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The Effect of Three Mile Island on Electric Utility Stock Prices: A Note

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THE IMPACT OF EVENTS on the time series properties of common stock returns has been the subject of numerous articles in the finance literature. Most studies have shown that capital markets are highly efficient in the sense that prices quickly adjust to publicly available information as investors act to receive a return commensurate with the level of perceived risk.

This note examines the effect on the stock returns of public utility firms of the Three Mile Island (TMI) nuclear accident. In stock valuation models based on investor rationality, permanent price declines are brought about either by a decline in expected cash flows or by an increase in the rate used to discount future cash flows. Such a nuclear accident may directly affect investors' perceptions of both the expected cash flows of utilities and their risk. These future cash flows are affected because a nuclear accident may cause additional costs due to extended shutdowns or abandonment of nuclear plants, expenses of responding to a nuclear accident, and costs of purchasing replacement power.

The response of utility returns to TMI is analyzed at three levels. First, the risk-adjusted returns for the utility experiencing the nuclear accident (General Public Utilities (GPU)) are measured over monthly time periods surrounding TMI. The same analysis is performed on an aggregate sample of electric utility firms to assess the direction and magnitude of TMI's impact on other firms in the industry. Lastly, the sample is divided into utilities with significant nuclear generating capacity at the time of TMI and utilities with no nuclear generating capacity, so that the differential impact of the nuclear accident on nuclear and non-nuclear public utilities may be assessed. Both a single and two index market model are used to estimate risk-adjusted returns. The latter index model includes an interest rate index as well as an equity market index.

I. Data and Methodology

In order to estimate the effect of TMI on public utility equity prices, a sample of 30 non-nuclear and 34 nuclear utilities was selected from those electric utilities whose common stock was traded on the New York Stock Exchange for the period examined and whose distribution of generation capacity was reported in Moody's Public Utility Manual. Utilities with at least 10% installed nuclear generating

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capacity at the end of 1979 were classified as nuclear. The non-nuclear subset had no installed nuclear generating capacity.[1]

The risk-adjusted return procedure used in this study follows that suggested by Mandelker [5] and Brown and Warner [2]. The returns for each sample security were formed into three portfolios: (1) all utilities; (2) nuclear utilities; and (3) non-nuclear utilities. The returns of General Public Utility (GPU), the parent firm of the operator of TMI, were examined separately and not included in the other portfolios.

For GPU and each portfolio, the monthly risk-adjusted returns were first estimated using the single index market model. The single index market model as specified in equation (1) was estimated over the 36-month period February 1975–February 1978. The monthly parameter estimates were used to calculate residuals or abnormal returns (AR_t) according to Equation (2) for the period beginning 13 months before and ending 12 months after TMI.[2]

$$R_{jt} = \alpha_j + \beta_j R_{mt} + \varepsilon_{jt}, \qquad t = -48, \cdots -14 \tag{1}$$

where

$$\begin{aligned} R_{jt} &= \text{Return of } jth \text{ portfolio in month } t; \\ R_{mt} &= \text{Return on the market index (S\&P 500) in month } t; \text{ and} \\ AR_t &= R_{jt} - (\hat{\alpha}_j + \hat{\beta}_j R_{mt}) = e_{jt} \qquad t = -13, -12 \cdots, 0, 1, \cdots 12; \end{aligned} \tag{2}$$

In these equations $t = 0$ corresponds to March 1979, the month of the TMI accident.

The cumulative abnormal returns (CAR_t) across the full public utility sample and subsamples (nuclear and non-nuclear) for each month were determined according to equation (3):[3]

$$CAR_t = \sum_{-13}^{t} AR_t, \qquad t = -13, -12, \cdots, 0, 1, \cdots 12 \tag{3}$$

In addition to a single index market model (Equation (1)), a two index model was also used to measure abnormal returns over the test period in order to eliminate from residuals the common influence of interest rate changes. The second index, R_I, was defined as the monthly return on the S&P AAA long term industrial bond index.[4] Following procedures analogous to those described in

[1] Utilities in each group were drawn from all regions of the country to reduce the impact of regional bias. Four of the utilities classified as non-nuclear had nuclear plants under construction. All analysis was redone with these four utilities omitted from non-nuclear subsample. The results were essentially unaffected. (A list of firms included in each set is available from authors).

[2] Measurements of abnormal return were begun a year before TMI in order to focus on the impact of TMI relative to other events that influence the residuals before and after the accident.

