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A Further Investigation of the Weekend Effect in Stock Returns

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ABSTRACT

This study uses a longer time period and additional stocks to further investigate the weekend effect. We find consistently negative Monday returns (1) for the S & P Composite as early as 1928, (2) for Exchange-traded stocks of firms of all sizes, and (3) for actively traded over-the-counter (OTC) stocks. The OTC results are based on bid prices and therefore appear to reject specialist-related explanations. For the 30 individual stocks of the Dow Jones Industrial Index, the average correlation between Friday and Monday returns is positive and the highest of all pairs of successive days. The latter finding is inconsistent with fairly general measurement-error explanations.

SOME OF THE MOST puzzling empirical findings reported in recent years indicate that the distribution of common stock returns varies by day of the week. Most notably, the average return for Monday (close Friday to close Monday) is significantly negative. Cross [3] and French [6] find negative Monday returns using the Standard and Poor's Composite Index, and Gibbons and Hess [7] find negative Monday returns for the 30 individual stocks of the Dow Jones Industrial Index.[1] This negative Monday return, or "weekend effect," has yet to be explained.

This study undertakes a further investigation of the weekend effect in stock returns. We examine additional time periods, extending the total period covered to 55 years; we examine additional stocks, such as those of small (low-capitalization) firms and those traded over the counter. In all cases, the data exhibit a weekend effect that is at least as strong as that reported in previous studies. The study also readdresses potential explanations for the effect, such as measurement error, but concludes that none of these explanations is satisfactory.

The first section presents a history of the weekend effect from 1928 through 1982 based on the Standard and Poor's Composite Index. We essentially double the length of the period (beginning in 1953) examined by French [6]. The results indicate consistently negative Monday returns throughout the 55-year period. During much of the 25-year period from 1928 through 1952, the New York Stock Exchange was open on Saturdays, so Monday's return is then computed from Saturday's close to Monday's close.[2] These returns for "one-day" weekends are consistently negative and not significantly different from the "two-day" weekend

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[1] Other studies suggest that the weekend effect is not confined to the stock market. Stickel [15] and Roll [13] find weekend effects in futures prices. Gibbons and Hess [7] conclude that mean first differences in Treasury Bill returns are not constant throughout the week.

[2] Bruch [2] also examines returns by day of the week using the S & P Composite for the ten-year period from 1934–1943.

returns reported in previous studies. We do find, though, that Friday's return is lower when Friday is followed by a Saturday trading day. Also, Saturday's return tends to be higher than returns on other days. In conjunction with the evidence in section II, these results suggest a tendency for the last price of the week to be "high".

The second section investigates possible relations between the weekend effect and firm size. We find a weekend effect for firms in all size deciles. Our results indicate, however, that the smaller the firm the greater is the tendency for average returns to be high on Friday. We conjecture that such results suggest some form of upward bias in week-ending prices that is reversed on Monday, but a formal test based on a comparison of means fails to support such a hypothesis.

Section III addresses the issue of measurement error in a different fashion. If the low Monday returns are even partially due to positive "errors" in prices on Friday, and if these errors vary over time, then higher-than-average errors on Friday would tend to produce lower-than-average returns on Monday. This behavior would imply a lower (possibly negative) correlation between Friday's return and Monday's return than between returns on other successive days. Using returns of the 30 individual stocks in the Dow Jones Industrial Index, we find instead that correlations are *highest* between Friday returns and Monday returns. Our conclusion is that fairly general versions of measurement error are inconsistent with this result.

Finally, section IV investigates a specific potential source of bias—a specialist-related bias—by examining returns of stocks traded actively in the over-the-counter (OTC) market. Closing prices reported for stocks listed on the Exchanges usually reflect the price of an actual transaction. If these transactions involve the specialist, then the closing price is essentially a "bid" price or an "ask" price. If the frequency of transactions at the bid relative to transactions at the ask varies systematically through the week, then a day-of-the-week effect in *computed* returns would result. Using closing bid and ask quotations for actively traded NASDAQ stocks, we compute returns going bid to bid (and ask to ask). The OTC results appear to be inconsistent with a specialist-related explanation of the weekend effect: the day-of-the-week patterns for OTC stocks are remarkably similar to those for stocks on the Exchanges.

I. The Weekend Effect: 1928–1982

We begin by compiling a fifty-five year record of returns by day of the week using the Standard and Poor's Composite Stock Price Index. The "S & P Composite," for which a daily history begins on January 3, 1928, is a value-weighted price index based on 90 New York Stock Exchange (NYSE) stocks before March 1, 1957 and on 500 NYSE stocks thereafter. For each day, we compute a return as the percentage change in the value of the index from the preceding day.

During most of the period prior to June 1952, the NYSE conducted trading six days a week, Monday through Saturday. (On Saturdays, however, the Exchange was generally open only two hours—10:00 A.M. until noon.) Both Cross [3] and French [6] examine the weekend effect using the S & P Composite beginning in

Table I

Percent Returns on the S & P Composite Index by Day of the Week[a]

