] To separate out the holiday effect, we exclude the specific country from the return calculation of the global portfolio for the day preceding the country holiday. We then repeat the lunar regression using holiday adjusted returns of the global portfolio.

Table XI Lunar Holidays

This table reports 15-day window regression results of daily stock returns on lunar phases controlling for the January effect and the lunar holiday returns. Yomcum dummy equals to 1 for the day of and the day following Yom Kippur. Roshcum dummy equals to 1 for the first day of Rosh Hashanah and the day following. Other lunar holiday dummies are constructed for each country/religion specific lunar holidays.

Independent variables / Dependent variable	Intercept	Lunardummy	January dummy	Yomcum dummy	Roshcum dummy	Other lunar holiday dummry
Panel A: Country-by-country regressions						
U.S.	0.042*** (2.45)	-0.019 (-0.82)	0.068* (1.65)	-0.393** (-2.52)	0.173 (1.52)	
Israel	0.200*** (6.18)	-0.111** (-2.49)	0.088 (1.11)	-0.526 (-1.26)	0.714** (2.04)	
China	0.199** (2.23)	-0.096 (-0.79)	0.047 (0.21)			0.322 (0.60)
Japan	0.039** (2.23)	-0.046* (-1.90)	0.088** (2.00)			0.000 (0.01)
Korea	-0.000 (-0.01)	0.017 (0.24)	0.289** (2.23)			-0.039 (-0.12)
India	0.119** (2.32)	-0.084 (-1.19)	0.078 (0.62)			-0.121 (-0.47)
Indonesia	0.104 (1.43)	-0.188* (-1.89)	0.247 (1.35)			-0.290 (-0.86)
Jordan	0.029 (1.07)	-0.012 (-0.33)	0.089 (1.37)			-0.012 (-0.09)
Malaysia	0.083** (1.98)	-0.080 (-1.38)	0.007 (0.07)			0.231 (1.28)
Morocco	0.125*** (3.94)	-0.014 (-0.31)	0.095 (1.21)			-0.097 (-0.67)
Pakistan	0.048 (1.08)	-0.012 (-0.20)	-0.021 (-0.19)			-0.036 (-0.13)
Turkey	0.273*** (3.67)	-0.128 (-1.26)	0.546*** (3.04)			0.034 (0.11)
Panel B: Global portfolio						
Global Portfolio	0.076*** (7.65)	-0.041*** (-3.02)	0.140*** (5.81)	-0.182** (-1.96)	0.003 (0.05)	

***, **, * indicate 1%, 5%, 10% significance levels respectively using a two-tailed test

Table XI
30-day Cycles and Stock Returns

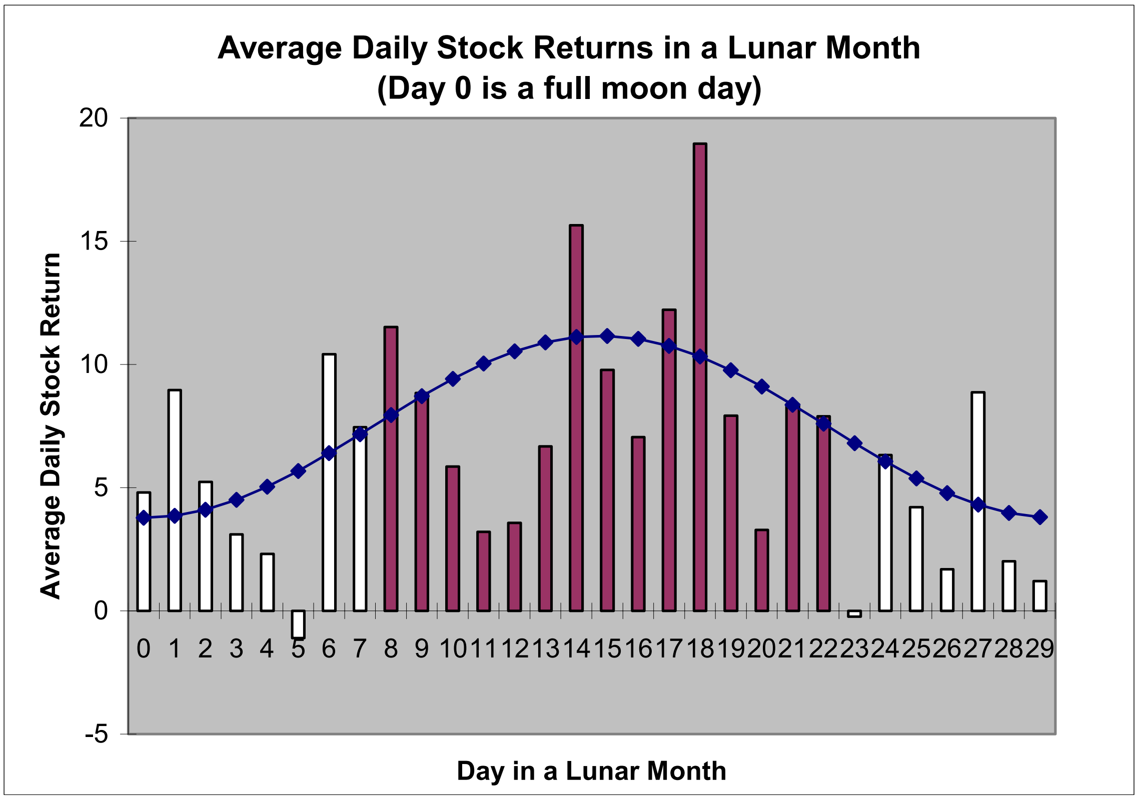
This table reports the estimates of a pooled regression with panel corrected standard errors (PCSE): $R_{it} = \alpha_i + \beta * 30daydummy_t + e_{it}$ for a 15-day window when we shift lunar phases by N calendar days. More specifically, we start a 30-day cycle N days after the first full moon (N=1 to 29), and then estimate the 30-day cycle effect for each specification. 30daydummy takes on a value of one for 7 days before the starting day + the starting day + 7 days after the starting day, and a value of zero otherwise. The lunar cycle is represented by N=0. We display β in column 2 and column 4. T-statistics are reported in the parentheses. The daily returns are in basis points.

