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Day of the Week Effects and Asset Returns*

A traditional distributional assumption regarding the returns on a financial asset specifies that the expected returns are identical for all days of the week. Contrary to this plausible assumption, this paper discovers that the expected returns on common stocks and treasury bills are not constant across days of the week. The most notable evidence is for Monday's returns where the mean is unusually low or even negative. Several explanations of the results are investigated, but none proves satisfactory. Aside from documenting significant day of the week effects, the implications of the results for tests of market efficiency are examined. While market-adjusted returns continue to exhibit day of the week effects, these effects are no longer concentrated on Monday.

I. Introduction

The number of empirical studies using daily stock returns is rapidly increasing.[1] Researchers generally assume that the distribution of stock returns is identical for all days of the week—a convenient statistical assumption but not a necessary condition of market equilibrium. Nevertheless, there are reasons to suspect that the distribution of returns may vary according to the day of the week; the most obvious is the impact of weekends on Monday's return. Since Monday's return is calculated over three instead of one calender day, the mean and variance may well be higher on Monday compared with any other daily return (perhaps three times as large).

Previous research has examined the daily distribution of stock returns for a Monday effect. While Fama (1965) does not compare daily mean returns, he does report that Monday's variance is about 20% greater than other daily returns. With

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1. The list of papers using daily stock returns is too long to name. Recent examples include Charest (1978), Dodd (1980), Banz (1981), and Reinganum (1981).

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a different methodology Godfrey, Granger, and Morgenstern (1964) reach a similar conclusion. More recently Cross (1973) and French (1980)[2] uncover evidence of negative average returns for Monday using the Standard and Poor's 500 (hereafter, S & P 500).

This paper further examines asset returns for day of the week effects. In addition to confirming conclusions of previous studies, we also find that the negative return for Monday is remarkably uniform across individual stocks and that treasury bills earn a below-average return on Monday. Several explanations are investigated; none prove satisfactory. Our results, supporting day of the week effects in equilibrium returns, suggest the need for further investigation of the determinants of equilibrium over time. In the closing sections of the paper, the impact of the day of the week effects on tests of market efficiency is examined. It is interesting to note that market-adjusted returns exhibit day of the week effects, but the effects are not concentrated on a particular day of the week. Because of this the power of market efficiency tests should be improved by accounting for day effects in raw and market-adjusted returns.

II. Empirical Results

The initial tests are conducted with the S & P 500 and the value- and equal-weighted portfolios constructed by the Center for Research in Security Prices (hereafter, CRSP). Such indexes only provide a rather general picture of asset returns, but if weekends have the same qualitative impact on all assets, the effect should be detectable. In addition, these tests allow confirmation of the results given by Cross (1973) and French (1980).

Table 1 lists the sample means and variances for each of the indexes during the period July 2, 1962–December 28, 1978, and for several shorter periods. While the sample mean returns on Monday are generally negative, the sample variances do not exhibit a strong Monday effect. To test for day of the week effects, consider the following model:

$$\tilde{R}_{it} = \alpha_{1i}D_{1t} + \alpha_{2i}D_{2t} + \alpha_{3i}D_{3t} + \alpha_{4i}D_{4t} + \alpha_{5i}D_{5t} + \tilde{v}_{it}, \qquad (1)$$

where $\tilde{R}_{it}$ is the return of index (or security) i in period t, $\tilde{v}_{it}$ is a disturbance, D_{1t} is a dummy variable for Monday (i.e., $D_{1t} = 1$ if observation t falls on a Monday and 0 otherwise), D_{2t} is a dummy variable for Tuesday, etc. The vector of disturbances, $\tilde{v}_t$, is assumed to be independently and identically distributed as $N(0,\Sigma)$ where Σ is not assumed to be diagonal. The coefficients of (1) are the mean returns for

2. While writing the first draft of this paper, we learned of a similar paper by French (1980). French documents similar day of the week effects for the Standard and Poor's 500.

Monday through Friday. To confirm the identical distribution assumption requires the equality of the regression coefficients. This hypothesis is separately checked[3] for each index, and table 2 reports these test statistics. Our formal tests confirm the general pattern in table 1. For all sample periods except the November 29, 1974–December 28, 1978 period, the hypothesis of equality is rejected for each index. These results are not necessarily explained entirely by Monday; Tuesday appears to be slightly low, and Wednesday and Friday appear to be somewhat higher than Tuesday or Thursday. While these other days may contribute to rejecting the hypothesis of equality, Monday remains the most unusual day of the week.[4] For the overall sample, the average annual return on Monday ranges from −33.5% (the S & P 500) to −26.8% (the equal-weighted index)!