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	All Days[b]
1928–1982							
Mean	−.1859	.0484	.0941	.0496	.0635	.1474	.0207
Std. Dev.	1.215	1.094	1.176	1.093	1.134	1.010	1.162
t Statistic	−7.81	2.26	4.16	2.35	2.88	4.72	2.17
Observations	2610	2603	2707	2692	2649	1046	14,863
F (p-value)[c]							26.1 (.0001)
1928–1952							
Mean	−.2230	.0756	.0836	.0659	.0287	.1474	.0161
Std. Dev.	1.511	1.395	1.526	1.432	1.507	1.010	1.459
t Statistic	−5.13	1.85	1.91	1.61	0.66	4.72	0.95
Observations	1207	1171	1219	1218	1195	1046	7326
F (p-value)[c]							9.88 (.0001)
1953–1982							
Mean	−.1539	.0261	.1028	.0361	.0920		.0251
Std. Dev.	0.883	0.763	0.780	0.697	0.688		0.771
t Statistic	−6.53	1.30	5.08	1.99	5.10		2.82
Observations	1403	1432	1488	1474	1454	0	7537
F (p-value)[c]							25.9 (.0001)
1928–1932							
Mean	−.4850	.0380	.0813	.1650	.1269	.0060	−.0414
Std. Dev.	2.093	1.936	2.480	2.037	2.287	1.376	2.117
t Statistic	−3.58	0.30	0.51	1.26	0.86	0.07	−0.75
Observations	238	240	246	243	238	229	1485
F (p-value)[c]							3.18 (.0076)
1933–1937							
Mean	−.2233	.2085	.1389	.0229	.0203	.1524	.0435
Std. Dev.	1.983	1.418	1.649	1.796	1.709	1.203	1.729
t Statistic	−1.75	2.24	1.31	1.99	1.84	1.94	0.97
Observations	242	232	241	243	240	234	1487
F (p-value)[c]							2.10 (.0626)

Table I (continued)

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	All Days[b]
1938–1942							
Mean	−.1493	.0960	−.0439	−.0569	−.1367	.2831	.0035
Std. Dev.	1.273	1.556	1.280	1.218	1.330	0.924	1.312
t Statistic	−1.83	0.95	−0.54	−0.73	−1.59	4.79	0.10
Observations	244	235	246	243	239	245	1505
F (*p*-value)[c]							4.04 (.0013)
1943–1947							
Mean	−.1136	.0482	.1031	.0958	.0477	.1389	.0345
Std. Dev.	0.898	0.905	0.795	0.812	0.797	0.492	0.843
t Statistic	−1.97	0.82	2.02	1.84	0.92	3.94	1.56
Observations	242	234	242	243	238	195	1449
F (*p*-value)[c]							2.85 (.0146)
1948–1952							
Mean	−.1486	−.0122	.1404	.1021	.0857	.1447	.0425
Std. Dev.	0.791	0.797	0.671	0.850	0.876	0.451	0.785
t Statistic	−2.92	−0.23	3.27	1.89	1.52	3.84	2.03
Observations	241	230	244	246	240	143	1400
F (*p*-value)[c]							4.91 (.0002)
1953–1957							
Mean	−.2202	.0066	.1484	.0686	.1452		.0353
Std. Dev.	0.887	0.746	0.736	0.625	0.621		0.743
t Statistic	−3.82	−0.14	3.17	1.72	3.65		1.68
Observations	237	239	247	247	243	0	1258
F (*p*-value)[c]							10.4 (.0001)
1958–1962							
Mean	−.1654	.0563	.0798	.0544	.1278		.0386
Std. Dev.	0.839	0.723	0.650	0.610	0.577		0.694
t Statistic	−3.02	1.21	1.94	1.41	3.45		1.98
Observations	235	239	249	250	243	0	1259
F (*p*-value)[c]							6.50 (.0001)

1963–1967							
Mean	−.1371	.0397	.1030	.0584	.0962		.0351
Std. Dev.	0.579	0.499	0.546	0.490	0.425		0.531
t Statistic	−3.62	1.23	2.98	1.89	3.52		2.35
Observations	234	238	249	251	242	0	1259
F (p-value)[c]							8.73 (.0001)
1968–1972							
Mean	−.1641	−.0039	.1494	.0024	.1052		.0187
Std. Dev.	0.775	0.621	0.745	0.650	0.590		0.684
t Statistic	−3.21	0.10	3.05	0.06	2.75		0.96
Observations	230	239	232	225	238	0	1234
F (p-value)[c]							7.34 (.0001)
1973–1977							
Mean	−.1339	.0062	.0107	.0512	−.0175		−.0124
Std. Dev.	1.034	0.960	0.996	0.912	0.930		0.967
t Statistic	−1.98	0.10	0.17	0.88	−0.29		−0.46
Observations	235	239	255	248	244	0	1263
F (p-value)[c]							1.25 (.2890)
1978–1982							
Mean	−.1016	.0652	.1304	−.0209	.0960		.0352
Std. Dev.	1.084	0.924	0.901	0.803	0.839		0.917
t Statistic	−1.43	1.09	2.32	−0.41	1.79		1.36
Observations	232	238	256	253	244	0	1264
F (p-value)[c]							2.55 (.0375)

[a] Returns computed as $r_t = (v_t/v_{t-1} - 1) \cdot 100$, where v_t is the value of the S & P Composite index on day t.

[b] Number of observations may exceed the total of the individual weekdays. The results for individual weekdays exclude any multiple-day returns (or returns over more than three days for Monday).

[c] For subperiods before 1953, the F statistic tests equality of means across all six days from Monday through Saturday. For the overall period and the subperiods after 1953, equality is tested across the five weekdays. The degrees of freedom are $K - 1$ and $T - K$, where K is the number of weekdays (five or six) and T is the number of observations.

1953, after Saturday trading was discontinued. The twenty-five years of history prior to 1953 provide a record of the weekend effect when weekends were, in terms of trading, only about half as long.

Table I displays average returns on the S & P Composite by day of the week. The results for the 1928–1952 period are strikingly similar to those reported by French [6] for the 1953–1977 period. Most prominent is the significantly negative average Monday return. In fact, Monday's average for 1928–1952 is even slightly more negative than the average for the later period from 1953–1982. The statistical significance of the negative average Monday return is reinforced by consistency: average Monday returns are negative in each of the eleven five-year subperiods. Also prominent in the 1928–1952 period is the surprisingly large average return for Saturday, nearly twice that of the next largest average (Wednesday's). The hypothesis of equal means across days of the week is rejected at any reasonable significance level in the overall period and in the two large subperiods. Equality is rejected at a five-percent significance level in nine of the eleven five-year subperiods.