[3] It should be noted that residual analysis is still regarded as a valid empirical methodology [6] despite the recent questions [8] as to the existence of an ex ante inefficient market index proxy. Using monthly data, beta stability tests by authors indicated no significant differences in total (variance) or market (beta) risk for nuclear or non-nuclear based public utilities (except GPU) before or after TMI. Tests however were conducted using only 12 post TMI monthly observations. Pettway [7] found similar results (no significant shift in beta) using weekly observations.

[4] Monthly holding-period returns for S&P bond yield index were calculated by assuming the purchase of a par value bond at the beginning of each month yielding that month's index and the

Table I

Abnormal Returns before and after TMI for General Public Utility (GPU) and Other Utility Firms

		Single Index Model				Two Index Model			
		GPU		Other Utilities		GPU		Other Utilities	
Month		AR	CAR	AR	CAR	AR	CAR	AR	CAR
February 1978	−13	2.1	2.1	.2	.2	2.2	2.2	.3	.3
March	−12	−1.3	.8	−1.9	−1.3	−1.3	.9	−1.9	−1.6
April	−11	−4.7	−3.9	−4.5	−6.2	−4.3	−3.4	−4.0	−5.6
May	−10	−7.9*	−11.8	−3.8	−10.0	−7.1*	−10.5	−2.9	−8.5
June	− 9	−1.5	−13.3	1.3	−8.7	−1.4	−11.9	1.4	−7.1
July	− 8	.3	−13.0	−.7	−9.4	.4	−11.5	−.5	−7.6
August	− 7	−9.0*	−22.0	−3.3	−12.7	−9.7*	−21.2	−4.1	−11.7
September	− 6	2.5	−19.5	−1.0	−13.7	3.1	−18.1	−.3	−12.0
October	− 5	−5.8	−25.3	−4.6	−18.3	−5.9	−24.0	−4.7	−16.7
November	− 4	5.7	−19.6	3.8	−14.5	5.9	−18.1	4.0	−12.7
December	− 3	−4.5	−24.1	−5.6*	−20.1	−3.9	−22.0	−4.9	−17.6
January 1979	− 2	1.7	−22.4	3.9	−16.2	1.6	−20.4	3.7	−13.9
February	−1	−4.2	−26.6	−.8	−17.0	−3.7	−24.1	−.2	−14.1
March (TMI)	0	−10.9*	−37.5	−5.0	−22.0	−10.8*	−34.9	−4.9	−19.0
April	1	−34.6*	−72.1	−4.3	−26.3	−34.3*	−69.2	−4.0	−23.0
May	2	−16.1*	−88.2	3.1	−23.2	−16.9*	−86.1	2.2	−20.8
June	3	11.1*	−77.1	.1	−23.1	10.7*	−75.4	−.4	−21.2
July	4	−3.0	−80.1	−.4	−23.5	−2.5	−77.9	.3	−20.9
August	5	−5.5	−85.6	−4.1	−27.6	−5.2	−83.1	−3.7	−24.6
September	6	−10.3*	−95.9	−5.3*	−32.9	−9.6*	−92.7	−4.5	−29.1
October	7	−4.3	−100.2	−1.8	−34.7	−1.6	−94.3	1.4	−27.7
November	8	−4.7	−104.9	1.6	−33.1	−5.0	−99.3	−1.2	−26.5
December	9	4.8	−100.1	−6.6*	−39.7	5.6	−93.7	−5.7*	−32.2
January 1980	10	−11.9*	−112.0	−6.4*	−46.1	−8.8*	−102.5	−2.6	−34.8
February	11	−24.1*	−136.1	−5.6*	−51.7	−21.0*	−123.5	−1.9	−36.7
March	12	−23.2*	−159.3	5.8*	−45.9	−24.1*	−147.6	4.7	−32.0

* Significantly different from zero at the 5% level of confidence.

Equations (1) and (3), AR_t and CAR_t were calculated using the two index model as specified in Equation (4) for each month in the year before and after TMI.[5]

$$R_{jt} = \lambda_j + \beta_{ljt}R_{mt} + \beta_{2jt}R_{It} + W_{jt} \tag{4}$$

For both the single and two index model, the residual is normalized using the procedure described in Beaver [1]. The normalized residual $[AR_t^*]$ in period t is

sale of the bond at the beginning of the following month priced to yield that month's index yield. Results were also determined using a utility industry index and are available from the authors. These were similar to those presented using an interest rate index. An industry index would itself be influenced by TMI and therefore would obscure the effect of the event as measured by the residuals. The interest rate index used in the analysis admittedly may not capture all utility industry effects such as changes in fuel prices and shifts in the regulating environment.