The tests reported in table 2 are convincing but subject to an important limitation. The estimated autocorrelations at lag 1 for the S & P 500 and the value-weighted indexes are about .2, and the estimated autocorrelation for the equal-weighted index is on the order of .4. According to Scholes and Williams (1977), these autocorrelations may be explained by nontrading of securities. Not only does the autocorrelation distort the reported standard errors but the misspecification may lead to more subtle problems. If small issues tend to trade more frequently on Friday than other days of the week, the mean of the observed returns of an index would be high on Friday and low (but not negative) on Monday—reducing the magnitude and, therefore, the statistical importance of the observed effects.

To avoid the nontrading problem, as well as to determine the extent of the Monday phenomenon across securities, tests are also conducted with individual securities with equation (1) as the underlying statistical model. For these tests, the firms of the Dow Jones 30 (these securities are listed in the appendix) are selected, since these securities are actively traded. The sample means for each day of the week are summarized in figures 1 and 2 for periods July 3, 1962–December 28, 1978; July 3, 1962–October 27, 1970; and October 30, 1970–December 28, 1978. Apparently, negative Monday effects are not limited to a few securities. In fact, for the overall period and the first subperiod, all 30 securities have a negative mean on Monday! Our formal tests[5] are

3. Instead of checking each index separately, a joint test for all three indexes is feasible. Such a joint hypothesis was investigated, and the qualitative results presented in table 2 remain unaffected.

4. The unusual appearance of Monday relative to other weekdays can be formally confirmed. By altering equation (1) to an intercept with a set of four dummies (arbitrarily eliminating one of the dummies), the t-statistics for the coefficients on the dummies verify the claim in the text.

5. For individual securities, the test for a day of the week effect relies on a multivariate hypothesis that $\alpha_{1i} = \alpha_{2i} = \alpha_{3i} = \alpha_{4i} = \alpha_{5i}$, a linear hypothesis for Zellner's seemingly unrelated regression model (Zellner 1962; Theil 1971, chap. 7).

TABLE 1 Sample Means and Variances of the Percentage Return by Day of the Week: Stock Indexes

		S & P 500		CRSP Value-weighted		CRSP Equal-weighted	
Time Period*	Day of the week	Mean	Variance	Mean	Variance	Mean	Variance
July 3, 1962– December 28, 1978 (4,132)	Monday	−.134	.670	−.117	.660	−.107	.794
	Tuesday	.002	.551	.010	.518	−.013	.520
	Wednesday	.096	.644	.105	.626	.132	.623
	Thursday	.028	.483	.047	.469	.099	.542
	Friday	.084	.479	.106	.456	.216	.501
July 3, 1962– October 27, 1970 (2,069)	Monday	−.165	.474	−.148	.491	−.131	.701
	Tuesday	.006	.398	.020	.389	−.004	.459
	Wednesday	.134	.476	.145	.475	.181	.568
	Thursday	.027	.338	.038	.339	.087	.480
	Friday	.104	.277	.120	.280	.209	.385
October 30, 1970– December 28, 1978 (2,061)	Monday	−.102	.871	−.086	.834	−.082	.890
	Tuesday	−.002	.705	.001	.647	−.023	.583
	Wednesday	.059	.804	.067	.769	.085	.672
	Thursday	.030	.632	.056	.603	.111	.606
	Friday	.063	.680	.092	.633	.223	.617

July 3, 1962– August 12, 1966 (1,037)	Monday	−.103	.292	−.085	.282	−.050	.339
	Tuesday	.023	.362	.038	.334	.008	.308
	Wednesday	.096	.294	.110	.277	.134	.245
	Thursday	.043	.211	.052	.192	.115	.212
	Friday	.139	.204	.150	.193	.219	.201
August 15, 1966– October 27, 1975 (1,032)	Monday	−.225	.648	−.210	.691	−.212	1.048
	Tuesday	−.009	.432	.003	.441	−.016	.605
	Wednesday	.175	.670	.183	.690	.233	.917
	Thursday	.011	.465	.023	.485	.060	.746
	Friday	.070	.347	.093	.362	.199	.563
October 30, 1970– November 27, 1974 (1,030)	Monday	−.218	.992	−.207	.972	−.201	1.054
	Tuesday	.056	.769	.046	.719	−.050	.626
	Wednesday	.030	.940	.036	.904	.018	.764
	Thursday	.034	.745	.047	.724	.033	.720
	Friday	.025	.779	.051	.718	.157	.639
November 29, 1974– December 28, 1978 (1,031)	Monday	.015	.721	.036	.666	.038	.694
	Tuesday	−.059	.635	−.045	.572	.004	.538
	Wednesday	.089	.664	.098	.631	.153	.570
	Thursday	.026	.520	.065	.482	.189	.479
	Friday	.100	.577	.133	.545	.288	.587

*Figures in parentheses = number of observations during each period.

