The Journal of Applied Business Research - Fall 1987

ON THE DAY OF THE WEEK EFFECT: AN EXAMINATION OF INTRADAY PRICES FOR THE S&P 500 FUTURES CONTRACT

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Abstract

Research into the day of the week effect focuses on systematic price movements from close to close in the cash market and from settle to settle in the futures markets. This research investigates the day of the week effect using a variety of intraday data in determining price movements. The following results demonstrate that the conclusions from day of the week effect research predicate on the measurement interval and may, therefore, be spurious.

INTRODUCTION

The finance literature is replete with anomalous evidence related to the day of the week effect in the various investment arenas: in the S&P Composite [Cross, 1973; French, 1980; Gibbons and Hess, 1981; and Junkus, 1986], on the NYSE, AMEX, OTC markets, [Cross, 1973; French, 1980; Lakonishok and Levi, 1982; and Keim and Stambaugh, 1984], the T-bill market [Gibbons and Hess, 1981]; and the gold market [Booth and Kaen, 1979; and Wa, 1986].

Numerous explanations for these anomalies have been posited ranging from depression over the weekend [Conine, Giaccotto and Tamarkin, 1984] to stock settlement procedures [Gibbons and Hess, 1981] to errors in measurement [Keim and Stambaugh, 1984]. The purpose of this paper is to investigate another explanation for these anomalies. More specifically, this paper will examine the selection of the measurement period for the returns used in the testing procedures as it relates to the day of the week effect.

Most researchers measure returns from the closing price (or settlement price) from day t-1 to the closing price on day t. Implicit in the procedure is the assumption that price changes are monotonic. That is to say, the price increases (or decreases) continuously from day t-1 to day t. Evidence provided in a later section of this paper will demonstrate that this assumption is untenable; for an overwhelming majority of days, the high (low) on day t exceeds (is less than) the close from day t-1. Consequently, any results obtained from using only settlement prices may be spurious.

The next section defines the return generating process for asset returns and describes the data set used in the subsequent tests. Section two contains an explanation of the trading hypotheses examined in this research -- the trading time hypothesis and the calendar time hypothesis. The third section includes a summary of the returns by day of the week. Sections four and five contain the results of the tests of the trading time hypothesis and the calendar time hypothesis, respectively. The paper closes with a summary.

I. RETURN GENERATING PROCESS FOR ASSETS

The returns on any assets are assumed (1) to be drawn from a distribution of returns with a constant expected return and a constant variance and (2) to follow a random walk with a continuously compounded expected return in the form:

$$R(t) = \ln[P(t)/P(t-1)] = E[R(t)] + e(t)$$

where P(t) is the settlement price on day t, E[R(t)] is the expected return on day t, and e(t) is the mean zero, serially independent error term.

Daily data was obtained from the prices listed in The Wall Street Journal for the period 28 March, 1986 through 30 January, 1987. In addition to the closing prices for the S&P 500 cash; open, high, low, and settle prices were also obtained for the S&P 500 futures contracts; however, two problems were encountered during the selection of which futures contract to employ.

First, depending on the nature of the trading in a particular contract, the settlement price will either be market determined (for actively traded contracts) or will be made by committee (for less actively traded contracts) [Kolb, 1985]. Since the purpose of this research is to examine the market's pricing mechanism, only those contracts which are determined to be market settled should be considered. Second, Samuelson [1965] argues that the variance in the pricing of the futures contract increases as the term to maturity decreases. Since the above model assumes and constant variance, following a single contract through time would violate the constant variance assumption of the model. For the above reasons, the price information on the near term S&P 500 contract was collected -- for April and May, the June contract is the near term; for June, July, and August, the September contract information was obtained etc. With this method, market settled contracts with a reasonably constant time to maturity are used.

II. TRADING HYPOTHESES

Two alternative scenarios are generally tested when examining the return generating process. First, the trading time hypothesis assumes that the distribution of the returns is expected to be constant regardless of the day of the week. This follows since prices technically change only during the hours of trading. For this to hold, the returns for each day of the week must be identically distributed.

