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The Effect of Three Mile Island on Utility Bond Risk Premia: A Note

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ON MARCH 28, 1979, one of the two nuclear reactors operated by General Public Utilities (GPU) at its Three Mile Island (TMI) power generating plant failed. The ensuing public uproar had dramatic ramifications for the shares of GPU and for equity returns throughout the electric utility industry [4, 9]. Although utility stocks in general were affected, public utilities with commitments to nuclear power generation seem to have been hardest hit. The sharp downward stock price shifts appear to have been caused by investors' changing risk perceptions, an occurrence likely to have affected bond issues as well. Clearly, potential creditors could be expected to react to the possibility of losses related to nuclear accidents, and to the prospect of larger marginal costs associated with compliance with stricter regulation by Public Utility Commissions.

This study tests for the effects of the TMI accident on bond risk premia in the public utility industry. The following four null hypotheses are tested:

1. Bond risk premia did not increase in the industry as a whole because of the accident at TMI.
2. Bond risk premia were not affected by a firm's commitment to generate nuclear power.
3. Bond risk premia were not affected by the extent of the firm's commitment to nuclear power generation.
4. Bond risk premia were not influenced by the brand of reactor operated.

Section I of the study briefly reviews the research that documents the effects of TMI on utility equities and considers previous models of bond risk premia. Based on those findings, Section II specifies the null hypotheses in a testable form using a model of the risk premium that is consistent with the previous bond risk literature and is designed to control for bond-specific factors and for the state of the economy. Results of the hypothesis testing appear in Section III. Section IV contains the study's conclusions.

I. Review of the Bond Risk Premia and TMI Literature

Hill and Schneeweis [9] and Bowen, Castanias, and Daley [4] apply cumulative average residual techniques to assess the impact of TMI on returns to shareholders of electric utility firms. They agree in finding a large, negative, overall impact and differential effects for firms with and without nuclear-generating capacity.

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The latter study also discovered differentially poor equity return performance for firms with commitments to generate a large proportion (20% or greater) of their power with nuclear plants, and for firms utilizing reactors manufactured by Babcock and Wilcox, the maker of the failed TMI reactor. The results of these studies are quite strong, and are consistent with ex ante expectations.[1] The CAR technique is not suitable for analyzing differential returns among bonds, however, since estimation problems arise when applying the market model to long-term, fixed-coupon investments [1, 16]. Hence, our study examines the effect of TMI on bond risk premia, allowing us to specifically test each of the four null hypotheses stated previously.

Previous empirical research in bond risk differentials falls into two principal categories—cross-sectional analyses of risk premia on individual bonds or time-series analyses of bond indices. The cross-sectional studies exhibit a considerable diversity in their findings, but do seem to agree that maturity and the security characteristics of issues are important [6, 14, 18, 21]. Time-series studies have achieved a wide measure of agreement on the effects of macroeconomic factors. For example, risk premia tend to widen in recessionary periods and narrow during economic expansions [2, 3, 10, 12, 19, 20] while varying directly with the level of Treasury yields [7, 10, 22]. Since this study analyzes a time series of cross-sectional individual bond data, the model developed in the next section considers macroeconomic influences, as well as issue-specific features.

II. Models of Bond Risk Premia

Previous researchers have proposed a variety of different measures of the risk premium. Time-series analyses often use the difference between two bond indices [7, 10, 11] while cross-sectional studies often rely on the difference between a risky bond's yield and the yield on a Treasury security maturing in the same year [6]. Indices abstract from individual issue characteristics, while the arithmetic difference between two yields ignores the effect of at least three potentially important determinants of yield to maturity: maturity, coupon, and duration.[2]

This study uses a duration-based measure of the risk premium, defining it as an individual bond yield minus a duration equivalent Treasury bond yield.[3] The

[1] In a study with markedly contrasting results, Pettway [15] concludes that the effects of TMI "...were not felt widely by other electric utilities taken together as a group or individually by their involvement in nuclear power generation" (p. 19). Pettway examined the effect of TMI relative to other major events affecting public utilities, such as the omission of the dividend by Consolidated Edison in 1974 and the Arab oil embargo. Also, he used a Brown, Durbin, and Evan technique and the Quandt likelihood ratio to test for shifts in the parameters of the market model. This may account for the differences in conclusions.