TABLE 2 **Test for Day of the Week Effects: Stock Indexes**

Time Period	Degrees of Freedom	S & P 500		CRSP Value-weighted		CRSP Equal-weighted	
		F	P-Value*	F	P-Value*	F	P-Value*
July 3, 1962–December 29, 1978	4;4,128	12.12	.0001	12.59	.0001	22.05	.0001
July 3, 1962–October 27, 1970	4;2,064	14.12	.0001	13.72	.0001	15.37	.0001
October 30, 1970–December 29, 1978	4;2,057	2.49	.001	2.89	.001	8.65	.0001
July 3, 1962–August 12, 1966	4;1,032	6.31	.0001	6.33	.0001	8.86	.0001
August 15,1966–October 27, 1970	4;1,029	8.58	.0001	8.11	.0001	8.38	.0001
October 30, 1970–November 28, 1974	4;1,025	3.08	.0152	3.14	.0137	4.55	.0001
November 29, 1974–December 29, 1978	4;1,027	1.37	.2429	1.63	.1642	4.84	.0111

NOTE.—$\tilde{R}_{it} = \alpha_{1i}D_{1t} + \alpha_{2i}D_{2t} + \alpha_{3i}D_{3t} + \alpha_{4i}D_{4t} + \alpha_{5i}D_{5t} + \tilde{\nu}_{it}$; H_0: $\alpha_{1i} = \alpha_{2i} = \alpha_{3i} = \alpha_{4i} = \alpha_{5i}$ (for one particular value of i).
*The minimum P-value reported is .0001.

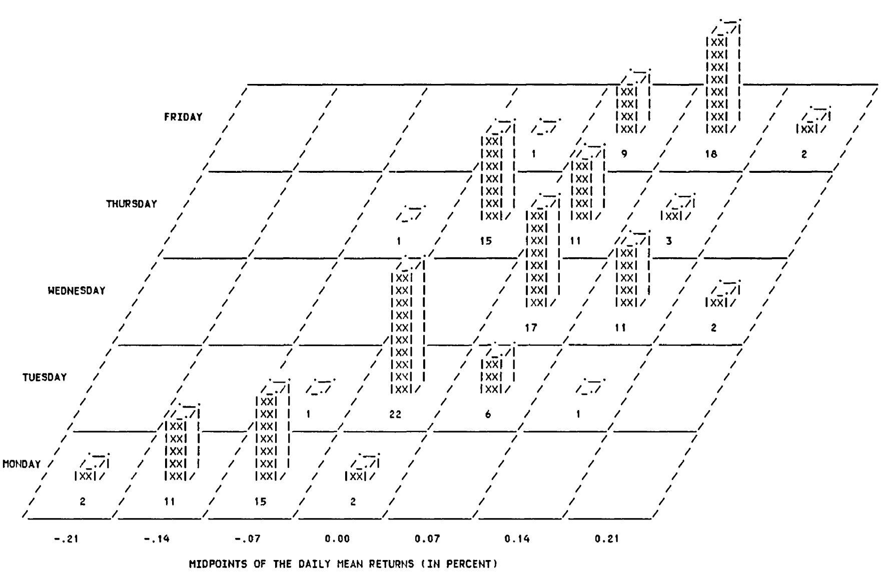

FIG. 1.—Daily distributions of mean returns for the Dow Jones 30, July 3, 1962–December 28, 1978.

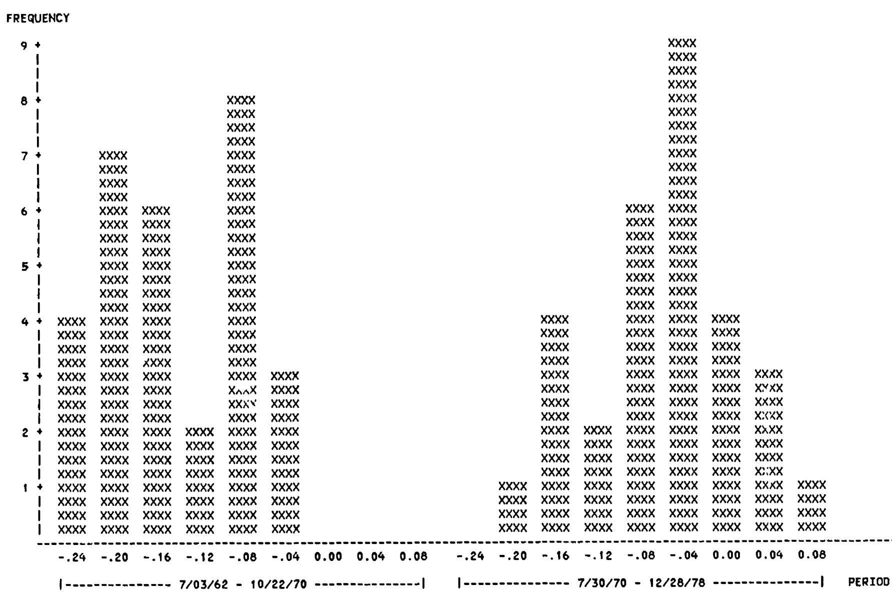

FIG. 2.—Distributions of Monday mean returns for the Dow Jones 30, July 3, 1962–October 22, 1970, and July 30, 1970–December 28, 1978.