The second hypothesis, the calendar time hypothesis, contends that prices change continuously; even if trading has ceased for the weekend or a holiday. Therefore, the return obtained when measuring price changes from Friday to Monday should reflect three days of return; the two weekend days plus the trades for Monday. The remaining days of the week will only reflect one day's trading. Of course, if the markets are closed for a holiday, the return for the day following the holiday would reflect a two day return. To properly examine the calendar time hypothesis, as it applies to the day of the week effect, the day following any holiday was eliminated from the analysis. This brought the total number of observations in the data set to 206.

III. RESULTS -- INTRADAY PRICE MOVEMENTS

Table 1 contains the average returns, by day of the week, from close to close for the cash market as well as return information from the settle on day t-1 to the high, the low, the open and the settle for day t; from the high on day t-1 to the high, the low, the open and the settle for day t; from the low on day t-1 to the high, the low, the open and the settle for day t; and

Table 1

Average Return and Standard Deviation by Day of the Week for the S&P 500 Cash Index and Selected Futures

P(t-1)/P(t)	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
CLOSE/HIGH	0.00141 (0.0039)*	0.00146 (0.0035)	0.001733 (0.00350)	0.00145 (0.0039)	0.00130 (0.0006)
CLOSE/LOW	-0.00156 (0.0057)	-0.00156 (0.0055)	-0.001156 (0.00426)	-0.00167 (0.0069)	-0.00166 (0.0060)
CLOSE/OPEN	-0.00004 (0.0033)	-0.00006 (0.0016)	0.000006 (0.00145)	-0.00003 (0.0015)	0.00001 (0.0013)
CLOSE/CLOSE	0.00039 (0.0049)	0.00013 (0.0047)	0.000659 (0.00342)	-0.00006 (0.0063)	-0.00033 (0.0044)
HIGH/HIGH	-0.00024 (0.0048)	0.00024 (0.0048)	0.000289 (0.00376)	0.00044 (0.0036)	-0.00009 (0.0047)
HIGH/LOW	-0.00321 (0.0097)	-0.00279 (0.0087)	-0.002601 (0.00798)	-0.00268 (0.0088)	-0.00305 (0.0101)
HIGH/OPEN	-0.00169 (0.0069)	-0.00128 (0.0053)	-0.001438 (0.00554)	-0.00105 (0.0043)	-0.00139 (0.0057)
HIGH/CLOSE	-0.00126 (0.0069)	-0.00109 (0.0069)	-0.000785 (0.00055)	-0.00107 (0.0072)	-0.00173 (0.0079)
LOW/HIGH	0.00280 (0.0067)	0.00344 (0.0078)	0.003445 (0.00714)	0.00320 (0.0073)	0.00276 (0.0067)
LOW/LOW	-0.00017 (0.0046)	0.00042 (0.0049)	0.000556 (0.00327)	0.00008 (0.0059)	-0.00020 (0.0038)
LOW/OPEN	0.00135 (0.0042)	0.00192 (0.0044)	0.001718 (0.00378)	0.00172 (0.0041)	0.00146 (0.0036)
LOW/CLOSE	0.00178 (0.0062)	0.00212 (0.0069)	0.002372 (0.00561)	0.00169 (0.0073)	0.00112 (0.0043)
OPEN/HIGH	0.00114 (0.0055)	0.00173 (0.0072)	0.001827 (0.00614)	0.00212 (0.0061)	0.00129 (0.0066)
OPEN/LOW	-0.00183 (0.0078)	-0.00129 (0.0080)	-0.001062 (0.00680)	-0.00100 (0.0072)	-0.00167 (0.0083)

Table 1 continued

Average Return and Standard Deviation
by Day of the Week for the S&P 500
Cash Index and Selected Futures

P(t-1)/P(t)	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
OPEN/OPEN	-0.00031 (0.0057)	0.00022 (0.0061)	0.000100 (0.00539)	0.00063 (0.0039)	-0.00001 (0.0054)
OPEN/CLOSE	0.00012 (0.0064)	0.00041 (0.0076)	0.000754 (0.00597)	0.00061 (0.0073)	-0.00034 (0.0071)
CASH MARKET	0.00002 (0.0041)	0.00029 (0.0048)	0.000514 (0.00396)	0.00002 (0.0054)	-0.00005 (0.0034)