N	β	N	β
1	-3.79** (-1.96)	16	3.12 (1.61)
2	-3.18 (-1.65)	17	3.39* (1.75)
3	-2.72 (-1.41)	18	2.55 (1.32)
4	-3.16 (-1.64)	19	2.35 (1.22)
5	-3.30* (-1.71)	20	3.38* (1.75)
6	-3.12 (-1.62)	21	2.16 (1.12)
7	-0.59 (-0.31)	22	-0.08 (-0.04)
8	0.294 (0.15)	23	0.22 (0.11)
9	0.58 (0.30)	24	-1.14 (-0.59)
10	1.92 (0.99)	25	-1.91 (-0.99)
11	3.95** (2.04)	26	-4.24** (-2.19)
12	4.58** (2.37)	27	-5.27** (-2.73)
13	5.07*** (2.62)	28	-4.85** (-2.51)
14	4.89** (2.53)	29	-4.53** (-2.34)
15	5.04** (2.61)	0	-5.18*** (-2.63)

***, **, * indicate 1%, 5%, 10% significance levels respectively using a two-tailed test.

Figure 1
Average Daily Return of the Global Portfolio by Lunar Dates

This figure graphs, for each day of the lunar month, the average daily stock returns of an equal-weighted global portfolio of the 48 country stock indices in bars. Day 0 is a full moon day and day 15 is around a new moon day[16]. The line is the estimated sinusoidal model of the lunar effect on stock returns from the last row of Table V. More specifically, it is : $R_{it} = 7.47 - 3.69 * \text{cosine}(2\pi d/29.53)$, where d is the number of days since the last full moon.



[16] Day 15 is around new moon day since the length of a lunar month varies.

Figure 2
Average Daily Stock Returns of Global Portfolio by Lunar Windows

This figure plots the average daily stock returns of an equal-weighted global portfolio of the 48 country stock indices in a full moon period and a new moon period. The two bars on the left are average returns of a 15-day window; the two bars on the right are average returns of a 7-day window. All returns are in basis points.