A comparison of the 1928–1952 period with the later 1953–1982 period indicates that Friday's return is lower in weeks that include Saturday trading. In the early period, Friday's mean is the second lowest of the week (next to Monday's), and the t statistic for Friday is only 0.66. In contrast, Friday's mean for the later period is the second highest (next to Wednesday's), and the t statistic is 5.10. This suggests a tendency for higher returns on the last trading day of the week, whether that last day is a Friday or a Saturday.

To test the above hypothesis more formally, we concentrate on a subperiod containing both five-day and six-day trading weeks. In each year from 1945 through 1952, the Exchange was closed on Saturdays for several months, usually June through September.[3] We wish to test the hypothesis that the average return on Fridays that precede one-day weekends (Saturday trading) equals the average return on Fridays that precede two-day weekends. During this eight-year period, however, the occurrence of two-day weekends is almost perfectly correlated with the occurrence of the months June through September. In order to distinquish a separate June–September effect, if any, we include an additional eight years of data: four years on each side of the 1945–1952 period. The period from 1941 through 1944 contains virtually all one-day weekends; the 1953–1956 period contains only two-day weekends.

Using Friday returns from 1941 through 1956, we estimate the regression,

$$r_t = \underset{(.040)}{\underset{.037}{\theta_1}} w_{1,t} + \underset{(.057)}{\underset{.234}{\theta_2}} w_{2,t} + \underset{(.066)}{\underset{-.167}{\theta_3}} s_t + u_t, \tag{1}$$

where r_t is Friday's return (in percent), $w_{1,t} = 1$ for a one-day weekend (zero otherwise), $w_{2,t} = 1$ for a two-day weekend, and $s_t = 1$ if the return occurs in June through September. Parameter estimates and standard errors are shown directly below equation (1). The hypothesis $\theta_1 = \theta_2$ is rejected with a p-value of

[3] In 1945, the Exchange was closed on Saturdays during July and August. Beginning June 1952, Saturday closing become permanent.

0.18% ($F = 9.77$; degrees of freedom: 1;735). This test indicates that Friday's return is significantly larger if Friday is the last trading day of the week and confirms the hypothesis that, for the period examined, the last trading day of the week tends to have a higher average return.

We also test whether the length of the weekend affects Monday's average return. Using Monday returns for the same 1941–1956 period, we estimate the regression,

$$r_t = \underset{(.043)}{\underset{-.039}{\theta_1 w_{1,t}}} + \underset{(.061)}{\underset{-.135}{\theta_2 w_{2,t}}} + \underset{(.072)}{\underset{-.099}{\theta_3 s_t}} + u_t, \tag{2}$$

where r_t is Monday's percent return and the independent variables are as defined for (1). Although the average Monday return following two-day weekends is lower, the difference is not statistically significant. A test of $\theta_1 = \theta_2$ yields a p-value of 15.6% ($F = 2.02$; degrees of freedom: 1;767). Thus, the *length* of the weekend does not appear to exert a significant effect on Monday's returns.

The history presented here also sheds some additional light on the likely importance of settlement effects in explaining day-of-the-week behavior. Both Gibbons and Hess [7] and Lakonishok and Levi [10] investigate settlement effects and find that such effects are unable to explain the weekend effect.[4] We simply note that, in terms of absolute magnitudes, the weekend effect is slightly stronger in the earlier 1928–1952 period, when interest rates were considerably lower than in later periods. Since settlement effects should be related to interest costs, it is unlikely that such effects are important in explaining the observed weekend phenomenon.[5]

II. Cross-Sectional Differences in the Weekend Effect

Most research on the day-of-the-week effect has examined the phenomenon with either large stocks (e.g., the individual Dow Jones 30) or with indices of primarily large stocks (e.g., Dow Jones 30 or S & P 500). Gibbons and Hess [7], however, also examine the CRSP equal-and value-weighted indices of all NYSE and AMEX stocks. Their findings suggest that the magnitude of the weekend effect varies cross-sectionally with firm size. In particular, they report average Friday returns that are much larger for the equal-weighted index (which is more influenced by small firms) than the value-weighted index (which is dominated by large firms). Average Monday returns are, however, virtually the same for both indices. In this section, we examine this cross-sectional difference in more detail and discuss some implications of the difference for potential explanations of the weekend effect.

[4] "Settlement effects" refer to the distortions in prices that may result when transactions are settled several business days after the transaction rather than instantaneously.

[5] It is not clear that the marginal interest cost should apply to the entire amount of a transaction. Much of the need for transfer of funds (as well as delivery of securities) is obviated by the clearing process. For example, Leffler and Farwell [11] report that in 1960, deliveries worth $48 billion required a net cash settlement of only $7 ½ billion.