* Standard Deviation of Daily Return

Table 2

Results of Tests of the Trading Time Hypothesis

R(t) = b(0) + b(2)D(2t) + b(3)D(3t) + b(4)D(4t) + b(5)D(5t) + e(t)

	b(0)	b(2)	b(3)	b(4)	b(5)	
P(t-1)/P(t)	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	F-Statistic
CLOSE/HIGH	0.00725 (6.70)*	-0.00025 (-0.17)	0.00086 (0.58)	0.00004 (0.03)	-0.00019 (-0.12)	0.18
CLOSE/LOW	-0.00806 (-6.10)	0.00055 (0.30)	0.00262 (1.44)	-0.00035 (-0.19)	-0.00096 (-0.51)	1.14
CLOSE/OPEN	-0.00213 (-0.31)	-0.00003 (-0.06)	0.00024 (0.25)	0.00005 (0.05)	0.00021 (0.22)	0.04
CLOSE/CLOSE	0.00200 (1.16)	-0.00136 (-0.57)	0.00109 (0.46)	-0.00228 (-0.94)	-0.00381 (-1.55)	1.26
HIGH/HIGH	-0.00125 (-0.80)	0.00239 (1.10)	0.00260 (1.20)	0.00345 (1.57)	0.00078 (0.35)	0.82

Table 2 continued

Results of Tests of the Trading Time Hypothesis

R(t) = b(0) + b(2)D(2t) + b(3)D(3t) + b(4)D(4t) + b(5)D(5t) + e(t)

	b(0)	b(2)	b(3)	b(4)	b(5)	
P(t-1)/P(t)	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	F-Statistic
HIGH/LOW	-0.01654 (-8.89)	0.00319 (1.23)	0.00436 (1.70)	0.00306 (1.17)	0.00001 (0.00)	1.18
HIGH/OPEN	-0.00871 (-6.30)	0.00259 (1.35)	0.00198 (1.04)	0.00346 (1.78)	0.00118 (0.60)	0.93
HIGH/CLOSE	-0.00650 (-3.11)	0.00128 (0.44)	0.00282 (0.98)	0.00113 (0.38)	-0.00284 (-0.95)	1.02
LOW/HIGH	0.01440 (9.76)	0.00209 (1.02)	0.00173 (0.85)	0.00168 (0.81)	0.00057 (0.27)	0.37
LOW/LOW	-0.00088 (-0.54)	0.00289 (1.26)	0.00349 (1.53)	0.00129 (0.56)	-0.00020 (-0.08)	1.06
LOW/OPEN	0.00694 (5.96)	0.00228 (1.41)	0.00111 (0.69)	0.00169 (1.03)	0.00097 (0.58)	0.55
LOW/CLOSE	0.00915 (4.71)	0.00098 (0.36)	0.00195 (0.73)	-0.00064 (-0.24)	-0.00306 (-1.10)	0.96
OPEN/HIGH	0.00589 (2.82)	0.00242 (0.83)	0.00267 (0.92)	0.00475 (1.62)	0.00113 (0.38)	0.74
OPEN/LOW	-0.00942 (-4.08)	0.00322 (1.00)	0.00443 (1.39)	0.00437 (1.35)	0.00036 (0.11)	0.88
OPEN/OPEN	-0.00158 (-0.83)	0.00262 (0.99)	0.00205 (0.78)	0.00476 (1.77)	0.00153 (0.56)	0.84
OPEN/CLOSE	0.00064 (0.26)	0.00131 (0.38)	0.00289 (0.85)	0.00243 (0.70)	-0.00250 (-0.70)	0.76
CASH MARKET	0.00012 (0.08)	0.00124 (0.56)	0.00228 (1.04)	-0.00004 (-0.02)	-0.00041 (-0.18)	0.52

* t-statistic for coefficient

from the open on day t-1 to the high, the low, the open and the settle for day t. In addition, Table 1 also contains the standard deviations for the returns for each day of the week for the various approaches to measuring returns.

