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Is the Research Agenda for Calendar Anomalies "Much Ado About Nothing"?

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Abstract: Calendar anomalies are a class of financial market phenomena which links periodic, time-specific dummy variables and variations in the market price of an asset. Prior studies which report a calendar anomaly are seen by some as refutations of the efficient market hypothesis. In this paper, we estimate, test for the presence of, and find no evidence of, the day-the-week effects in the S&P 500, 2013-2023. That is, in this paper, we show that the daily-dummy variables (both individually and collectively) are independent of the S&P 500. This finding supports those who have argued that the day-the-week effects, and (by extension) all calendar anomalies, are "chimera delivered by intensive data mining" or, quite simply, such anomalies are "much ado about nothing".

Keywords: *Efficient market hypothesis, Behavioral finance, Calendar anomalies, Day-of-the-week effects, Ordinary least-squares estimation, Newey-West (1987) standard error correction, S&P 500 Index*

JEL Classification: *C22 (Time-Series Models), C52 (Model Evaluation, Validation, and Selection), and C58 (Financial Econometrics)*

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1. Introduction

In a recent review of the literature on calendar anomalies in asset markets, Patel and Sewell (2015) made it clear that (in general) calendar anomalies vary across time and space.[2] For example, many anomalies are known (or have been observed) to disappear, to reappear, and to reverse direction over time [e.g., Lakonishkov and Smidt (1988), Connolly (1989), Kohers et al. (2004), Marquering et al. (2006), Robins and Smith (2016), Kumar (2017), and Plastun et al. (2019)]. Likewise, many anomalies are known (or have been observed) to be present in one country, while (at the same time) to be absent in a second country [e.g., Agrawal and Tandon (1994), and Rossi and Gunardi (2018)]. In both cases, the research literature fails to offer its readers a definition of the causal mechanism, which would account for such facts or observations.

The great merit of the survey by Patel and Sewell (2015) is that it documents numerous examples of this fluidity or ephemerality of the calendar anomalies across time and space.[3] Eight of such examples are as follows:

- "Tryfonidis et al. (2007) analysed the Athens Stock Exchange during 1986–2006; they found that the day-of-the-week effect, a lunar effect and the interaction between the two were all significant. This was also confirmed by Tsangarakis (2007) who analysed the Athens Stock Exchange during 1981–2002; the author

[2] Other literature reviews include Pettengill (2003), Dzhabarov and Ziemba (2012), Rossi (2015), Kumar (2017), and Plastun et al. (2019).

[3] The ephemerality of calendar anomalies is reported in Mark Rubinstein's (2001) article in the Financial Analysts Journal. There he wrote: "The Monday effect is the strongest of the calendar anomalies. Although the U.S. stock market has risen at about 10 percent a year since 1928, the Friday close–Monday close three-day return has been negative ..." He continued: "Despite its persistence, the Monday effect is not large enough to support a profitable trading strategy if one assumes realistic trading costs. Sullivan, Timmerman, and White (1999) showed that the effect could easily be the result of data mining. They examined a large universe of potential calendar effects and argued that even an effect as strong as the Monday effect could easily occur by chance. Dumping more water on the calendar fire (and perhaps quenching it) is the fact that after 1987, the Monday effect disappeared. Indeed, for 1989–1998, not only have Monday returns been positive, but Monday has been the best day of the week." He then stated: "Fans of calendar effects should not despair, however, since a new effect has been inaugurated, the 'Thursday effect,' with negative returns over this recent 10-year period."

found a day-of-the-week effect, specifically a Monday effect, in the year 2001, and also found the reverse Monday effect in the years 1986 and 1990."

- "Significant positive monthly effects were found in Australia and Canada, whilst Japan's market had a negative monthly effect."
- "However, for Argentina, no day-of-the-week anomaly was observed. Whilst Kumar and Deo (2007) found positive Wednesday and negative Friday returns in the Indian market during 1997–2005. Agathee (2008) found higher Friday returns compared with other days in the Stock Exchange of Mauritius during 1998–2006; however, these returns were not statistically significant."
- "Singh (2014) did not find a month-of-the-year effect in Brazil, Russia, India or China during 2003–2013; however, he found a day-of-the-week effect on Tuesday returns in the Chinese stock market. Whilst Nath and Dalvi (2004) found a day-of-the-week effect in the Indian market with a significant Friday effect; this is also justified as Friday is the last trading day of the week. They also found higher standard deviations on Mondays and Fridays."
- "Boudreaux (1995) analysed Denmark, France, Germany, Norway, Singapore, Malaysia, Spain and Switzerland during 1978–1992 for the monthly effect, meaning that the returns are larger in the beginning of the month than for the middle or end of the month. Significant positive monthly effects were found in Australia and Canada, whilst Japan's market had a negative monthly effect."
- "Whilst Pandey (2004) found February and December effects in the Malaysian market during 1987–2002. Zafar et al. (2010) examined the Karachi Stock Exchange during 1991–2007; in terms of a month-of-the-year effect, they found negative returns in the month of May when compared with that of January. But, Al-Jafari (2011) analysed the Bahrain Stock Exchange during 2003–2011, and there were no significant differences with regard to the monthly effect of the daily returns of the Bahrain Bourse in the two studied periods; this is consistent with Ahmed et al. (2009) who analysed the Malaysian market. Patel (2011) analysed the Indian market during 1999–2007, and the mean returns for November and December were significantly greater than those for the other ten months."