Table II

Cross-Sectional Differences in the Weekend Effect: Mean Percentage Returns (Standard Errors) by Day of the Week for Portfolios Constructed from Firms in each Decile of Size on the NYSE and AMEX from 1963 to 1979

Size Decile	Market Value of Equity[a]	Monday	Tuesday	Wednesday	Thursday	Friday	Mean Return Over All Days	F Stat[b]	P-value[c]
Smallest	$ 4.4	−0.037	0.034	0.166	0.184	0.348	0.137	24.11	.0001
		(0.034)	(0.028)	(0.030)	(0.030)	(0.029)	(0.014)		
2	10.5	−0.084	−0.015	0.144	0.135	0.300	0.094	26.27	.0001
		(0.034)	(0.027)	(0.029)	(0.029)	(0.027)	(0.013)		
3	18.9	−0.113	−0.008	0.146	0.128	0.261	0.081	25.48	.0001
		(0.034)	(0.027)	(0.029)	(0.027)	(0.026)	(0.013)		
4	30.3	−0.123	−0.011	0.133	0.121	0.232	0.069	22.76	.0001
		(0.033)	(0.027)	(0.030)	(0.027)	(0.027)	(0.013)		
5	46.7	−0.118	−0.017	0.120	0.106	0.219	0.060	21.23	.0001
		(0.033)	(0.026)	(0.029)	(0.026)	(0.026)	(0.013)		
6	73.4	−0.114	−0.006	0.117	0.101	0.183	0.055	17.81	.0001
		(0.032)	(0.026)	(0.028)	(0.026)	(0.025)	(0.012)		
7	118.1	−0.111	−0.014	0.115	0.088	0.173	0.049	18.39	.0001
		(0.031)	(0.025)	(0.027)	(0.024)	(0.023)	(0.012)		
8	210.2	−0.129	0.007	0.103	0.091	0.154	0.045	17.84	.0001
		(0.030)	(0.024)	(0.027)	(0.024)	(0.023)	(0.012)		
9	433.0	−0.112	0.005	0.105	0.069	0.132	0.039	14.80	.0001
		(0.029)	(0.024)	(0.027)	(0.023)	(0.023)	(0.011)		
Largest	1092.1	−0.106	0.012	0.090	0.056	0.099	0.030	11.34	.0001
		(0.027)	(0.024)	(0.026)	(0.023)	(0.022)	(0.011)		
F Statistic[d]		4.19	2.65	1.57	3.60	13.10			
P-Value		.0001	.0047	.1164	.0002	.0001			

[a] Market value of equity is measured by the average, across all sample years, of the median market values of the particular size decile in each year. Market values are in millions of dollars.

[b] The F statistic tests the equality of mean returns across days of the week. Degrees of freedom: 4; 4256.

[c] The lowest p-value reported is .0001.

[d] The F statistic tests the equality of mean returns across portfolios for a particular day. Degrees of freedom: 9; 42560.

We use the returns for ten portfolios based on market value of equity analyzed in Keim [9]. Data are obtained from the CRSP daily stock files for the seventeen-year period from January 2, 1963 to December 31, 1979. The sample consists of all firms listed on the NYSE or AMEX that have returns on the CRSP files during the entire calendar year under consideration. The number of sample firms in a given year ranges from 1,330 in January 1963 to 2,262 in February 1976.

Table II displays mean daily returns (standard errors) for the ten market-value portfolios averaged over all days (column 8) as well as separately for each day of the week (columns 3–7). We also report the average market value of equity for each portfolio. To test equality of mean returns across days of the week, as well as across portfolios, we estimate the system of seemingly unrelated regressions,

$$r_{pt} = \sum_{i=1}^{5} a_{pi} d_{it} + e_{pt} \qquad p = 1, \cdots, 10; \qquad t = 1, \cdots, T \tag{3}$$

where d_{it} is a dummy variable that is equal to 1 for day i and is zero otherwise. The hypothesis of equality of mean returns across days for a particular portfolio p is $a_{p1} = a_{p2} = a_{p3} = a_{p4} = a_{p5}$.[6] Test statistics and p-values for this hypothesis are reported in columns 9 and 10. The hypothesis of equality of mean returns across portfolios for a particular day i is $a_{1i} = a_{2i} = \cdots = a_{10i}$. The F statistics and p-values for this hypothesis, tested each day of the week, are reported in the bottom two rows of Table II.

Several interesting results emerge from Table II. First, Monday returns are consistently negative across all size portfolios. However, even though we reject the hypothesis that average Monday returns are equal across portfolios (F = 4.19), a systematic relation between Monday returns and size is not apparent. Second, average returns for all portfolios tend to increase as the week progresses. In fact, Friday returns are the largest returns of the week. Third, the tendency for returns to increase during the week is more pronounced for smaller firms. As a result, Friday returns are strongly related to size; the inverse relation is monotone and the differences in means are statistically significant (F = 13.10).[7] Finally, and consistent with the above evidence, the F statistics in column 9 indicate that the smaller the firms in the portfolio, the stronger is the day-of-the-week effect. The inverse relation between firm size and F statistics is nearly monotone. Thus, not only are there day of the week effects, but the magnitude of these effects appears to be related cross-sectionally to firm size.[8]

We find above that Friday returns are related to firm size. Gibbons and Hess [7, p. 591] suggest that the nature of the return patterns surrounding the weekend implies a possible bias for high prices on Fridays, and they suggest that "if Monday's negative results are explained by upwardly biased prices on Friday, the deviation of Monday's return from the overall mean should be exactly offset by

[6] See Theil [16, ch. 7] for the test of a general linear hypothesis within the seemingly unrelated regression model.

[7] Wednesday and Thursday returns also exhibit an inverse monotone relation with size, but equality is rejected at conventional significance levels only for Thursday.

[8] The average returns in Table II, particularly those for small firms, are upward biased by the bid-ask effect analyzed by Blume and Stambaugh [1]. For example, the smallest firms' returns are upward biased by roughly .05% per day. However, a comparison of rebalanced and buy-and-hold returns indicates that such a bias is constant throughout the week.

Table III

Test for Systematic Measurement Error in Observed Friday Prices: Average Sums of Mean-Adjusted Returns for Friday and Monday for Portfolios Constructed from Firms in each Decile of Size on the NYSE and AMEX from 1963 to 1979

Size Decile	Sum of Mean-Adjusted Returns for Friday and Monday[a]	
	Mean	t statistic
Smallest	0.050	1.09
2	0.039	0.76
3	−0.005	−0.02
4	−0.016	−0.33
5	−0.012	−0.24
6	−0.031	−0.62
7	−0.026	−0.58
8	−0.057	−1.27
9	−0.053	−1.25
Largest	−0.064	−1.61

[a] The number of observations is 887. The t-statistic tests the hypothesis that the mean-adjusted returns of Friday and Monday exactly offset each other. Fractiles of the t distribution: $t_\infty(95\%) = 1.96$, $t_\infty(99\%) = 2.58$.