As expected, the data indicates that the return earned over any period depends on the price paid when buying and the price received when selling. If a trader bought a near term contract every Friday at the close and sold the contract at the high price the following Monday, on average, the trader would earn 0.141% per contract. Comparing the CLOSE/HIGH information and the CLOSE/LOW statistics demonstrates that the high on day t exceeds the close from day t-1 and the low on day t is less than the close on day t-1. These results indicate that the price changes from day t-1 to day t are not monotonic. Therefore, the implied assumption in previous research about the behavior of prices from day to day is not supported.

IV. RESULTS -- TRADING TIME HYPOTHESIS

The following regression model was employed to test the trading time hypothesis:

$$R(t) = b(0) + b(2)D(2t) + \ldots + b(5)D(5t) + e(t)$$

where R(t) measures the return on the S&P 500 cash index or the return on the futures contract between any two points in time, b(0) measures the mean return on Monday, b(2) through b(5) measures the difference between the mean return on Monday and each other day of the week, and D(2t) through D(5t) represent dummy variables for each day of the week; D(2t) equals 1 for Tuesday, 0 otherwise; D(3t) equals 1 for Wednesday, 0 otherwise; D(4t) equals 1 for Thursday, 0 otherwise; and D(5t) equals 1 for Friday, 0 otherwise.

According to the results in Table 2, a trader buying at the open on Friday and selling at the high on the following Monday would expect to make 0.589% on Monday, however, the investor would make an additional 0.242% doing the same transaction from Monday's open to Tuesday's high.

Under the trading time hypothesis, the mean return for each day of the week should be the same. This can be tested using a null hypothesis that b(2) = b(3) = b(4) = b(5) = 0 against the alternative hypothesis that at least one coefficient is non-zero. The seventh column of Table 2 contains the F-statistic for the test of this hypothesis. In every case, the computed F-statistic is less than the critical F-statistic at the appropriate degrees of freedom of 2.41. This means that the trading time hypothesis cannot be rejected -- no evidence exists, under the trading time hypothesis, to support any day of the week effect. The returns for each day of the week would appear to being drawn from identical distributions.

V. RESULTS-CALENDARTIME HYPOTHESIS

Under the calendar time hypothesis, the mean return for Monday should be three times the mean return for every other day of the week, since the return for Monday represents the two weekend days as well as the return for Monday. To examine this hypothesis, the test of a calendar time hypothesis was performed using the following regression equation:

$$R(t) = b(0)[1 + 2D(1t)] + b(2)D(2t) + \ldots + b(5)D(5t) + e(t)$$

where the only difference between this regression equation and the equation used in testing the trading time hypothesis is that D(1t) equals 1 for a Monday return, 0 otherwise; all remaining variables are as defined above.

Table 3 contains the regression results for the test on the calendar time hypothesis. Below the coefficients reported in Table 3 are the t-statistics used to test the individual coefficients. Unlike the results from the test of the trading time hypothesis, the results here indicate that approximately 50 percent of the individual coefficients for Tuesday through Friday (33 out of a possible 68) are significantly different from zero.

To support the calendar time hypothesis, the expected return for Monday should be three times the expected return for every other day of the week. In other words, the null hypothesis that b(2) = b(3) = b(4) = b(5) = 0 can be tested against the alternative hypothesis that at least one coefficient. These results are contained in the seventh column of Table 3.

In eight of the 17 regression equations, the computed F- statistic from the model exceeds the critical F-statistic at the appropriate degrees of freedom which leads to a rejection of the calendar time hypothesis. More significant for this research is the fact that the calendar time hypothesis is rejected at least once for each starting point (high, low, open, and close) and the calendar time hypothesis cannot be rejected at least once for each starting point. Therefore, results of tests of the calendar time hypothesis predicate on the starting and ending points in the calculation of the daily return.

VI. SUMMARY AND CONCLUSIONS

The purpose of this research is to investigate the impact of the selection of the returns to use in tests for any day of the week effects in the S&P 500 futures contracts. The above results support the trading time hypothesis; the distribution of asset returns appears to be the same for each day of the week regardless of how returns are measured.