- "Rossi (2008) examined Brazil, Mexico, Argentina and Chile during 1997–2006; Chile witnessed lowest returns on Mondays and positive returns on Wednesdays and Fridays. In Mexico, Wednesdays had the highest returns. However, for Argentina, no day-of-the-week anomaly was observed. Whilst Kumar and Deo (2007) found positive Wednesday and negative Friday returns in the Indian market during 1997–2005. Agathee (2008) found higher Friday returns compared with other days in the Stock Exchange of Mauritius during 1998–2006; however, these returns were not statistically significant."
- "Haroon and Shah (2013) examined the Karachi Stock Exchange and found no day-of-the-week effect for the period 2004–2007, but a negative Monday and positive Friday effect for the period 2008–2011."

The original impetus for the present study was the survey by Patel and Sewell (2015). Our first reading of Patel and Sewell (2015) led us to seriously question the validity and viability of the econometric methodology upon which the literature on calendar-anomalies is built. This questioning led to the following line of inquiry ..

- Our assessment of the literature is that at its core it is comprised of no more than the regression of a data vector which measures the changes in the value of an asset against a set of periodic calendar-dummy variables. This analysis has been done without the benefit of: (a) a definition of the causal mechanism, which links the changes in market values with the periodic calendar-dummy variables, and (b) the usual battery of (specification) tests. In the end, the tangible outputs of this sort of statistical endeavor amount to nothing more than: (a) the test results for the statistical significance of individual variates from a set of calendar-dummy variables, and (b) the haphazard reporting of the estimate of the coefficient of determination. In our review of the literature, we found that if the coefficient of determination was reported, then it was (more often than not) less than 0.01.
- Our assessment of the literature then led us to our recollection of, and our reflection on, a pithy aphorism by a former faculty member of Simon Fraser University, Peter Kennedy (1943-2010). This aphorism is: "Thou shalt not

confuse statistical significance with substance" [see Kennedy's (2002 and 2008) "ten commandments of applied econometrics"].

- In view of all of the above, we were then led to ask ourselves: does Kennedy's commandment apply to the literature on calendar anomalies, or not?[4]
- We concluded that Kennedy's commandment did apply. Why? After all, the literature calendar anomalies is predicated on scant little. In particular:
    - The literature has never offered its readership a definition of the causal mechanism which connects periodic calendar dates and market outcomes.[5]
    - At the level of individual studies, (a) it is true that a subset of the calendar-dummy variables have been shown to be statistically significant. (b) But it is equally true that, as mentioned already, if it is reported at all, the coefficient of determination is oftentimes less than 0.01.
    - At the aggregate level, the literature offers estimates of, and tests for, calendar anomalies which (as mentioned already) vary widely across time and space.

In view of all of the above, we were motivated to ask one core question: is the research agenda on calendar anomalies "much ado about nothing"? This we answered by testing

[4] Three aspects of the literature are difficult to accept. These are as follows: (a) The reporting of the coefficient of determination appears to be optional. (b) If it is reported, then oftentimes the coefficient of determination is less than 0.01. (c) If the coefficient of determination is reported, and if it less than 0.01, then the author-of-the-piece deserts his/her obligation to comment on the fact that an econometric model with an R-square of less than 0.01 is also an econometric model which does not account for 99% of the variation in the data. That is, the signal-to-noise ratio for this econometric model is near zero. It is against this backdrop that one sees the wisdom in Kennedy's aphorism: "Thou shalt not confuse statistical significance with substance".

[5] Three methodological comments are warranted here: (a) We embrace the traditional econometric perspective, which is that the definition of a viable and plausible data-generating mechanism (DGM) must come before any data analysis. (b) Alternatively, the apparent inability of the calendar-anomalies research community to define the mechanism which connects calendar dates and market outcomes effectively relegates the calendar anomalies research project to the status of data mining. (c) The difference between these two competing perspectives (viz., the traditional versus the data-mining perspective) is captured by Maurice Allais (1911-2010) in his Nobel Laureate Lecture. There, he stated: "My approach has always been based on a twofold conviction: the conviction that, without theory, knowledge evidently remains confused and that an accumulation of facts only constitutes a chaotic and unavoidably incomprehensible aggregate; and the even stronger conviction that a theory which cannot be confronted with the facts or which has not been verified quantitatively by observed data, is, in fact devoid of any scientific value." [Allais (1997)].

for the presence of the day-of-the-week effects in the S&P 500, 2013-2023? [6,7] In the remainder of this paper, we will argue that calendar anomalies are indeed “much ado about nothing”, because our analysis shows that the day-of-the-week variates (at both the individual and aggregate level) are independent of changes in the S&P 500. That is, we will show: (a) that the coefficients of determination are less than 0.01 in our two econometric models which do not have lagged-dependent variables, (b) that the coefficients of determination are less than 0.04 in our two econometric models which have lagged-dependent variables, and (c) that none of the calendar-dummy variates in all of our four econometric models (that is, whether with or without lagged-dependent variables) is statistically significant.