Friday's." In light of our findings above, particularly for small firms, we readdress the hypothesis that mean-adjusted returns for Friday and Monday offset each other.[9]

In Table III we report the average sums of the mean-adjusted returns for Friday and Monday for each size portfolio.[10] Also reported are t statistics that

[9] Gibbons and Hess also test this hypothesis, but they adjust Friday and Monday returns with Wednesday's mean rather than the mean over all days. Such a test is biased if Wednesday's mean also differs from other days' means. In the tests that follow we allow that mean *computed* returns may differ day by day (due to, say, measurement error that varies by day of the week), but we assume these differences "wash" when averaged over the week so the mean *true* returns are equal day-by-day.

The hypothesis of exactly offsetting mean returns is not literally correct for the discrete returns used here. Two equal and precisely offsetting price movements (say, a \$1 increase on a \$10 stock followed by a \$1 decrease) will not result in equal and offsetting returns (in this case, 10% and −9.1%). Thus, even if Friday prices are upward biased, the deviation of Friday's return from the overall mean will not be exactly offset by Monday's. Although the offsetting would be exact with continuously compounded returns, different variances would make means comparison difficult. Fama [4] and Godfrey, Granger, and Morgenstern [8] conclude that Monday's return has a larger variance than returns on other days.

[10] To compute this mean for a portfolio, we first add the mean-adjusted returns for Friday and Monday for each weekend during the 1963–1979 period as $(r_F - \mu) + (r_M - \mu)$, where r_F is Friday's observed return, r_M is Monday's observed return and μ is the average return for the five weekdays. We then average these values over the entire sample period.

test whether the average sums of the mean-adjusted returns are equal to zero. The results in Table III support the hypothesis that the weekend effect is due to systematically biased Friday prices. For each size decile, the hypothesis that Friday and Monday returns are on average offsetting cannot be rejected at the five percent significance level.

Since returns are correlated across portfolios, we also perform a multivariate test. We estimate the following variant of model (3),

$$r^*_{pt} = \sum_{i=1}^{5} a_{pi}d_{it} + e_{pt} \qquad p = 1, \cdots, 10; \qquad t = 1, \cdots, T, \tag{4}$$

where $r^*_{pt} = r_{pt} - \hat{\mu}_p$ and $\hat{\mu}_p$ is the mean return across all days for portfolio p. The test for measurement error is now formalized as $a_{p1} + a_{p5} = 0$ over all p. The F-statistic of 2.05 rejects the null hypothesis with a p-value of 2.51% (degrees of freedom: 10, 42570). Thus, although the results for each size decile considered separately appear to support a measurement-error explanation, the results for all deciles considered jointly are inconsistent with that hypothesis.

III. A Test Based on Autocorrelations

Tests based on offsetting Friday and Monday *mean* returns, both the tests by Gibbons and Hess [7] and those presented in section II, fail to support the hypothesis of measurement error. Such means-based tests, however, require fairly specific assumptions about the process generating true returns and the nature of the underlying measurement errors. If, for example, true expected returns (those measured without "error") have different means on Friday and Monday, or if measurement errors occur on both Friday and Monday, then the means-based test will tend to reject incorrectly a measurement-error explanation. It may also be that measurement error contributes significantly to the weekend effect but is not its sole cause.

In this section, we present an alternative test for the presence of measurement error.[11] Suppose that Friday's closing price (and Friday's return) is subject to random "errors" that are, on average, positive. Monday's return is then subject to random errors that are, on average, negative. Larger than average positive errors on Friday will tend to be followed by larger negative errors in Monday's return. In other words, the errors on Friday will be negatively correlated with the errors on Monday.[12] If measurement error plays a more important role around the weekend, then the correlation between Friday's return and Monday's return will tend to be lower (perhaps negative) than between other successive days.

Cross [3] reports that declines in the S & P Composite on Monday occur with

[11] Another approach that might shed some light on this issue is to examine hour-by-hour data. Prince [12] computes daily returns (based on values of the Dow Jones 65 Composite Index) for each of six points during the day: opening, 11:00, 12:00, 1:00, 2:00, 3:00. His results suggest that the weekend effect diminishes as one moves further in *trading* time from the interval Friday close–Monday close. For example, returns from noon Friday to noon Monday are much less negative. (The latter result is similar to the findings of Smirlock and Starks [14].) Interestingly, though, Prince reports that returns from open Monday to open Tuesday (or 11:00 Monday to 11:00 Tuesday) are also large negative and about the same magnitude as close Friday to close Monday.

[12] This argument requires that the error be (more or less) independent of the underlying true return.