On the other hand, tests of the calendar time hypothesis are inconclusive; depending on when a trader buys and sells the futures contracts, the calendar time hypothesis is either supported or rejected. The results of the test of the calendar time hypothesis call for extended research in the pricing of futures contracts. Instead of using arbitrarily selected prices for the buying and the selling of futures contracts, more work needs to be done in determining the distributional properties of the returns for each day of the week. Once determined, those distributions can be used to test for any significant differences.

Table 3

Results of Tests of the Calendar Time Hypothesis

R(t) = b(0)[1+2D(1t)] + b(2)D(2t) + b(3)D(3t) + b(4)D(4t) +b(5)D(5t) + e(t)

	b(0)	b(2)	b(3)	b(4)	b(5)	
P(t-1)/P(t)	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	F-Statistic
CLOSE/HIGH	0.00242 (6.70)*	0.00458 (4.15)	0.00570 (5.21)	0.00487 (4.32)	0.00465 (3.98)	47.68
CLOSE/LOW	-0.00268 (-6.10)	-0.00481 (-3.58)	-0.00274 (-2.06)	-0.00571 (-4.16)	-0.00631 (-4.44)	35.27
CLOSE/OPEN	-0.00007 (-0.31)	-0.00020 (-0.28)	0.00010 (0.14)	-0.00009 (-0.13)	0.00007 (0.10)	0.63
CLOSE/CLOSE	0.00067 (1.16)	-0.00003 (-0.002	0.00242 (1.39)	-0.00095 (-0.53)	-0.00247 (-1.33)	1.22
HIGH/HIGH	-0.00042 (-0.80)	0.00156 (0.98)	0.00177 (1.12)	0.00262 (1.61)	-0.00005 (-0.03)	0.83
HIGH/LOW	-0.00551 (-8.89)	-0.00783 (-4.13)	-0.00667 (-3.55)	-0.00797 (-4.11)	-0.01101 (-5.49)	62.10
HIGH/OPEN	-0.00290 (-6.30)	-0.00322 (-2.28)	-0.00383 (-2.74)	-0.00235 (-1.63)	-0.00463 (-3.10)	25.93
HIGH/CLOSE	-0.00217 (-3.11)	-0.00305 (-1.43)	-0.00151 (-0.72)	-0.00321 (-1.47)	-0.00718 (-3.18)	9.11
LOW/HIGH	0.00480 (9.76)	0.01169 (7.76)	0.01133 (7.60)	0.01128 (7.33)	0.01017 (6.39)	116.23
LOW/LOW	-0.00029 (-0.54)	0.00230 (1.37)	0.00290 (1.74)	0.00070 (0.41)	-0.00079 (-0.44)	1.02
LOW/OPEN	0.00231 (5.96)	0.00691 (5.82)	0.00573 (4.88)	0.00631 (5.21)	0.00560 (4.46)	51.23
LOW/CLOSE	0.00305 (4.71)	0.00708 (3.57)	0.00805 (4.11)	0.00546 (2.70)	0.00305 (1.45)	23.31
OPEN/HIGH	0.00196 (2.82)	0.00635 (2.98)	0.00659 (3.12)	0.00868 (3.98)	0.00505 (2.24)	16.13
OPEN/LOW	-0.00313 (-4.08)	-0.00305 (-1.30)	-0.00184 (-0.79)	-0.00190 (-0.79)	-0.00591 (-2.38)	9.79

Table 3 continued

Results of Tests of the Calendar Time Hypothesis

$$R(t) = b(0)[1+2D(1t)] + b(2)D(2t) + b(3)D(3t) + b(4)D(4t) + b(5)D(5t) + e(t)$$

	b(0)	b(2)	b(3)	b(4)	b(5)	
P(t-1)/P(t)	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	F-Statistic
OPEN/OPEN	-0.00053 (-0.83)	0.00156 (0.80)	0.00100 (0.52)	0.00371 (1.86)	0.00048 (0.23)	0.78
OPEN/CLOSE	0.00021 (0.26)	0.00174 (0.69)	0.00332 (1.33)	0.00286 (1.11)	-0.00207 (-0.78)	1.02
CASH MARKET	0.00004 (0.08)	0.00132 (0.81)	0.00237 (1.48)	0.00004 (0.02)	-0.00032 (-0.19)	0.67

* t-statistic for coefficient

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