[5] Results using the two index model were also derived after orthogonalizing the independent variables. Since this orthogonalization does not affect prediction, abnormal return results were the same as those reported. Values of the regression coefficients or orthogonalized independent variables are available from authors.

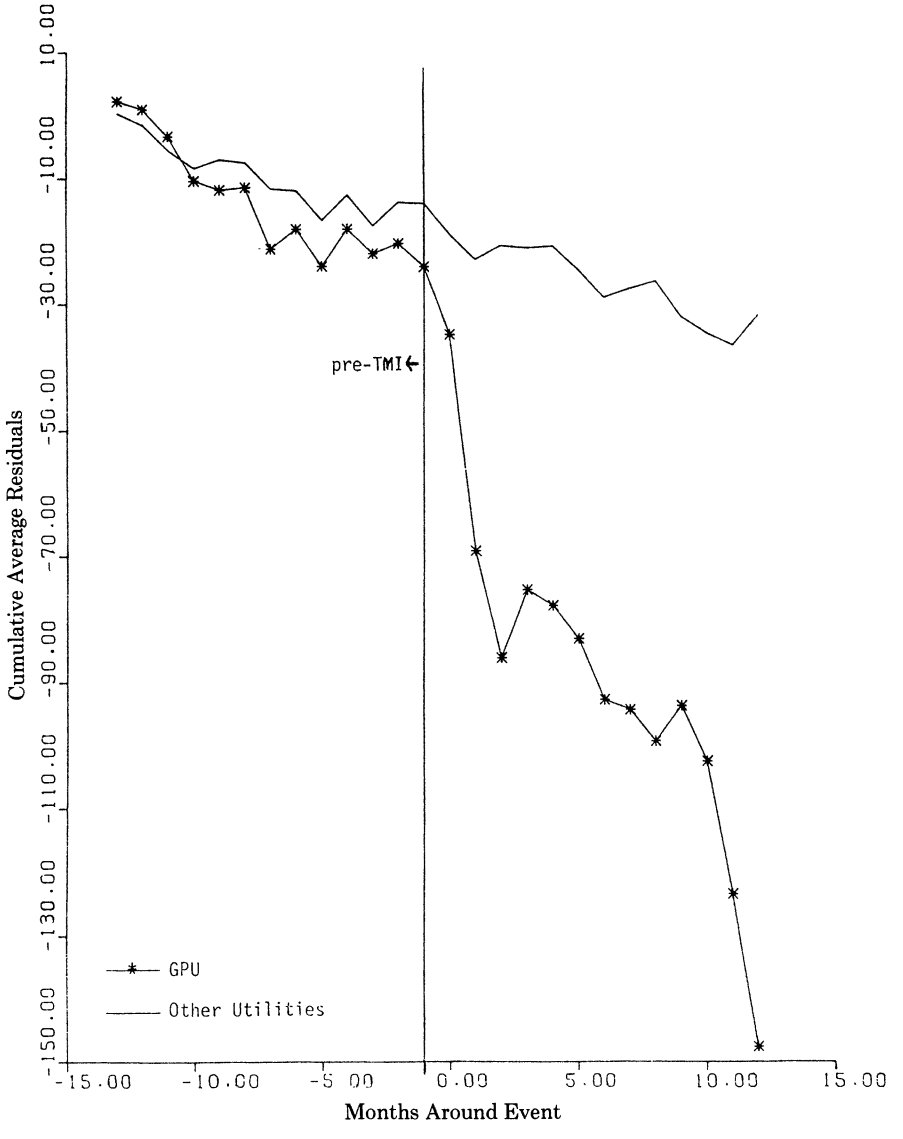

Figure 1. Cumulative Average Residuals (GPU) and other Utility Firms

calculated as follows:

$$AR_t^* = AR_t/S(AR_t) \tag{5}$$

where $S(AR_t)$ is the standard deviation of the residual for the period $t = -50$ to $t = -14$ (February 1975–February 1978). A standardized abnormal return AR_t^* less than -1.96 or greater than 1.96 implies an abnormal return significantly different from zero.[6]