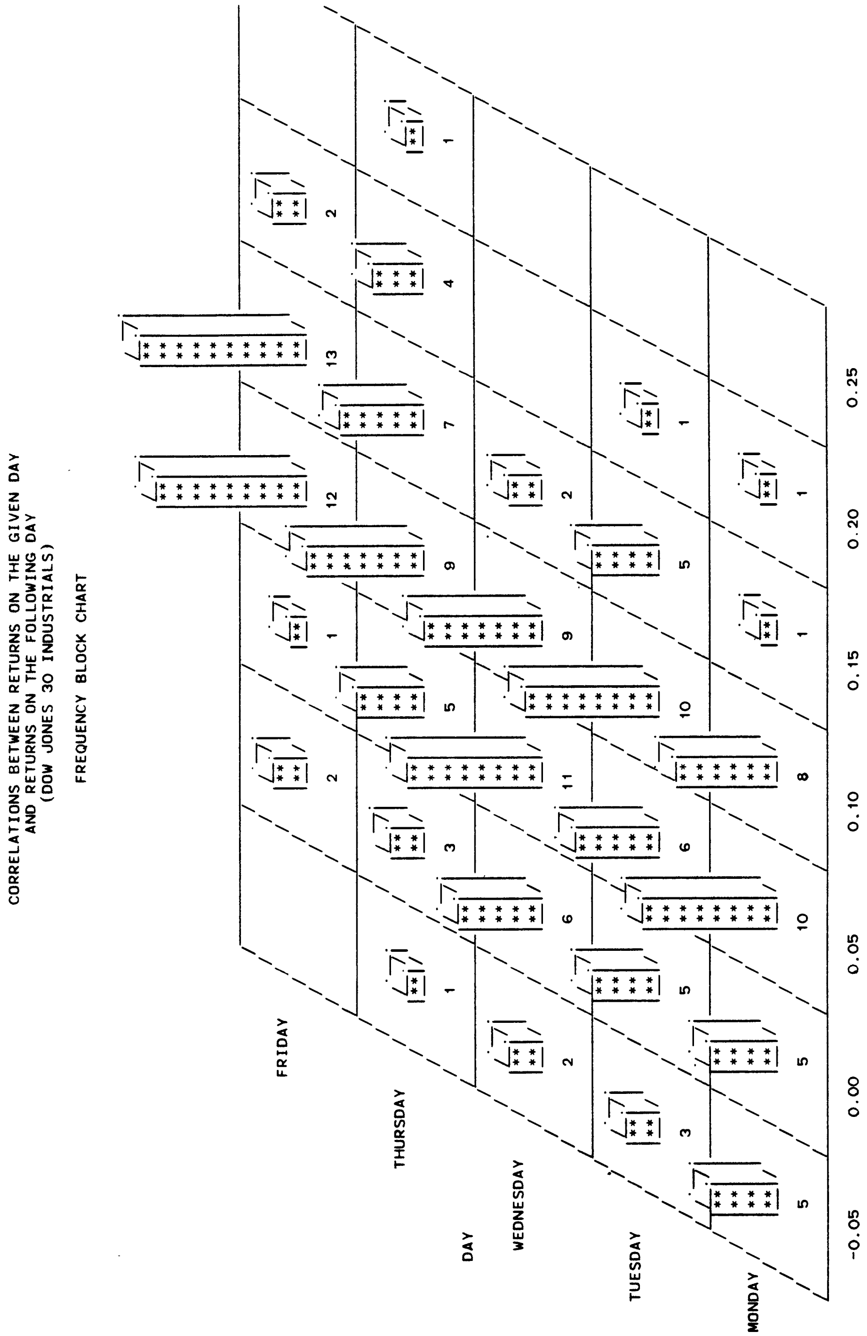
CORRELATIONS BETWEEN RETURNS ON THE GIVEN DAY
AND RETURNS ON THE FOLLOWING DAY
(DOW JONES 30 INDUSTRIALS)
FREQUENCY BLOCK CHART
FRIDAY
THURSDAY
WEDNESDAY
DAY
TUESDAY
MONDAY
-0.05
0.00
0.05
0.10
0.15
0.20
0.25
CORRELATION WITH RETURN FOR NEXT DAY

Figure 1

greater frequency after a decline on Friday. He also finds that the tendency to follow the direction of the previous day's move is most pronounced on Monday. In other words, his evidence suggests that correlations between Friday and Monday returns are the *highest* of any pair of successive days. This pattern is opposite to that predicted by the presence of measurement error, but such results for an index could be due to other factors. For example, it is well known that nonsynchronous trading of individual stocks can produce positive autocorrelation in index returns (Fisher [5]). Cross's results could simply reflect a tendency for less synchronous trading surrounding weekends.

In order to investigate the correlations between successive returns on individual stocks, we select the same 30 stocks of the Dow Jones Industrial Index used by Gibbons and Hess [7]. For each stock, we compute the correlation coefficient between the return on a given day of the week and the return on the following day. (Returns that span holidays or those that follow missing returns are eliminated.) Table IV displays, by day of the week, those correlation coefficients averaged over the 30 stocks. Figure 1 displays histograms of the distribution of coefficients across the 30 stocks. The pattern of correlations across days is consistent with the findings of Cross [3] for the S & P Composite. For the overall July 1962 through December 1982 period, as well as both subperiods, the average correlation between Friday's return and Monday's return is the *highest* of all days. Again, this is opposite to what a measurement-error explanation would predict.

Although the observed pattern in Table IV is inconsistent with measurement error, for other applications it may be useful to determine whether the autoregressive parameters differ significantly across days. To conduct such a test, we estimate the system of seemingly unrelated regressions,

$$r_{i,t} = \sum_{k=1}^{5} \alpha_{i,k} d_{t,k} + \sum_{k=1}^{5} \psi_{i,k} d_{t,k} r_{i,t-1} + \epsilon_{i,t}$$

$$t = 1, \cdots, T; \; i = 1, \cdots, 30 \qquad (5)$$

where $d_{t,1} = 1$ for $t =$ Monday, $d_{t,1} = 0$ otherwise, etc. We then test the hypothesis

$$\psi_{i,1} = \psi_{i,2} = \cdots \psi_{i,5}; \qquad i = 1, \cdots, 30, \qquad (6)$$

and the results of this test are reported in Table V. The hypothesis of equality is rejected at any reasonable significance level in the overall period and in both subperiods.