Further details on our methodology are as follows:…

- We began by defining a naïve, optimal model for the day-of-the-week effects [see Equation (1) below].
- This definition reminded us that any econometric model, which purports to be a daily model, cannot be a causal model if the daily data for the causal variates are unavailable, which we argue below is the case.
- In view of this, we then defined (what we saw as, and termed) four “‘sub-optimal models” for the day-of-the-week effects, in the sense that what we term sub-optimal are second best to our unattainable, naïve, optimal model.
- Then, using OLS, we estimated these four sub-optimal models [see Equations (2), (3), (4), and (5) below].
- Using the OLS results for Equations (2), (3), (4), and (5)]. we then tested three groups of hypotheses. A summary of these tests and our test results are as follows:

[6] The phrase, “much ado about nothing,” is used to describe the actions of someone, who is making a great fuss over something unimportant.

[7] To place “much ado about nothing” and econometrics in the same sentence brings to mind the claim that a calendar anomaly may be an illusion or (to quote Borges (2009)) a “chimera delivered by intensive data mining”. For more on data mining, and more on the intersection of the statistical analysis of calendar anomalies and data mining, see Agrawal and Tandon (1994), Rubinstein (2001), Sullivan et al. (2001), Borges (2009), Keogh (2011), Scarpa (2011), and Patel and Sewell (2015). Likewise, to place “much ado about nothing” and econometrics in the same sentence also brings to mind several critiques about the use and the abuse of econometric methods. These critiques include: Hendry (1980), Leamer (1983), McAleer et al. (1985), Kmenta (2011), Moosa (2017), Smith (2018a, 2018b, 2020, and 2021), Smith and Cordes (2019), and Sullivan et al. (2001).

- *Test 1:* In the case of Equations (2) and (4) [viz., the two regression models, without lagged-dependent variables], we found: (a) that the related R-squares were less than 0.01 and the related adjusted R-squares were 0.0000, and (b) that the null hypothesis that the independent variables (taken as a group) are independent of the market index was not rejected, on the basis of the F-test-for-overall-fit at the 1% level.
- *Test 2:* In the case of Equations (3) and (5) [viz., the two regression models, with lagged-dependent variables], we found: (a) that the related R-squares were less than 0.04 and the related adjusted R-squares were less than 0.0300, and (b) that the null hypothesis that the independent variables (taken as a group) are independent of the market index was rejected, on the basis of the F-test-for-overall-fit at the 1% level.
- *Test 3:* In the case of all of the four regression models, none of the individual daily-dummy variables were statistically significant, on the basis of the Newey-West t-test at the 1% level.

- In view of the above, we then conclude that there is no evidence of any day-of-the-week effects for the S&P 500, 2013-2023, and (on this basis) that the day-of-the-week effects for the S&P 500 are "much ado about nothing."

This paper is organized as follows. In Section 2, we define our theoretical framework. In Section 3, we describe the dataset that we used. In Section 4, we present our empirical results. Finally, in Section 5, we offer our summary remarks.

2. The Theoretical Framework

Let P_t denote the value of the S&P 500 Index on day t, where t = 1,T. Let P_{t-1} denote the value of the same index on day t-1. Finally, let $r_t = \ln(P_t / P_{t-1})$ denote the rate of return of the Index on day t, where t = 2,T.

2.1. Our Naïve, Optimal Model for the Day-of-the-Week Effects: Our naïve, optimal model for the day-of-the-week effects is defined as follows:

$$r_t = \alpha + \sum_{i-1}^{I} \beta_i X_{i,t} + \sum_{j=1}^{4} \delta_j r_{j-s} + \sum_{k=2}^{5} \phi_k D_{k,t}^{Day} + \sum_{l=2}^{12} \varphi_l D_{l,t}^{Month} + u_t \qquad (1)$$

where $X_{i,t}$ denotes the value of the ith causal variate on day t (whose inclusion in Equation (1) is justified only by reference to an a prior definition of a causal mechanism), where $D_{k,t}^{Day}$ denotes the kth daily-dummy variable for day t, and where $D_{l,t}^{Month}$ denotes the lth monthly-dummy variable for day t. The stochastic error term, u_t, in Equation (1) is assumed to satisfy the five standard or classical assumptions of regression analysis [Gujarati and Porter (2009)]. Next, we denote the coefficient of determination for Equation (1) as $R^2_{Equation\ (1)}$. Finally, we assume that $n>I+20$ and t = 5,T.