[6] Standardized average residuals (AR_t^*) are given in the Appendix. In addition to the method

Table II

Abnormal Returns before and after TMI for Nuclear and Non-Nuclear Utilities

		Single Index Model				Two Index Model			
		Nuclear		Non-Nuclear		Nuclear		Non-Nuclear	
Month		AR	CAR	AR	CAR	AR	CAR	AR	CAR
February 1978	−13	.1	.1	.4	.4	.2	.2	.5	.5
March	−12	−1.9	−1.8	−2.0	−1.6	−1.9	−1.7	−1.9	−1.4
April	−11	−5.6*	−7.4	−3.3	−4.9	−5.3	−7.0	−2.6	−4.0
May	−10	−3.8	−11.2	−3.9	−8.8	−3.1	−10.1	−2.6	−6.6
June	− 9	1.1	−10.1	1.6	−7.2	1.2	−8.9	1.7	−4.9
July	− 8	−.8	−19.9	−.5	−7.7	−.7	−9.6	−.4	−5.3
August	− 7	−3.3	−14.2	−3.4	−11.1	−3.8	−13.4	−4.4	−9.7
September	− 6	−1.0	−15.2	−1.1	−12.2	−.5	−13.9	−.2	−9.9
October	− 5	−4.3	−19.5	−5.0	−17.2	−4.3	−18.2	−5.1	−15.0
November	− 4	3.4	−16.1	4.2	−13.0	3.5	−14.7	4.4	−10.6
December	− 3	−6.2*	−22.3	−5.0	−18.0	−5.7*	−20.4	−4.0	−14.6
Jaunuary 1979	− 2	4.2	−18.1	3.5	−14.5	4.1	−16.3	3.3	−11.3
February	− 1	−1.3	−19.4	−.3	−14.8	−.9	−17.2	.5	−10.8
March (TMI)	0	−6.1*	−25.5	−3.9	−18.7	−6.0*	−23.2	−3.7	−14.5
April	1	−5.9*	−31.4	−2.7	−21.4	−5.6*	−28.8	−2.2	−16.7
May	2	3.2	−28.2	3.0	−18.4	2.6	−26.2	1.8	−14.9
June	3	.1	−28.1	.1	−18.3	−.3	−26.5	−.5	−15.4
July	4	−.8	−28.9	.1	−18.2	−.4	−26.9	1.0	−14.4
August	5	−4.0	−32.9	−4.2	−22.4	−3.8	−30.7	−3.7	−18.1
September	6	−5.2	−38.1	−5.4*	−27.8	−4.7	−35.4	−4.3	−22.4
October	7	−1.8	−39.9	−1.8	−29.6	.4	−35.0	2.5	−19.9
November	8	.4	−39.5	2.9	−26.7	.1	−34.9	2.3	−17.6
December	9	−6.8*	−46.3	−6.4*	−33.1	−6.2*	−41.1	−5.1	−22.7
January 1980	10	−7.4*	−53.7	−5.4*	−38.5	−4.8*	−45.9	−.3	−23.0
February	11	−4.9*	−58.6	−6.4*	−44.9	−2.4	−48.3	−1.4	−24.4
March	12	6.8*	−51.8	4.8	−40.1	6.0*	−42.3	3.3	−21.1

* Significantly different from zero at the 5% level of confidence.

II. Results

Table I contains the results for General Public Utility (GPU) and the rest of the sample. Figure 1 presents the CAR_t based on the two index model. For March 1979, the month of the accident, the AR was −10.8% for GPU. In the following month (April 1979) GPU reduced its dividend (from 45¢ to 25¢ per share) and the abnormal return was −34.3%. As shown in the plot of CAR_t, the AR's continue to be negative except for positive spikes in June and December. Further large negative returns were evident in February and March 1980. This result may

described in the paper, the standard deviation of abnormal returns from Equation (2)

$$\sqrt{\sum_{i=1}^{N} (AR_{it} - \overline{AR})^2/N}$$

in month t (where N was the number of firms in sample) was also used to determine if the average residual was significantly different from zero. This follows the methodology used in Brown [3]. Results are similar to those presented and are available from authors. It should also be noted that since the event dating (TMI) is the same for all firms, the results are indicative of TMI effect only if no other significant event occurred on that date.

have been caused in part by GPU's (TMI related) dividend curtailment announced 25 February 1980.