IV. A Test for Specialist-Related Bias

The evidence considered thus far is based on common stocks listed on the New York or American Stock Exchanges. Returns for these stocks are computed from "closing" prices, where the closing price is the price at which the day's last transaction occurs. On the Exchanges, this transaction often involves the specialist. The "bid" price at which the specialist fills a limit buy order (or buys for himself) is usually less than the "ask" price at which the specialist fills a limit sell order (or sells for himself). Thus, closing prices (or transaction prices recorded at any point in time) often represent a bid or an ask rather than the "true" price at which market orders would "cross" in a trade not involving the specialist.

Table IV

Average Correlation Between Returns on Day Shown and Returns on Following Day; Dow Jones 30 Industrials

Period	Monday	Tuesday	Wednesday	Thursday	Friday
July 1962–Dec. 1982	0.042	0.059	0.059	0.109	0.117
July 1962–Dec. 1972	0.064	0.058	0.092	0.103	0.107
Jan. 1973–Dec. 1982	0.030	0.076	0.042	0.115	0.126

Table V

Test of Equality of Coefficients on Lagged Return Across Days of the Week; Dow Jones 30 Industrials[a]

Period	Degrees of Freedom	F Statistic	P-value[b]
July 1962–Dec. 1982	120; 147,330	2.540	.0001
July 1962–Dec. 1972	120; 74,400	1.748	.0001
Jan. 1973–Dec. 1982	120; 72,630	2.295	.0001

[a] Test is based on the seemingly unrelated regression model

$$r_{i,t} = \sum_{k=1}^{5} \alpha_{i,k} d_{t,k} + \sum_{k=1}^{5} \psi_{i,k} d_{t,k} r_{i,t-1} + \varepsilon_{i,t}; \qquad i = 1, \ldots, 30.$$

The statistics in the table test the hypothesis, $\psi_{i,1} = \cdots = \psi_{i,5}$ for $i = 1, \ldots, 30$.

[b] Smallest value reported is .0001.

Transactions at bids and asks no doubt occur with equal frequency overall, but there could be systematic differences in their relative frequencies during the week. Consider a stock that sold on day $t - 1$ for $50.00 per share and has a bid-ask spread on day t of $0.50. An ask-price transaction on day t would result in a computed return 1% greater than a transaction at the bid price. If ask-price transactions on a given weekday occur with, say, 0.1 greater probability than bid prices, then computed returns will be biased upward by about 0.05%. (From Table II, the average daily return on "large" stocks is 0.03%.) Although purely hypothetical, this example suggests that relatively small variations in the bid-vs.-ask frequency during the week could contribute to day-of-the-week effects in computed returns.

In order to investigate the above conjecture, we examine returns computed with bid and ask quotations of stocks traded over the counter. The use of bid-to-bid (or ask-to-ask) returns allows a direct test of whether day-of-the-week effects are due to the bid-ask bias described above. More generally, such returns allow us to test whether day-of-the-week effects arise from factors attributable solely to the actions or presence of the specialist on the Exchanges.

The data are from the daily ISL over-the-counter (OTC) stock price files maintained at the Rodney White Center at the Wharton School. Our sample in each of the years 1978 through 1982 is drawn from a list in the NASDAQ Fact Book of the 50 most actively traded (in terms of share volume) OTC stocks in that calendar year. We further require that each firm have bid prices for the entire calendar year in which it appears among the 50 most active stocks. Note

Table VI

Mean Percentage Bid-to-Bid Returns (Standard Errors) by Day of the Week for a Portfolio of Actively Traded OTC Stocks for the Period 1978 to 1982

Year	Monday	Tuesday	Wednesday	Thursday	Friday	Average	F Stat.[a]	Degrees of Freedom	P-Value[b]
1978	−0.316	−0.145	0.355	0.110	0.487	0.107	4.06	4;246	.0033
	(0.170)	(0.165)	(0.162)	(0.163)	(0.163)	(0.076)			
1979	0.007	0.027	0.299	0.854	1.057	0.454	6.11	4;247	.0001
	(0.198)	(0.196)	(0.194)	(0.194)	(0.194)	(0.091)			
1980	−0.593	0.384	1.328	−0.075	1.332	0.486	6.04	4;247	.0001
	(0.351)	(0.344)	(0.341)	(0.347)	(0.347)	(0.162)			
1981	−0.461	−0.469	0.124	0.484	0.334	0.001	2.59	4;247	.0376
	(0.280)	(0.272)	(0.272)	(0.275)	(0.284)	(0.126)			
1982	−0.317	−0.006	0.358	0.352	0.244	0.133	1.97	4;247	.0989
	(0.209)	(0.199)	(0.199)	(0.201)	(0.203)	(0.091)			
1978–	−0.336	−0.043	0.493	0.347	0.694	0.236	13.76	4;1254	.0001
1982	(0.114)	(0.111)	(0.110)	(0.111)	(0.112)	(0.051)			

[a] The F statistic tests the hypothesis that mean returns are equal across days of the week; i.e., $r_1 = r_2 = r_3 = r_4 = r_5$ where r_j is the mean index return for day j.

[b] The lowest p-value reported is .0001.

that we do not require a firm to be on the list in each of the five years (only four firms appeared on the list in all years). Thus, the composition of our sample changes from year-to-year; the sample size is 37, 34, 36, 45 and 45 in each of the five years from 1978 to 1982.

For the tests that follow, we construct an equal-weighted "index" of the OTC stocks in our sample. As discussed above, the composition of the index changes from year to year but is constant within each year. Returns for the index are computed by combining the bid-to-bid returns of the component securities with equal weights, resulting in a time series of equal-weighted bid-to-bid returns.[13]

Table VI reports mean daily bid-to-bid returns (standard errors) for the OTC "index" for the entire period and also for each of the five years. The most striking feature of the data is the similarity of the pattern in bid-to-bid returns to the patterns reported in the previous sections. Monday returns are negative, and returns are large and positive toward the end of the week. Further, these patterns tend to persist throughout the sample period. The F statistic in the second-to-last column of Table VI tests the hypothesis of equality of mean returns across days of the week. The hypothesis is rejected easily for the overall period and is rejected at the ten percent level or higher in each year.