TABLE 3 Test for Day of the Week Effects: Dow Jones 30

Time Period	Observations per Security (N)	F-Statistic*	P-Value†
July 3, 1962–December 29, 1978	4,128	1.635	.0001
July 3, 1962–October 27, 1970	2,067	1.708	.0001
October 30, 1970–December 29, 1978	2,059	1.684	.0001
July 3, 1962–August 12, 1966	1,037	1.503	.0001
August 15, 1966–October 27, 1970	1,032	1.559	.0001
October 30, 1970–November 28, 1974	1,029	1.347	.0068
November 29, 1974–December 29, 1978	1,030	1.228	.0459

NOTE.—$\tilde{R}_{it} = \alpha_{1i}D_{1t} + \alpha_{2i}D_{2t} + \alpha_{3i}D_{3t} + \alpha_{4i}D_{4t} + \alpha_{5i}D_{5t} + \tilde{\nu}_{it}; H_0: \alpha_{1i} = \alpha_{2i} = \alpha_{3i} = \alpha_{4i} = \alpha_{5i}$ (for all values of i).

*The degrees of freedom in all cases = 120 and the number of observations less five times 30.

†The smallest P-value reported is .0001.

reported in table 3 and confirm the findings reached with the previous tables. The reader should keep in mind our statistical results account for any contemporaneous correlation in the disturbances, $\tilde{\nu}_{it}$, of (1).

Adjusting for Heteroscedasticity

The results are puzzling. Imagining why expected returns for stocks vary according to the weekday is difficult, and we are unaware of any theory which would predict negative Monday returns. Hence, we want to ensure that the results cannot be explained by inappropriate statistical assumptions. The previous estimation of equation (1) implicitly assumes that the covariance matrix is the same for all days of the week. While such a statistical assumption is convenient, its validity may be questioned. As previously indicated, returns on Mondays may have a higher variance relative to other days, and the results of table 1, as well as previous work by Godfrey, Granger, and Morgenstern (1964) and Fama (1965), confirm this conclusion. To avoid heteroscedasticity, equation (1) is standardized by the estimated standard deviations for each day of the week. Conditional on these estimates, the covariance matrix of disturbances in the weighted system equals the correlation matrix. Although the correlations among disturbances may also change throughout the week, the constancy of the correlation matrix seems reasonable a priori, so computational considerations lead to only an adjustment for changing variance.

The results from estimating the weighted system are shown in table 4. The heteroscedasticity adjustment has no important impact on the

TABLE 4 Test for Day of the Week Effects with an Adjustment for Heteroscedasticity: Dow Jones 30

Time Period	Observations per Security (N)	F-Statistic*	P-Value†
July 3, 1962–December 29, 1978	4,128	1.641	.0001
July 3, 1962–October 30, 1970	2,070	1.736	.0001
November 3, 1970–December 29, 1978	2,058	1.696	.0001

NOTE.—$\tilde{R}_{it}/S_{it} = \alpha_{1i}(D_{1t}/S_{it}) + \alpha_{2i}(D_{2t}/S_{it}) + \alpha_{3i}(D_{3t}/S_{it}) + \alpha_{4i}(D_{4t}/S_{it}) + \alpha_{5i}(D_{5t}/S_{it}) + \tilde{\nu}_{it}/S_{it}$; H_0: $\alpha_{1i} = \alpha_{2i} = \alpha_{3i} = \alpha_{4i} = \alpha_{5i}$ (for all i), where S_{it} = estimated SD of security i, assuming that the variance is not identical for different days of the week (i.e., S_{it} has five different values for each security i).

*The degrees of freedom = 120 and the number of observations less five times 30.

†The smallest P-value reported is .0001.

conclusions. In comparing tables 3 and 4, the F-statistics are virtually the same for both the weighted and unweighted systems.

Tests for Days of the Week Effects in the Treasury Bill Market

The results for common stocks indicate a strong negative Monday effect, but how widespread is this phenomeon across other types of financial assets? If other assets exhibit day of the week effects, institutional peculiarities of stock trading can be ruled out as likely explanations. Treasury bills (hereafter, T-bills) are good assets for such an investigation. When no formal auction market exists for T-bills, they are actively traded, and the returns to bills are approximately orthogonal to those of stocks.[6] The data available on T-bills consist of bid-ask quotes for maturities ranging from about 30 to 25 days.[7] From this series a constant maturity series is constructed by assuming a locally flat term structure.[8] Our return series is calculated as:

$$\tilde{R}_{Bt} = \frac{\tilde{P}_{29,t} - P_{30,t-1}}{P_{30,t-1}},$$

where $\tilde{R}_{Bt}$ is the return from holding a 30-day bill from the close of t to the close of $t - 1$; $P_{29,t}$ is the implied price of a 29-day bill at t; and $P_{30,t-1}$ is the implied price of a 30-day bill at $t - 1$.[9] This return series is

6. See Jaffe and Mandelker (1976), and Famma and Schwert (1977).

7. We are indebted to Truman Clark for providing us with this data.

8. The series is constructed to bias the results against finding a negative Monday effect. The implied price for a 24-day bill on a Monday is based on a bill with a typical maturity of 24 days, rather than 31 days which is also available. If a liquidity premium exists, the implied price from the former will be higher than the implied price from the latter; the higher price will inflate the return on Monday.