Regarding Equation (1), we offer these additional comments:

- Provided that: (a) the daily data for all of the causal variates (all of the Xs) are available, and (b) the supposed causal mechanism generates a falsifiable hypothesis for at least one of the causal variates of r_t then we term Equation (1) a well-defined econometric model. As such, then Equation (1) would invite one or more specification searches, such as Ramsey's (1969) Regression Specification Error Test (RESET).
- It is crucial to note here that the two sets of dummy variables in Equation (1) cannot be seen as causal variates of r_t. Rather, it is crucial to see that the two sets of dummy variables in Equation (1) must be seen as control variables or non-causal correlates, and hence as spurious correlates of r_t.[8]
- Clearly, if X_i is unknowable on a daily basis for all $i=1,I$ (which is the case), then $R^2_{Equation\ (1)}$ is also unknowable,

[8] In a classic article that appeared in JASA nearly seventy years ago, Herbert Simon (1954) defined spurious correlation as follows: "A spurious correlation is a situation in which two or more variables are statistically related, but in fact there is not any direct relation between them. This statistical relationship between two events may be caused by an unknown third variable, commonly called 'lurking variable'. In that case, the spurious correlation is often called "illusory correlation", because once we consider the third variable, the alleged relationship between the two original variables disappears." For more recent commentaries on the nature of spurious correlation, see Aldrich (1995), Haig (2007), Sheather (2011), Vigen (2015), and Calude and Longo (2017).

- In this paper, we maintain that X_i is unknowable on a daily basis, and all that this implies. One justification for this view is this two part argument: (a) Some financial analysts hold that two major drivers of changes in the S&P 500 Index are changes in the levels of corporate stock buybacks and dividend payments [Yardeni Research (2023)]. (b) However, it is not obvious to us how an econometrician might model and measure the effects of these two drivers on the S&P 500 on a daily basis.

2.2. Four Sub-optimal Models for the Day-of-the-Week Effects: Since the causal variables (the Xs) are not available on a daily basis (as argued above), our naïve, optimal model for the day-of-the-week effects [viz., Equation (1)] collapses to one of the following four sub-optimal regression models for the day-of-the-week effects, in the sense that all four of these regression models omit a vector of relevant variables:

Model 2: Since $X_{i,t}$ is unavailable on a daily basis, therefore $\beta_i = 0$ for all i. Furthermore, if $\delta_j = 0$ for all j and $\varphi_l = 0$ for all l, then Equation (1) reduces to:

$$r_t = \alpha + \sum_{k=2}^{5} \phi_k D_{k,t}^{Day} + u_t \tag{2}$$

Model 3: Since $X_{i,t}$ is unavailable on a daily basis, therefore $\beta_i = 0$ for all i. Furthermore, if $\varphi_l = 0$ for all l, then Equation (1) reduces to:

$$r_t = \alpha + \sum_{j=1}^{4} \delta_j r_{j\text{-}s} + \sum_{k=2}^{5} \phi_k D_{k,t}^{Day} + u_t \tag{3}$$

*Model 4***:** Since $X_{i,t}$ is unavailable on a daily basis, therefore $\beta_i = 0$ for all i. Furthermore, if $\delta_j = 0$ for all j, then Equation (1) reduces to:

$$r_t = \alpha + \sum_{k=2}^{5} \phi_k D_{k,t}^{Day} + \sum_{l=2}^{12} \varphi_l D_{l,t}^{Month} + u_t \tag{4}$$

Model 5: Since $X_{i,t}$ is unavailable on a daily basis, therefore $\beta_i = 0$ for all i, and then Equation (1) is:

$$r_t = \alpha + \sum_{j=1}^{4} \delta_j r_{j-s} + \sum_{k=2}^{5} \phi_k D_{k,t}^{Day} + \sum_{l=2}^{12} \varphi_l D_{l,t}^{Month} + u_t \tag{5}$$

The following is worth noting:

- In our view, the appropriate descriptor of each of Equations (2) (3) (4) or (5) is a spurious regression model, in the sense that these equations do not contain the causal variates (the Xs), or in the sense that $\beta_i = 0$ for all i is accepted for all four equations. [9] Instead, these four equations contain only dummy variables as explanatory variables, which (as noted above) must be seen as non-causal variates or spurious variates.
- Let the coefficients of determination associated with Equation (2), Equation (3), Equation (4), and Equation (5) be defined as $R^2_{Equation\ (2)}$, $R^2_{Equation\ (3)}$, $R^2_{Equation\ (4)}$, and $R^2_{Equation\ (5)}$.
- It should be noted that (in the literature) Equation (2) is the most popular specification for estimating and for testing the day-of-of-the-week effects. Examples of this specification include Brooks (2019), and Brooks and Persand (2001).

[9] The most widely-accepted definition of the term spurious regression is due to Granger and Newbold (1974). They define spurious regression when non-stationary data vectors are used in a regression model. In this event, a high R2-value may be obtained even if there is no causal relationship between the variables [Giles (2007)]. For more on spurious regression and spurious correlation, see Yule (1926), Hendry (1980), Ferson et al. (2003), Gujarati and Porter (2009, Chapter 21), Ventosa-Santaularia (2009, especially "Section 4. Spurious regression since the roaring twenties"), Swamy et al. (2019), and Smith (2020). In this paper, we maintain that the introduction of a second definition (and a more general definition) of spurious regression would prove useful. In particular, unlike Granger and Newbold (1974), this second definition is not predicated on non-stationary data vectors. Instead, this second definition of spurious regression captures the case of a regression model, in which the dependent variable is stationary and the independent variables contain a set of periodic, time-specific dummy variables. Within this analytical framework, it is clear that variations in the periodic, time-specific dummy variables do not (in any real sense) cause variations in the dependent variable. In other words, any statistical relationship between the periodic, time-specific dummy variables and variations in the dependent variable must necessarily be a spurious relationship, and this spurious relationship is due to the inability of the analyst to define a physical mechanism which links the periodic, time-specific dummy variables and variations in the dependent variable.