To determine the extent of the weekend effect across individual securities, we also estimated the mean daily returns for the four firms that remained in the sample for the entire five-year period.[14] The same day-to-day pattern in returns is evident for each of these firms. All four securities have negative mean bid-to-bid returns on Monday, and Friday mean returns are the largest of the week. The joint hypothesis that security returns are equal across days of the week for all securities is easily rejected ($F = 5.87$; degrees of freedom: 16, 4764).

The evidence in this section indicates that the day-of-the-week effect is not due to systematic differences between true prices and closing prices recorded on the Exchanges. The OTC results reflect bid quotations of competing market makers for actively traded stocks.[15] It is, therefore, unlikely that the presence of the specialist accounts for day-of-the-week effects.

[13] Much of the analysis below was also conducted with ask-to-ask returns, and the results were virtually identical to those reported here.

[14] The four firms are De Beers Consolidated Mines Ltd. (ADR), Energy Reserve Group, MCI Communications and Tampax, Inc.

[15] Prior to July 7, 1980, the reported bid and ask prices reflect the median quotations. After that date, the "best" bids and asks are reported.

REFERENCES

1. M. Blume and R. Stambaugh. "Biases in Computed Returns: An Application to the Size Effect." *Journal of Financial Economics.* 12 (November 1983), 387–404.
2. F. Bruch. "Day-of-the Week Effect." Manuscript, University of Chicago, 1982.
3. F. Cross. "The Behavior of Stock Prices on Fridays and Mondays." *Financial Analysts Journal.* November–December 1973, 67–69.
4. E. Fama. "The Behavior of Stock Market Prices." *Journal of Business.* 28 (January 1965), 34–105.
5. L. Fisher. "Some New Stock Market Indices." *Journal of Business.* 29 (1966), 191–255.
6. K. French. "Stock Returns and The Weekend Effect." *Journal of Financial Economics.* 8 (March 1980), 55–69.
7. M. Gibbons and P. Hess. "Day of the Week Effects and Asset Returns." *Journal of Business.* 54 (October 1981), 579–596.

8. M. Godfrey, C. Granger, and D. Morgenstern. "The Random Walk Hypothesis and Stock Market Behavior." *Kyklos*. 17 (January 1964), 1–30.
9. D. Keim. "Size-Related Anomalies and Stock Return Seasonality: Further Empirical Evidence." *Journal of Financial Economics*. 12 (June 1983), 13–32.
10. J. Lakonishok and M. Levi. "Weekend Effects on Stock Returns: A Note." *Journal of Finance*. 37 (June 1982), 883–889.
11. G. Leffler and L. Farwell. *The Stock Market*. New York: Ronald Press, 1963.
12. P. Prince. "Day of the Week Effects: Hourly Data." Manuscript, University of Chicago, 1982.
13. R. Roll. "Orange Juice and Weather." Manuscript, UCLA, 1983.
14. M. Smirlock and L. Starks. "Day of the Week Effects in Stock Returns: Some Intraday Evidence." Manuscript, University of Pennsylvania and Washington University, 1983.
15. S. Stickel. "Empirical Tests of Futures Prices." Manuscript, University of Chicago, 1982.
16. H. Theil. *Principles of Econometrics*. New York: John Wiley and Sons, 1971.

DISCUSSION

RICHARD J. ROGALSKI*: The Monday effect refers to the average return for Monday (from Monday close to the previous Friday close) being negative. Several papers have identified and attempted to explain the Monday effect, but to no avail. Keim and Stambaugh [2] extend earlier evidence on the Monday effect historically back to 1928. They rule out various kinds of measurement errors and specialist-related biases and document that the Monday effect is similar for all ten of their size portfolios. The paper is well-written, straightforward, and methodologically sound. Therefore, I will interject in my discussion some new evidence I have uncovered by distinguishing between trading and non-trading day returns that may help direct future research toward an understanding of the Monday effect, and more generally, day of the week and seasonal anomalies.[1]

New York Stock Exchange Composite Index (NYSE) values were obtained as of 10:15 a.m. and 4:00 p.m. (close) every trading day during October 1, 1974 to December 9, 1983. In addition, opening and closing S&P Composite Index (SP500) values for December 29, 1978 to December 9, 1983 were collected. Excluding holidays and holiday-weekends, close to close returns are computed as the natural logarithm of the ratio of successive closing index values. The close to close returns are decomposed into trading and non-trading day returns. Trading day returns are calculated from close to previous open (or 10:15 a.m.) index values. Non-trading period returns are computed from open (or 10:15 a.m.) to previous close index values.

Monday close to close returns for NYSE and SP500 are on average negative as reported by Keim and Stambaugh [2]. However, all of the negative average return for NYSE and SP500 occurs during the non-trading period from Monday open to previous Friday close. We dub this the weekend effect. In particular, the average Monday close to close returns for SP500 (NYSE) are −.1097 (−.0554) percent whereas the corresponding Monday open to previous Friday close averages are −.1283 (−.0738) percent.[2] Thus, the Monday effect discovered by French [1] and updated by Keim and Stambaugh [2] may actually be a weekend effect.

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[1] All of the results to follow are contained in Rogalski [4].

[2] The SP500 close to close Monday mean of −.1097 percent for 1979–1983 is similar to the Monday average of −.1016 for 1978–1982 reported in Table 1 of Keim and Stambaugh [2].