9. The implied price, P^*, for a bill with S periods till maturity, based on the actual price, P, of a bond with T periods till maturity, is $P^* = F(P/F)^{T/S}$, where F is the face value of the pure discount bonds.

calculated for the period December 28, 1962–December 27, 1968. The return measures interest for 1 day plus any capital gains or losses due to changes in the interest rate.

As Fama (1976, chap. 6) has noted, the nominal interest rate resembles a random walk; therefore, our return series is not likely to be stationary. In fact, all the estimated autocorrelations out to lag 38 are in the vicinity of .2, (the highest estimate is .249 at lag 9 and the lowest is .165 at lag 23); thus, a model like equation (1) with a white-noise disturbance will not be adequate. In order to achieve stationarity, a differenced version of (1) is considered:

$$\tilde{R}_{Bt} - R_{Bt-1} = \alpha_{1b}D_{1t} + \alpha_{2B}D_{2t} + \alpha_{3B}D_{3t} + \alpha_{4B}D_{4t} + \alpha_{5B}D_{5t} + \tilde{\nu}_{Bt}. \tag{2}$$

The coefficients of (2) equal the differences in means for each day of the week. For example, α_{1B} is Monday's mean less Friday's, and α_{4B} is Thursday's less Wednesday's. If the return series is stationary and if each day of the week has the same mean return, all the coefficients of (2) are zero. While the differenced series is stationary, the disturbances of (2) still exhibit heteroscedasticity (related to the day of the week) and first-order autocorrelation. Weighting the observations by the SD for a particular weekday achieves a homoscedastic disturbance. Representing the process underlying $\tilde{\nu}_{Bt}$ (after adjusting for heteroscedasticity) as a first-order moving average, equation (2) is estimated,[10] and these results along with several tests are reported in table 5.

The estimates of (2) reveal a pattern in t-bill returns similar to stock returns. Monday's return is on average lower, the Wednesday's return on average is higher than other days of the week. The hypothesis that the mean effects are the same for each day of the week is easily rejected. Apparently, t-bills, like stocks, have strong day of the week effects, and the effects for bills and stocks are qualitatively the same.

Settlement Effects

In the tradition of past empirical work, the above analysis has been framed as if security transactions result in instantaneous payment and delivery. In fact, most transactions are settled several business days after the quote or transaction date. The observed quotations then are not spot prices but forward prices.[11] These forward prices equal the

10. After adjusting for heteroscedasticity, the residuals from equation (2) have a first-order sample autocorrelation of −.485 while the higher autocorrelations are well within 2 SEs of zero. Such evidence is consistent with a first-order, moving average process, and fitting such a model to the residuals yields $\hat{\nu}_{Bt} = a_t - .77a_{t-1}$ where a_t is white noise. For ease of computation, both sides of equation (2) (after adjusting for heteroscedasticity) are multiplied by $(1 - .77B)^{-1}$, where B is the backshift operator, and this infinite order polynomial is truncated after lag 40. Box and Jenkins (1976) discuss this type of inversion.

11. The forward price is set such that the forward contract has zero value.

TABLE 5 Estimates of and Tests for Day Effects in Treasury Bills with Adjustments for Heteroscedasticity and Autocorrelation

	Estimates*						Test of Null Hypothesis		
Time Period	$\hat{\alpha}_{1B}$	$\hat{\alpha}_{2B}$	$\hat{\alpha}_{3B}$	$\hat{\alpha}_{4B}$	$\hat{\alpha}_{5B}$	$\hat{\rho}_1$	Degrees of Freedom	F	P-Value†
December 28, 1962–December 27, 1968	−.357 (.234)	−2.236 (.406)	3.209 (.447)	.212 (.334)	−.790 (.284)	.03	4;1449	20.99	.0001
December 28, 1962–June 21, 1965	−.250 (.195)	−1.324 (.337)	2.025 (.367)	.167 (.274)	−.579 (.232)	.04	4;701	12.85	.0001
June 22, 1965–December 27, 1968	−.500 (.412)	−3.100 (.713)	4.337 (.797)	.253 (.594)	−.955 (.509)	.03	4;743	12.00	.0001

NOTE.—The SEs for the regression coefficients are reported in parentheses below the estimates. $\tilde{R}_{Bt} - R_{Bt-1} = \alpha_{1B}D_{1t} + \alpha_{2B}D_{2t} + \alpha_{3B}D_{3t} + \alpha_{4B}D_{4t} + \alpha_{5B}D_{5t} + \tilde{\nu}_{Bt}$; H_0: $\alpha_{1B} = \alpha_{2B} = \alpha_{3B} = \alpha_{4B} = \alpha_{5B}$.