- It should also be noted that (in the literature) Equation (3) is a popular specification, but not as popular as Equation (2). Examples of this specification include Abrahamsson and Creutz (2018), Apolinario et al. (2006), Berument and Kyimaz (2001), Corredor and Santamaría (1996), Easton and Faff (1994), and Kiymaz and Berument (2003).
- Finally, it should also be noted that we have yet to find (in the literature) any examples which use Equation (4) or Equation (5).

3. The Dataset

The dataset, and of the statistical features of the dataset, used in this paper are described in this section,

3.1. The Dataset: The daily data for the S&P 500 Index were retrieved from an online database operated by the Federal Reserve Bank of St. Louis [viz., Federal Reserve Economic Data or FRED]. Moreover, the time span of our dataset ranges from February 25th, 2013 to February 23rd, 2023.

3.2. A Summary of the Statistical Properties of The Rate of Return of the S&P 500 Index, 2013-2022: The statistical properties of the rate of return of the S&P 500 Index, 2013-2022, are reported in Table 1:

(insert Table 1 here)

Likewise, the statistical properties of the rate of return of the S&P 500 Index, 2013-2022, by the day of the week are reported in Table 2:

(insert Table 2 here)

4. The Empirical Results

In this section, we estimate, and test for, the effect of the daily-dummy variables on the S&P 500 Index under four scenarios [viz., Equations (2), (3), (4), and (5)]. In all four scenarios, we show that the daily-dummy variables (both individually and collectively) are unrelated to, or uncorrelated with, the S&P 500 Index.

4.1. The Empirical Results for Model 2 or Equation (2): To remind, Equation (2) is defined as:

$$r_t = \alpha + \sum_{k=2}^{5} \phi_k D_{k,t}^{Day} + u_t \qquad (2)$$

The Statistical Significance of the Individual Variates in Equation (2): None of the daily-dummy variables in this model (that is, none of the ϕ_is in Equation (2), as well as the intercept, α) are statistically significant, on the basis of the Newey-West t-test at the 1% level. [10,11]

The Goodness-of-Fit for, and the Statistical Significance of, Equation (2): Two measures of the goodness-of-fit of, and the statistical significance of one measure of the goodness-of-fit for, Equation (2) are as follows:

$R^2_{\text{Equation (2)}} = 0.0009$ Adjusted-$R^2_{\text{Equation (2)}} = 0.0000$

$\hat{F}_{\text{Equation (2)}} = 0.574$ $F^c_{\alpha,k-1,n-k} = F^c_{.01,15,2500} \approx F^c_{.01,15,\infty} = 2.040$

In summary, we conclude that our estimate of Equation (2) is due to chance.

4.2. The Empirical Results for Model 3 or Equation (3): To remind, Equation (3) is defined as:

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[10] The following methodology has been applied to all four of our econometric models, viz., Models 2 to 5: The Newey-West standard error estimator was used when there was evidence of both autocorrelation and heteroskedasticity in the residuals. In the present case, evidence of autocorrelation and heteroskedasticity in the residuals took these two forms: (a) Using the Ljung-Box Q-test, we found that (in the case of residual autocorrelation with 1 through 5 lags) the null hypothesis of no autocorrelation is not rejected. (b) Using the Ljung-Box Q-test, we also found that (in the case of residual autocorrelation with 6+ lags) the null hypothesis of no autocorrelation is rejected. (c) Using the Engle test for residual heteroskedasticity, we found that the null hypothesis of no conditional heteroskedasticity is rejected.

[11] The critical value for all t-tests reported in this paper is $t^c_{\alpha/2,\ n-k} = t^c_{0.005,\ 2500} \approx t^c_{0.005,\ \infty} = 2.576$

$$r_t = \alpha + \sum_{j=1}^{4} \delta_j r_{j\text{-}s} + \sum_{k=2}^{5} \phi_k D_{k,t}^{Day} + u_t \qquad (3)$$

The Statistical Significance of the Individual Variates in Equation (3):

- None of the daily-dummy variables in this model (namely, none of the ϕ_js in Equation (3), as well as the intercept, α) are statistically significant, on the basis of the Newey-West t-test at the 1% level.
- Three of the four lagged-dependent variables in this model (namely, three of δ_ss in Equation (3)) are significant, on the basis of the Newey-West t-test at the 1% level.

The Goodness-of-Fit for, and the Statistical Significance of, Equation (3): Two measures of the goodness-of-fit of, and the statistical significance of one measure of the goodness-of-fit for, Equation (3) are as follows:

$R^2_{\text{Equation (3)}} = 0.0304$ Adjusted-$R^2_{\text{Equation (3)}} = 0.0273$

$\hat{F}_{\text{Equation (3)}} = 9.8100$ $F^c_{\alpha,k-1,n-k} = F^c_{.01,8,2500} \approx F^c_{.01,8,\infty} = 2.510$

We conclude that our estimate of Equation (3) is not due to chance. But we also conclude that this outcome is attributable to the presence of the lagged-dependent variables.