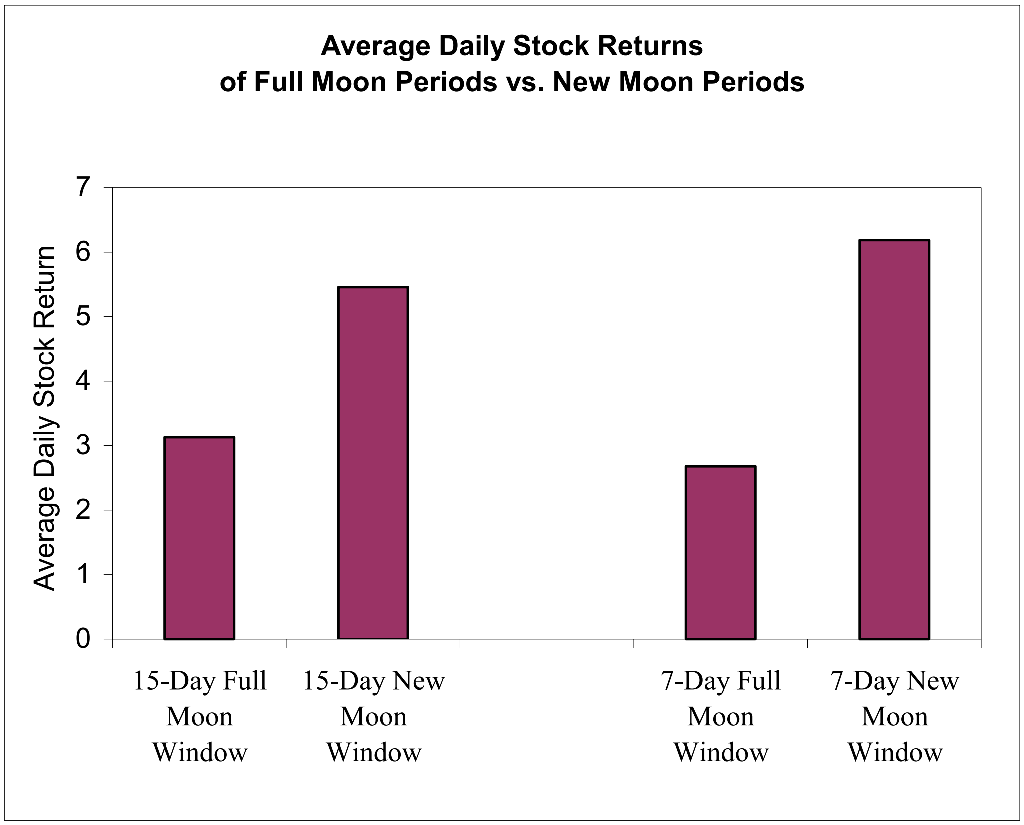


Figure 3
Distribution of Full Moon Days on Days of Week

This figure plots the number of full moon days on days of week in the sample.

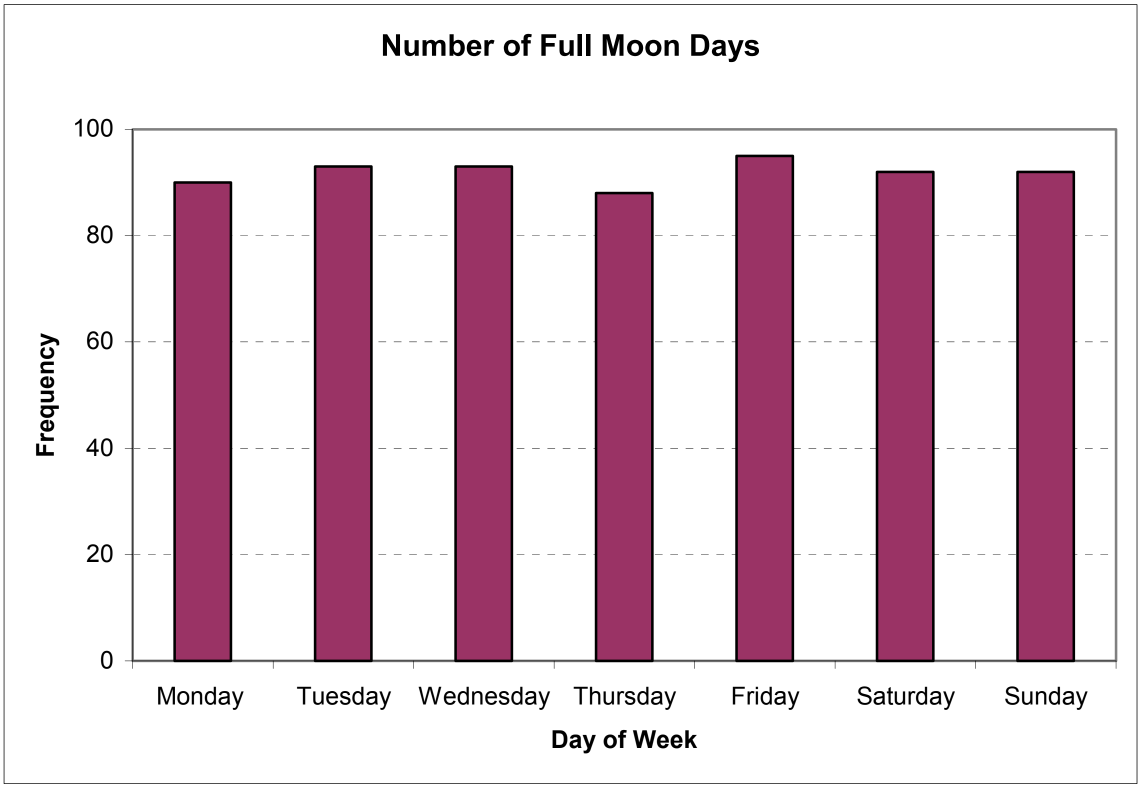


Figure 4
30-Day Cycles and Stock Returns

This figure graphs the estimates of a pooled regression with panel corrected standard errors (PCSE): $R_{it} = \alpha_i + \beta * 30daydummy_t + e_{it}$ for a 15-day window when we shift lunar phases by N calendar days. More specifically, we start a 30-day cycle N days after the first full moon (N=1 to 29), and then estimate the 30-day cycle effect for each specification. 30daydummy takes on a value of one for 7 days before the starting day + the starting day + 7 days after the starting day, and a value of zero otherwise. The lunar cycle is represented by N=0. The X-axis indicates 30-day cycles ordered by N. 0 represents the lunar month cycle. The Y-axis marks β estimates. The daily returns are in basis points.