*All estimates have been multiplied by 1,000.

†The smallest P-value reported is .0001.

spot prices grossed up by the riskless rate of interest for the length of the settlement period. Since settlement days are calculated in terms of business days, any settlement period that is not a multiple of five will introduce a day of the week effect; currently, the settlement period for stocks is 5 business days. Before February 10, 1968, however, the settlement period was 4 business days. Prior to this data, Monday's price should be grossed up by 4 days of interest, whereas Tuesday's through Friday's prices should be grossed up by 6. This asymmetry in settlement periods creates a day of the week effect similar to the one documented above—a low and, perhaps, negative return on Monday. Given that the first subperiod shows a stronger Monday effect than the latter subperiod in table 3, the empirical examination of settlement seems warranted, even though negative returns on Monday are still observed after 1968. What about T-bills? In the bill market, delivery occurs in 1 business day; therefore, Friday's price includes 2 extra days of interest. Again, Monday's return should be low. If daily interest rates are observable, quoted prices could be transformed into true spot prices. Since daily interest rate data are not easily available, an alternative technique is used. If the negative effect on Monday is due to settlement periods, stock returns should be high enough on Tuesday to compensate for Monday's falloff. In the bill market, Friday's return should compensate for Monday's. By testing for these effects, the linkage between the day of the week anomaly and settlement procedures can be examined.

The easiest way to test for the impact of different settlement procedures is to write (1) and (2) in a mean-adjusted form, that is, allow the intercept term to represent one day of the week:

$$\tilde{R}_{it} = \alpha^*_{0i} + \alpha^*_{1i}D_{1t} + \alpha^*_{2i}D_{2t} + \alpha^*_{4i}D_{4t} + \alpha^*_{5i}D_{5t} + \tilde{v}^*_{it} \tag{3}$$

and

$$\tilde{R}_{Bt} - R_{Bt-1} = \alpha^*_{0B} + \alpha^*_{1B}D_{1t} + \alpha^*_{2B}D_{2t} + \alpha^*_{4B}D_{4t} + \alpha^*_{5B}D_{5t} + \tilde{v}^*_{Bt}. \tag{4}$$

Arbitrarily, a dummy variable for Wednesday is excluded. The coefficients of this model are the means for each day of the week deviated from Wednesday. To study settlement effects, the equality between the coefficients for Monday and Tuesday for all stocks is tested, and for bills the equality between Monday's and Friday's coefficients is examined.[12] These results are shown in table 6, and as expected given the post-1968 results, differing settlement periods do not explain the earlier results.

12. As in table 5, equation (4) is estimated with an adjustment for heteroscedasticity as well as autocorrelated disturbances.

TABLE 6 Test for Settlement Effects

Time Period	Degrees of Freedom	F-Statistic	P-Value*
	A. Dow Jones 30		
July 3, 1962– February 9, 1968	30;42,210	1.939	.0001
	B. Treasury Bills†		
December 27, 1962– December 28, 1968	1;1,449	40.73	.0001
December 27, 1962– December 28, 1965	1;701	18.63	.0001
December 29, 1965– December 28, 1968	1;743	33.96	.0001

NOTE.—Part A: $\tilde{R}_{it} = \alpha^*_{0i} + \alpha^*_{1i}D_{1t} + \alpha^*_{2i}D_{2t} + \alpha^*_{4i}D_{4t} + \alpha^*_{5i}D_{5t} + \tilde{v}_{it}$; H_0: $\alpha^*_{1i} + \alpha^*_{2i} = 0$ (for all i). Part B: $\tilde{R}_{Bt} - R_{Bt-1} = \alpha^*_{0B} + \alpha^*_{1B}D_{1t} + \alpha^*_{2B}D_{2t} + \alpha^*_{4B}D_{4t} + \alpha^*_{5B}D_{5t} + \tilde{v}_{Bt}$; H_0: $\alpha^*_{1B} + \alpha^*_{5B} = 0$.

*The smallest P-value reported is .0001.

†Adjusted for heteroscedasticity and autocorrelation.

Observed versus True Prices

The preceding empirical work assumes that the prices of securities are observed without measurement error. Of course, this assumption is not literally true. Perhaps the most obvious violation occurs when securities trade infrequently, and quoted prices are out of date. With no a priori reason, these errors may introduce systematic biases across different weekdays. Given the nature of the results, the possible biases are high prices on Friday and/or low prices on Monday. Previous tests for settlement asymmetries in the stock market have implicitly tested for low Monday prices without success. Further, table 1 and figure 1 generally indicate that Tuesday's return is slightly below average, which is inconsistent with a systematically low price on Monday. Friday's return, on the other hand, does reveal a tendency for above-normal returns, especially for the equally weighted index.