4.3. The Empirical Results for Model 4 or Equation (4): To remind, Equation (4) is defined as:

$$r_t = \alpha + \sum_{k=2}^{5} \phi_k D_{k,t}^{Day} + \sum_{l=2}^{12} \varphi_l D_{l,t}^{Month} + u_t \qquad (4)$$

The Statistical Significance of the Individual Variates in Equation (4):

- None of the daily-dummy variables in this model (namely, none of the ϕ_js in Equation (4)), as well as the intercept, α) are statistically significant, on the basis of the Newey-West t-test at the 1% level.

- None of the monthly-dummy variables in this model (that is, none of the φ_ls in Equation (4), as well as the intercept, α) are statistically significant, on the basis of the Newey-West t-test at the 1% level.

The Goodness-of-Fit for, and the Statistical Significance of, Equation (4): Two measures of the goodness-of-fit of, and the statistical significance of one measure of the goodness-of-fit for, Equation (4) are as follows:

$R^2_{\text{Equation (4)}} = 0.0043$ Adjusted-$R^2_{\text{Equation (4)}} = 0.0000$

$\hat{F}_{\text{Equation (4)}} = 0.7260$ $F^c_{\alpha,k-1,n-k} = F^c_{.01,15,2500} \approx F^c_{.01,15,\infty} = 2.040$

In summary, we conclude that our estimate of Equation (4) is due to chance.

4.4. The Empirical Results for Model 5 or Equation (5): To remind, Equation (5) is defined as:

$$r_t = \alpha + \sum_{j=1}^{4} \delta_j r_{j-s} + \sum_{k=2}^{5} \phi_k D^{\text{Day}}_{k,t} + \sum_{l=2}^{12} \varphi_l D^{\text{Month}}_{l,t} + u_t \quad (5)$$

The Statistical Significance of the Individual Variates in Equation (5):

- None of the daily-dummy variables in this model (that is, none of the ϕ_ks in Equation (5), as well as the intercept, α) are statistically significant, on the basis of the Newey-West t-test at the 1% level.
- None of the monthly-dummy variables in this model (that is, none of the φ_ls in Equation (5), as well as the intercept, α) are statistically significant, on the basis of the Newey-West t-test at the 1% level.
- Two of the four lagged-dependent variables in this model (that is, two of the δ_js in Equation (5)) are significant, on the basis of the Newey-West t-test at the 1% level.

The Goodness-of-Fit for, and the Statistical Significance of, Equation (5): Two measures of the goodness-of-fit of, and the statistical significance of one measure of the goodness-of-fit for, Equation (5) are as follows:

$R^2_{\text{Equation (5)}} = 0.0349$ $\quad$ Adjusted-$R^2_{\text{Equation (5)}} = 0.0276$

$\hat{F}_{\text{Equation (5)}} = 4.7500$ $\quad$ $F^c_{\alpha,k-1,n-k} = F^c_{.01,15,2500} \approx F^c_{.01,15,\infty} = 2.040$

We conclude that our estimate of Equation (5) is not due to chance. But we also conclude that this outcome is attributable to the presence of the lagged-dependent variables.

5. Summary Remarks

The purpose of the present paper is limited to answering one question: is literature on calendar anomalies "much ado about nothing"? This question was addressed by testing for the presence of the day-of-the-week effects in the S&P 500, 2013-2023, across five potential econometric models.

Our analysis of the results for these five potential models was organized as follows. In Section 2, we defined our theoretical framework. In Section 3, we described the dataset that we used. In Section 4, we presented the empirical results (or lack thereof) for these models. In particular,

- Because of the unavailability of daily data for the causal variates, we ruled out the first model [viz., Equation (1)] as unworkable or infeasible.
- We then proceeded to use OLS to estimate the remaining four models [viz., Equations (2), (3), (4), and (5)].
- In the case of all of these four models, we performed three types of tests. These tests and our test results are as follows:
    - *Test 1:* In the case of Equations (2) and (4) [viz., the two regression models, without lagged-dependent variables], we found: (a) that the related R-squares were less than 0.01 and the related adjusted R-squares were 0.0000, and (b) that the null hypothesis that the independent variables (taken as a group) are independent of the market index was not rejected, on the basis of the F-test-for-overall-fit at the 1% level.

- *Test 2:* In the case of Equations (3) and (5) [viz., the two regression models, with lagged-dependent variables], we found: (a) that the related R-squares were less than 0.04 and the related adjusted R-squares were less than 0.0300, and (b) that the null hypothesis that the independent variables (taken as a group) are independent of the market index was rejected, on the basis of the F-test-for-overall-fit at the 1% level.
- *Test 3:* In the case of all of the four regression models, none of the individual daily-dummy variables were statistically significant, on the basis of the Newey-West t-test at the 1% level.