While TMI had clear effects in GPU's returns, our concern was with the effect of TMI on other utilities' returns. The average residual for all utilities in the month of TMI based on the single (two) index market model was −5.0(−4.9%) and −4.3(−4.0%) for the following month. Compared to the effect of TMI on GPU's returns, the results from the single as well as the two index model did not indicate a statistically significant TMI effect on the utility sample as a whole.

The question of the effect of TMI on firms with nuclear based versus non-nuclear based generating capacity, remains to be considered. Table II shows results for the overall sample broken into the two subsamples–nuclear and non-nuclear–for both single and two index models. Previous to TMI, abnormal return levels for the nuclear and non-nuclear samples were similar. For the month of the TMI accident as well as the month following TMI in which GPU reduced its dividend by 50%, however, nuclear utilities had significantly negative abnormal returns as measured either by the single or two index model. In contrast the non-nuclear sample did not experience significantly negative abnormal returns in either month. In the months surrounding GPU's dividend cut of February 1980,

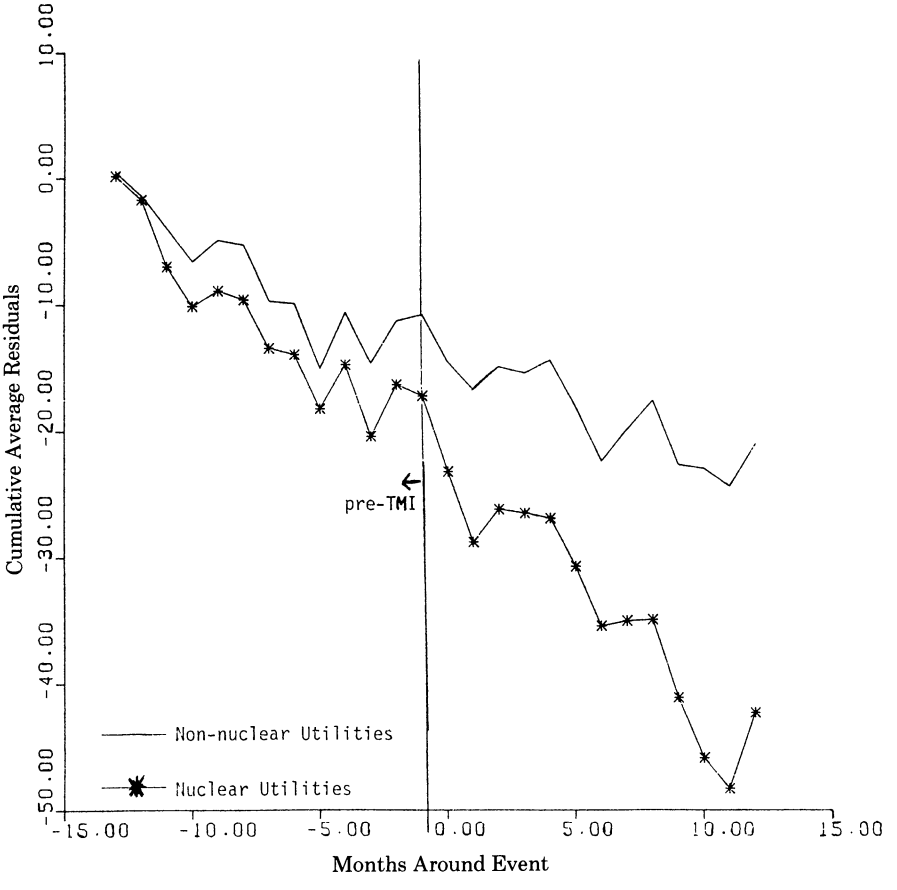

Figure 2. Cumulative Average Residuals Nuclear and Non-Nuclear Utilities

the nuclear and non-nuclear subsets also exhibited markedly different abnormal return performance. For the two index model, the abnormal returns in January and February 1980 for the nuclear utilities were −4.8% and −2.4% as compared to −.3% and −1.4% for the non-nuclear utilities. The importance of the two index model in determining abnormal return was most apparent in the period December 1979 through February 1981. Using the single index model for this period, the estimated non-nuclear residuals were significantly negative. In contrast, using the two index models for this period the non-nuclear residuals were less negative and statistically insignificant. The differences in the AR measures for the two index model can be explained by the fact that the two index model removed the effects of interest rate changes that were not captured in movements of equity index on security returns. To the degree that this period of rising long-term interest rates negatively affected asset returns, abnormal returns which include the interest rate effect would be expected to be more negative than returns from which interest rate effects have been purged.