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 Friday's. This implication is tested by estimating equation (3) for stocks. Since the coefficients of this equation are mean-adjusted returns, the hypothesis that Monday's coefficient equals zero is tested. These results are shown in table 7, and the hypothesis is rejected by any reasonable level of significance.

In contrast, previous tests for settlement asymmetries in the t-bill market have implicitly tested for high Friday prices without success. If Monday's below-average return for bills is explained by downwardly biased prices on Monday, the deviation of Monday's return from the overall mean should be exactly offset by Tuesday's. This implication is

TABLE 7 Test for Systematic Measurement Error in Observed Prices

A. Dow Jones 30

Time Period	Observations per Security (N)	F-Statistic*	P-Value†
July 3, 1962–December 29, 1978	4,128	1.96	.0012
July 3, 1962–October 27, 1970	2,067	2.27	.0001
October 30, 1970–December 30, 1978	2,059	2.00	.0009

B. Treasury Bills‡

Time Period	Number of Observations	F-Statistic§	P-Value
December 27, 1962–December 28, 1968	1,449	59.57	.0001
December 29, 1962–December 28, 1965	701	22.02	.0001
December 29, 1965–December 28, 1968	743	42.07	.0001

NOTE.—Part A: $\tilde{R}_{it} = \alpha^*_{0i} + \alpha^*_{1i}D_{1t} + \alpha^*_{2i}D_{2t} + \alpha^*_{4i}D_{4t} + \alpha^*_{5i}D_{5t} + \tilde{\nu}_{it}$; H_0: $\alpha^*_{1i} + \alpha^*_{5i} = 0$ (for all i). Part B: $\tilde{R}_{Bt} - R_{Bt-1} = \alpha^*_{0B} + \alpha^*_{1B}D_{1t} + \alpha^*_{2B}D_{2t} + \alpha^*_{4B}D_{4t} + \alpha^*_{5B}D_{5t} + \tilde{\nu}_{Bt}$; H_0: $\alpha^*_{1B} + \alpha^*_{2B} = 0$

*The degree of freedom in the case of Dow Jones 30 = 30 and the total number of observations less five times 30.

†The smallest P-value reported is .0001.

‡Adjusted for heteroscedasticity and autocorrelation.

§The degrees of freedom in the case of bills = 1 and the number of observations.

tested by estimating equation (4) for bills. Again, these results are reported in table 7, and the hypothesis is rejected at any reasonable level of significance. Systematic errors in the data do not provide an adequate explanation of the Monday phenomenon for either stocks or bills.

III. Implications for Tests of Market Efficiency

At least two competing conjectures may explain the results. One interpretation of the findings is market inefficiency. Such a conclusion implicitly assumes that the market attempts to price securities to yield the same expected return for all days of the week. While the assumption of equal expected returns for all weekdays is statistically convenient, it is not a necessary condition of capital market equilibrium. From a scientific point of view, it is more useful to conclude that the results are strong evidence that equilibrium returns vary across days of the week. This interpretation gives meaning to two related questions: (1) What causes equilibrium to depend on the day of the week? and (2)

What are the implications of the results for past and future empirical work? Leaving the former question to future research, the following sections address the latter.

Tests of Market Efficiency: Mean-adjusted Returns

Much of the empirical research in finance has been directed at testing the efficiency of capital markets. One general class of tests focuses on the impact of various types of announcements on the prices of securities, and efficiency is judged by the speed at which prices adjust. As noted by Fama (1976), all tests of market efficiency condition on a model of market equilibrium. One popular methodology assumes that equilibrium returns are constant and calculates mean-adjusted returns relative to announcement dates;[13] the foundations for such a methodology are inconsistent with our results. Tests of market efficiency should condition on a model of market equilibrium which includes variation in mean returns according to the day of the week. Operationally this extended model requires little more than calculating mean-adjusted returns relative to the day of the week.

Tests of Market Efficiency: Market-adjusted Returns

While only adjusting raw returns from the overall sample mean may be misleading, market-adjusted returns may avoid the day of the week effect given the results in table 1 and figure 1. This question is significant not only for future research, but it also has clear implications for the interpretation of previous empirical tests. This issues is investigated by checking for day of the week effects in market-model residuals. Extending equation (3), the statistical model becomes:

$$\tilde{R}_{it} = \alpha_{0i} + \beta_i \tilde{R}_{mt} + \delta_{1i} D_{1t} + \delta_{2i} D_{2t} + \delta_{4i} D_{4t} + \delta_{5i} D_{5t} + \tilde{\mu}_{it}, \quad (5)$$

where $\tilde{R}_{mt}$ is the return on the CRSP value-weighted index, and a dummy variable is included for every day of the week except Wednesday. Although more sophisticated procedures are available for calculating market-adjusted returns, this regression should capture the major impact of these adjustments. Table 8 reports tests of day of the week effects in market-adjusted returns over various subperiods. Figure 3 charts the average market-model residuals by day of the week for all firms of the Dow Jones 30. The results of table 8 and figure 3 are interesting; while the hypothesis of no day effect is still rejected, the average residuals on Monday are not predominantly negative. Market-adjusted portfolio returns may avoid systematic biases due to a weekend effect.