In view of all of the above, we conclude that there was no evidence of any day-of-the-week effects for the S&P 500, 2013-2023. We conclude this because the daily-dummy variables (both individually and collectively) were shown to be uncorrelated to the S&P 500, 2013-2023.

References

Abrahamsson, A., and S. Creutz (2018), Stock Market Anomalies: The Day-Of-The-Week-Effect -- An empirical study on the Swedish Stock Market: A GARCH Model Analysis, Jönköping International Business School (JIBS), Jönköping University.

Agrawal, A., and K. Tandon (1994), "Anomalies of illusions? Evidence from stock markets in eighteen countries," Journal of International Money and Finance 13 (1), 83–106.

Aldrich, J. (1995), "Correlations genuine and spurious in Pearson and Yule," Statistical Science 10 (4), 364-376.

Allais, M. (1997), "An outline of my main contributions to economic science," American Economic Review 87 (6), 3-12.

Apolinario, R.M.C., O.M. Santana, L.J. Sales, and A.R. Caro (2006), "Day of the week effect on European stock markets," International Research Journal of Finance and Economics 2.

Berument, H., and H. Kyimaz (2001), "The day of the week effect on stock market volatility," Journal of Economics and Finance 25 (2), 181-193.

Borges, M.R. (2009), "Calendar effects in stock markets: Critique of previous methodologies and recent evidence in European countries," Working Paper, Lisbon School of Economics and Management, Universidade de Lisboa.

Brooks, C. (2019), Introductory Econometrics for Finance, 4th edition (Cambridge: Cambridge University Press).

Brooks, C., and G. Persand (2001), "Seasonality in Southeast Asian stock markets: Some new evidence on day-of-the-week effects?," Applied Economics Letters 8, 155-158.

Calude, C.S., and G. Longo (2017), "The deluge of spurious correlations in big data," Foundations of Science 22 (3), 595-612.

Connolly, R.A. (1989), "An examination of the robustness of the weekend effect," Journal of Financial and Quantitative Analysis 24 (2), 133-169.

Corredor, P., and R. Santamaría (1996), "El efecto día de la semana: Resultados sobre algunos mercados de valores Europeos," Revista española de Financiación y Contabilidad XXV (86), 235-252

Dzhabarov, C.S., and W.T. Ziemba (2012), "Calendar anomalies." Chapter 1 in Calendar Anomalies and Arbitrage (Singapore: World Scientific Publishing), 1-81

Easton, S., and R. Faff (1994), "An examination of the robustness of the day of the week effect in Australia," Applied Financial Economics (4), 99-110.

Ferson, W.E., S. Sarkissian, and T. Simin (2003), "Spurious regressions in financial economics?," Journal of Finance 58, 1393-1413.

Giles, D. (2007), "Spurious regressions with time-series data: Further asymptotic results," Communications in Statistics: Theory and Methods 36 (5), 967-979.

Granger, C.W.J., and P. Newbold (1974), "Spurious regressions in econometrics," Journal of Econometrics 2, 111-120.

Gujarati, D.N., and D.C. Porter (2009), Basic Econometrics. 5th edition (Boston: McGraw-Hill).

Haig, B. (2007), "Spurious correlation," in N. Salkind, ed., Encyclopedia of Measurement and Statistics (Thousand Oaks, CA: Sage), 937-940.

Hendry, D.F. (1980), "Econometrics: Alchemy or science?," Economica 47 (188), 387-406.

Kennedy, P. (2002), "Sinning in the basement: What are the rules? The ten commandments of applied econometrics," Journal of Economic Surveys 16 (4): 569–589.

Kennedy, P. (2008), A Guide to Econometrics, 6th edition (Cambridge, MA: Wiley-Blackwell).

Keogh, E.J. (2011), "Data mining time series data," in E.S. Ahmed, E. Raheem, S. Hossain, and M. Lovric, editors, International Encyclopedia of Statistical Science (Berlin: Springer), 339-342.

Kiymaz, H. and H. Berument (2003), "The day-of-the-week effect on stock market volatility and volume: International evidence," Review of Financial Economics 12, 363-380.

Kmenta, J. (2011), "Econometrics: A failed science?," in E.S. Ahmed, E. Raheem, S. Hossain, and M. Lovric, editors, International Encyclopedia of Statistical Science (Berlin: Springer), 412-415.

Kohers, G., N. Kohers, V. Pandey, and T. Kohers (2004), "The disappearing day-of-the-week effect in the world's largest equity markets," Applied Economics Letters 11, 167–171.

Kumar, S. (2017), "A review on the evolution of calendar anomalies," Studies in Business and Economics 12 (1).

Lakonishkov, J., and S. Smidt (1988), "Are seasonal anomalies real? A ninety year perspective," Review of Financial Studies 1 (4), 403-425.

Leamer, E.E. (1983), "Let's take the con out of econometrics," American Economic Review 73 (1), 31-43.

Marquering, W., J. Nisser, and T. Valla (2006), "Disappearing anomalies: A dynamic analysis of the persistence of anomalies," Applied Financial Economics 16 (4), 291-302.