[2] Since duration measures "effective maturity," ignoring it is likely to result in errors in the measurement of the risk premium, ([5]). Duration has recently been criticized as a complete measure of bond risk by [23] and [8], however. We do not use duration to measure the risk of the various bonds. Rather, it is employed to control for the unavoidable differences in coupon and maturity characteristics between the risky bonds in our sample and the risk-free bonds against which we will measure the risk premium, an application consistent with the findings in [8].

[3] The analyses reported here were also conducted using arithmetic differences. The impact of TMI was found to be essentially the same.

"duration equivalent" Treasury bond yield is determined by using Treasury bond[4] durations immediately above and below that of a sample bond to create a weighted two-bond portfolio that has the same duration as the sample bond, then applying those weights to the yields of the two Treasury bonds in order to linearly interpolate the yield of a Treasury bond having the same duration as the sample bond.[5]

We assert that this model expresses risk premium measure as a function of the following variables:

Control Variable	Expected Sign	Definition
MAT	?	Maturity of the bond in years.
MORT	–	1 if the bond is a first mortgage bond, 0 else.
SINK	–	1 if the bond is protected by a sinking fund, 0 else.
SIZE	+	Par value of the issue.
RATE-A	+	1 if the Moody's bond rating is A, 0 else[6].
RATE-BAA	+	1 if the Moody's bond rating is BAA, 0 else.
RATE-BA	+	1 if the Moody's bond rating is BA, 0 else.
DISC	–	(100 – current price)/100.
LEVEL	+	Average of the 3-month and 10-year constant maturity Treasury yields.
PROD	–	Quarterly change in total industrial production.
TERM	+	(10 year–3 month constant maturity Treasury yield.
OCT79	+	1 for observations after the third quarter 1979, 0 else.

The signs are hypothesized with respect to OLS regression coefficients.

Four variables require comment. Given the conflicting theoretical and empirical evidence on the relationship between risk premia and maturity, no sign is hypothesized for MAT. The variable TERM allows for inflationary expectations, rather than merely past inflation rates. The DISC variable is included to control for the tax effect discussed by Robichek and Niebuhr [17]. Finally, we include OCT79 to allow for the change in Federal Reserve monetary policy regimes that was initiated in October 1979.

Data for this study consist of large volume transaction prices provided by a major investment banking firm for 76 public utility bonds over the period 1977–1982. Observations are quarterly and reflect the bond trade in the quarter, if the trade occurred on or after the 25th of the month ending the quarter. Empirical studies are often criticized if they rely on matrix pricing or market prices on

[4] The Treasury bonds used were 6⅜ August 1984, 8¼ May 1990, 10½ February 1995, 11¾ February 2001, 8¼ May 2000–2005, 10⅜ November 2004–2009, and 12 August 2008–2013. Yields and durations were based on the maturity date.

[5] Although duration is not a linear function, interpolation is acceptable here because the bellwether Treasury bonds have small gaps in their durations. If the duration of a utility bond exceeded the duration of all of the Treasury bonds, then the Treasury yield was represented by that of the longest duration Treasury bond.

[6] Our sample included no AAA-rated bonds, so AA bonds are our omitted class. We anticipate that the coefficients will increase in magnitude as the rating deteriorates.

small-sized transactions. Our data set avoids both of these pitfalls. The bonds in the sample have an average maturity of 24.32 years, an average coupon rate of 9.28%, an average issue size of $111.18 million, and include 73 first mortgage bonds and 61 sinking funds bonds. The 1982 cutoff avoids any confounding effects caused by the impending default by the Washington Public Power Supply Service.[7] Since TMI occurred on March 28, 1979, we omit data from the first quarter of 1979.

III. The Effects of TMI on Bond Risk Premia

The following seven TMI specific variables are employed in order to test the four null hypotheses stated previously:

Test Variable	Expected Sign	Definition
NUCDUM	+	1 for observations after TMI, 0 else.
NUCLEAR1	0	1 before TMI if the firm has nuclear commitment, 0 else.
NUCLEAR2	+	1 after TMI if the firm has nuclear commitment, 0 else.
PERCENT1	0	Percentage of committed nuclear-generating capacity before TMI, 0 else.
PERCENT2	+	Percentage of committed nuclear-generating capacity after TMI, 0 else.
BW1	0	1 before TMI if the firm has a Babcock and Wilcox reactor, 0 else.
BW2	+	1 after TMI if the firm has a Babcock and Wilcox reactor, 0 else.