13. Brown and Warner (1980) present simulations for various situations which suggest this methodology is preferred to more elaborate techniques which adjust for the market portfolio.

TABLE 8 Test for Day of the Week Effects: Market Adjusted Returns

Time Period	Observations per Security (N)	F-Statistic*	P-Value†
July 3, 1962–December 29, 1978	4,128	1.331	.0090
July 3, 1962–October 27, 1970	2,067	1.281	.0208
October 30, 1970–December 29, 1978	2,059	1.653	.0001
July 3, 1962–August 12, 1966	1,037	1.367	.0048
August 15, 1966–October 27, 1970	1,032	1.341	.0077
October 30, 1970–November 28, 1974	1,029	1.256	.0304
November 29, 1974–December 29, 1978	1,030	1.242	.0374

NOTE.—$\tilde{R}_{it} = \alpha_{0i} + \beta_i R_{mt} + \delta_{1i} D_{1t} + \delta_{2i} D_{2t} + \delta_{4i} D_{4t} + \delta_{5i} D_{5t} + \tilde{\mu}_{it}$; H_0: $\delta_{1i} = \delta_{2i} = \delta_{4i} = \delta_{5i} = 0$ (for all i).

*The degrees of freedom in all cases = 120 and the total number of observations less five times 30.

†The smallest P-value reported is .0001.

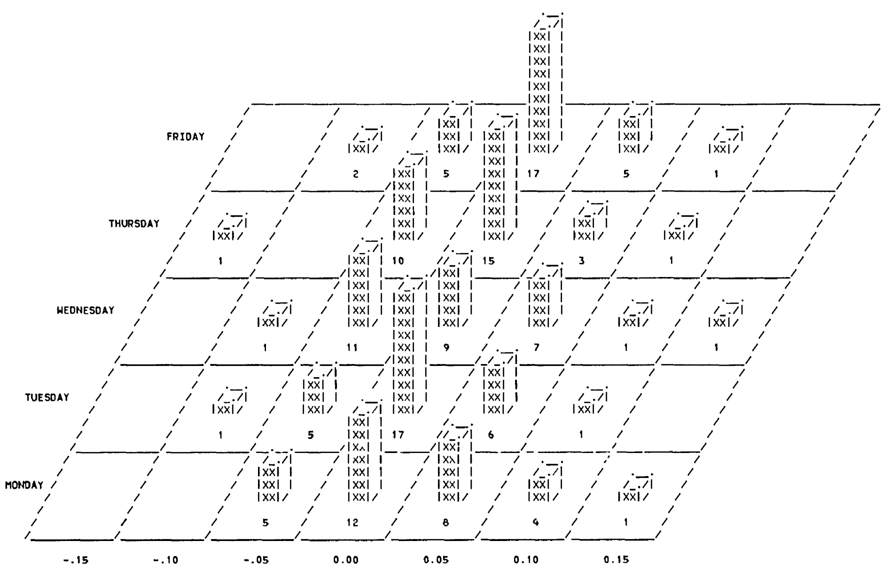

FIG. 3.—Daily distributions of average market-model residuals for the Dow Jones 30, July 2, 1962–December 31, 1978.

IV. Summary and Conclusions

The existence of day of the week effects in asset returns has been documented. The most obvious manifestation of the daily seasonal is the strong and persistent negative mean returns on Monday for stocks and below-average returns for bills on Mondays. Several explanations for the results are suggested and examined; unfortunately, none adequately describe the data. An obvious and challenging empirical anomaly remains. Finally, the impact of our results on tests of market efficiency has been considered. Even after adjusting for the market, stock returns still exhibit day of the week effects, although the qualitative nature of the effect differs from that in raw returns. Future tests of market efficiency, especially event-type studies, should allow for day of the week effects in both raw returns and market-adjusted returns. The aggregation of returns into portfolios, however, may zero out the day of the week effects in market-adjusted returns.

Appendix
Securities Included in the Dow Jones 30

Allied Chemical Corporation; Aluminum Company of America; American Brands Inc.; American Can Company; American Telephone & Telegraph Company; Bethlehem Steel Corporation; Chrysler Corporation; Du Pont E. I. De Nemours & Company; Eastman Kodak Company; Esmark Inc.; Exxon Corporation; General Electric Company; General Foods Corporation; General Motors Corporation; Goodyear Tire & Rubber Company; Inco Ltd.; International Harvester Company; International Paper Company; Johns Manville Corporation; Minnesota Mining & Manufacturing Company; Owens Ill. Inc.; Proctor & Gamble Company; Sears Roebuck & Company; Standard Oil Company of California; Texaco Inc.; Union Carbide Corporation; United States Steel Corporation; United Technologies Corporation; Westinghouse Electric Corporation; F. W. Woolworth Company.

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