McAleer, M., A. Pagan, and P. Volker (1985), "What will take the con out of econometrics?," American Economic Review 75 (3), 293-307.

Moosa, I.A. (2017), Econometrics as a Con Art: Exposing the Limitations and Abuses of Econometrics (Cheltenham, UK: Edward Elgar Publishing)

Newey, W.K., and K.D. West (1987), "A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix,' Econometrica 55 (3), 703-708.

Patel, N., and M. Sewell (2015), "Calendar anomalies: A survey of the literature," International Journal of Behavioural Accounting and Finance 5 (2), 99-121

Pettengill, G.N. (2003), "A survey of the Monday effect literature," Quarterly Journal of Business and Economics 42 (3/4), 3-27

Plastun, A., X. Sibande, R. Gupta, and M.E. Wohar (2019), "Rise and fall of calendar anomalies over a century," North American Journal of Economics and Finance 49, July, 181-205.

Ramsey, J.B. (1969), "Tests for specification error in classical linear least squares regression analysis," Journal of the Royal Statistical Society, Series B 31, 350-371.

Robins, R.P., and G.P. Smith (2016), "No more weekend effect," Critical Finance Review 5, 417-424

Rossi, M. (2015), "The efficient market hypothesis and calendar anomalies: A literature review," International Journal of Managerial and Financial Accounting 7 (3/4), 285-296.

Rossi, M., and A. Gunardi (2018), "Efficient market hypothesis and stock market anomalies: Empirical evidence in four European countries," Journal of Applied Business Research 34 (1), 183-192.

Rubinstein, M. (2001). "Rational markets: Yes or no? The affirmative case," Financial Analysts Journal 57 (3), 15-29.

Scarpa, B. (2011), "Data mining," in E.S. Ahmed, E. Raheem, S. Hossain, and M. Lovric, editors, International Encyclopedia of Statistical Science (Berlin: Springer), 336-339.

Sheather, S.J. (2011), "Spurious correlation," in E.S. Ahmed, E. Raheem, S. Hossain, and M. Lovric, editors, International Encyclopedia of Statistical Science (Berlin: Springer), 1374-1377.

Simon, H. (1954), "Spurious correlation: A causal interpretation," Journal of the American Statistical Association 49 (267), 467-479.

Smith, G. (2018a), "Step away from stepwise," Journal of Big Data 5 (32).

Smith, G. (2018b), The AI Delusion (Oxford: Oxford University)

Smith, G. (2020), "Data mining fool's gold," Journal of Information Technology 35, 182-194.

Smith, G. (2021), "The paradox of big data," SN Applied Sciences 2, 1-8.

Smith, G., and J. Cordes (2019), The 9 Pitfalls of Data Science (Oxford: Oxford University Press).

Sullivan, R., A. Timmermann, and H. White (2001), "Dangers of data mining: The case of calendar effects in stock returns," Journal of Econometrics 105: 249-86.

Swamy, P., P. von zur Muehlen, J.S. Mehta, and I-Lok Chang (2019), "Spurious regressions in econometrics: Reconsideration," Available at SSRN.

Ventosa-Santaularia, D. (2009), "Spurious regression," Journal of Probability and Statistics, Article ID 80297.

Vigen, T. (2015), Spurious Correlations (Nashville, TN: Hachette Books).

Yardeni Research, Inc. (2023), S&P 500 Buybacks & Dividends, Glen Head, New York, March 24.

Yule, G.U. (1926), "Why do we sometimes get nonsense-correlations between time-series? A study in sampling and the nature of time-series." Journal of the Royal Statistical Society 89 (1), 1-69.

Table 1:
A Statistical Summary of the Dependent Variable

Mean	0.03941%
Standard deviation	1.116%
Skewness	- 0.8313
Kurtosis	19.38
Minimum	- 12.77%
Maximum	8.968%
Sample Size	2517

Table 2:
A Statistical Summary of The Dependent Variable
By the Day of the Week

	Monday	Tuesday	Wednesday	Thursday	Friday
No of observ	471	519	516	508	503
Mean	-0.009936%	0.07675%	0.07192%	-0.01010%	0.04336%
Std	1.245%	1.047%	1.057%	1.1370%	1.098%
Skewness	-2.712	1.331	-0.4901	-1.644	0.4833
Kurtosis	31.29	15.75	7.8453	18.73	12.34
Maximum	6.797%	8.968%	4.840%	6.054%	8.881%
Minimum	-12.77%	-4.420%	-5.322	-9.994%	-4.433%

Declarations

- **List of abbreviations** - Not applicable
- **Ethics approval and consent to participate** - Not applicable
- **Consent for publication** - Not applicable
- **Availability of data and materials -** Via the Federal Reserve Bank of St. Louis' FRED database and/or the first author's MS OneDrive account.
- **Competing interests -** None or not applicable
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- **Authors' contributions** – RS was responsible for the overall conceptualization and execution of the paper. This includes the review of the literature, and the preparation of all drafts of the paper (from start to finish). GG gathered the data from FRED, ran the OLS regression equations on MATLAB, and then offered comments on all drafts of the paper. Both authors read and approved the final manuscript.
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