Figure 2 presents the CAR_t based on the two index model and further illustrates the relative impact of TMI on nuclear and non-nuclear subsamples. Previous to TMI, the graphs of the cumulative residuals based on the two index model for nuclear and non-nuclear utilities were almost parallel. In the month of TMI both the nuclear and non-nuclear firms experienced negative abnormal returns. The return decline was significantly greater for the nuclear firms than for the rest of the sample.

III. Conclusions

An immediate impact of TMI on equity prices for nuclear as well as non-nuclear based was shown by this study. Use of a two index market model revealed that the impact of the accident on non-nuclear firms was less than that on nuclear based utilities even after removing interest rate effects. It is also important to note that while the abnormal returns remained negative for only two months after TMI, returns patterns in the following months did not indicate a return to price levels predating TMI. Results demonstrated that TMI affected primarily existing stockholders of nuclear-based firms at the time of TMI.

Longer term effects of TMI on utility returns were more difficult to pinpoint. Subsequent dividend reductions by the firm experiencing the nuclear accident were shown to coincide with periods of large but not statistically significant negative abnormal returns for other nuclear utilities. The accident may have also increased the long term costs of operation for other utilities by encouraging new sets of government safety regulations for nuclear plants. The negative abnormal returns in other months of 1979 and 1980 cannot be entirely attributed to TMI. The impact of TMI was part of a set of problems which utilities experienced during this period including rising fuel costs, costly environmental regulations, and rising construction costs. What appears in this analysis to be a relatively large number of abnormally negative returns may in fact be the first signs of a shift to a new riskier environment in which both the expected cash flows to shareholder and their volatility are no longer adequately measured by ex post return data.

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APPENDIX

Standardized Abnormal Residuals

	Single Index Model				Two Index Model			
	GPU	ALL	Nuclear	Non-Nuclear	GPU	ALL	Nuclear	Non-Nuclear
February 1979	.53	.09	.03	.14	.54	.11	.04	.18
March	−.33	−.72	−.59	−.72	−.32	−.71	−.68	−.72
April	−1.17	−1.66	−2.03	−1.21	−1.07	−1.49	−1.91	−.98
May	−1.96	−1.41	−1.35	−1.43	−1.77	−1.07	−1.13	−.98
June	−.38	.49	.39	.57	−.36	.54	.42	.64
July	.09	−.24	−.29	−.19	.12	−.20	−.26	−.13
August	−2.25	−1.23	−1.19	−1.23	−2.14	−1.53	−1.38	−1.09
September	.64	−.38	.35	−.39	.78	−.12	−.18	−.05
October	−1.46	−1.71	−1.54	−1.83	−.147	−1.75	−1.56	−1.91
November	1.43	1.41	1.23	1.56	1.47	1.44	1.28	1.67
December	−1.11	−2.07	−2.23	−1.82	−.97	−1.84	−2.08	−1.51
January 1979	.43	1.42	1.50	1.28	.40	1.39	1.48	1.24
February	−1.05	−.31	−.48	.12	−.92	−.08	−.32	.19
March (TMI)	−2.72	−1.86	−2.20	−1.43	−2.70	−1.84	−2.18	−1.40
April	−8.58	−1.60	−2.10	−1.00	−8.54	−1.48	−2.02	−.83
May	−4.01	1.14	1.14	1.09	−4.21	.81	.93	.66
June	2.76	.03	.01	.05	2.67	−.14	−.10	−.19
July	−.76	−.14	−.29	.02	−.62	.11	−.13	.37
August	−1.38	−1.52	−1.44	−1.55	−1.31	−1.40	−1.36	−1.40
September	−2.55	−1.96	−1.88	−1.97	−2.40	−1.69	−1.70	−1.62
October	−1.08	−.68	−.66	−.67	−.40	.53	−.13	.96
November	−1.17	.59	.14	−1.05	−1.26	.45	.05	.87
December	1.19	−2.44	−2.46	−2.33	1.40	−2.12	−2.24	−1.91
Jaunuary 1980	−2.96	−2.38	−2.66	−1.98	−2.10	−.99	−2.75	−.11
February	−5.99	−2.07	−1.96	−2.34	−5.24	−.71	−.85	−.52
March	−5.76	2.15	2.45	1.76	−6.02	1.75	2.17	1.23