The NUCDUM variable allows us to examine null hypothesis (1). NUCLEAR and the PERCENT are to examine null hypotheses (2) and (3). BW1 and BW2 pertain to our fourth null hypothesis.

First, we test for the presence of industry-wide shifts in bond risk premia after TMI by including NUCDUM in the control model. The results are presented in column 1 of Table I. All of the statistically significant control variables have the hypothesized sign. The coefficient for NUCDUM is positive and significant, indicating an increase in risk premia for the industry following the TMI incident. Consequently, we reject null hypothesis (1).

The next test results include NUCDUM, NUCLEAR1, and NUCLEAR2, and are reported in column 2 of Table I. Here, NUCLEAR1 is insigificantly negative and NUCLEAR2 is significantly positive. Further, NUCLEAR2 is statistically larger than NUCLEAR1.[8] Thus, we have evidence that bonds of nuclear firms carried a significantly higher relative risk premium after TMI, allowing the rejection of null hypothesis (2).

Perhaps the market considers the extent, not the existence, of nuclear commitment [null hypothesis (3)]. This proposition is tested in column 3 of Table I.

[7] One might expect the WPPSS default to have bond risk premia effects similar to those of TMI. That problem appeared gradually, through a series of legal decisions. Since our methodology is not an event study (e.g., Schwert), the effect of the WPPSS default cannot be measured here.

[8] See Kmenta [13, p. 372, equation (10.46)] for the test statistic employed.

Table I

Industry-wide Effects of TMI on Bond Risk Premia

Variable	Equation (1)		Equation (2)		Equation (3)
MAT	−0.00685		−0.00614		−0.00650
	(−2.62)		(−2.35)		(−2.46)
MORT	−0.13957		−0.06754		−0.03043
	(−2.42)		(−1.06)		(−0.45)
SINK	−0.07663		−0.07313		−0.08006
	(−2.49)		(−2.39)		(−2.58)
SIZE	−0.03028		−0.06109		−0.05195
	(−1.29)		(−2.57)		(−2.18)
RATE-A	0.28292		0.31653		0.30195
	(9.55)		(10.59)		(10.21)
RATE-BAA	0.86869		0.91221		0.90315
	(23.24)		(24.20)		(23.87)
RATE-BA	0.98185		1.04128		1.05842
	(17.31)		(17.78)		(18.09)
DISC	−0.01521		−0.01600		−0.01587
	(−11.55)		(−12.13)		(−12.02)
TERM	0.08010		0.08413		0.08165
	(7.91)		(8.38)		(8.14)
LEVEL	0.10977		−0.11556		0.11331
	(10.05)		(10.65)		(10.43)
PROD	−2.63030		−2.63446		−2.64872
	(−4.13)		(−4.19)		(−4.20)
OCT79	0.46292		0.46551		0.46772
	(8.55)		(8.70)		(8.71)
NUCDUM	0.21753		0.17016		0.20441
	(4.05)		(2.56)		(3.46)
		NUCLEAR1	−0.00804	PERCENT1	−0.14403
			(−0.16)		(−0.87)
		NUCLEAR2	0.09688	PERCENT2	0.14243
			(3.35)		(1.32)
		BW1	0.20005		0.20643
			(3.64)		(3.80)
		BW2	0.14373		0.13619
			(4.04)		(3.83)
Constant	0.32149		0.25295		0.23013
R^2 (ADJ)	0.62567		0.63551		0.63299
Std. Err.	0.41433		0.40886		0.41027
N. Obsv.	1290		1290		1290

Notes: t-statistics appear in parentheses. Sample period is 77:Q1 to 82:Q4.

Although neither PERCENT coefficient is significant, PERCENT2 is statistically larger than PERCENT1, indicating that the extent of nuclear commitment also caused an upward shift in risk premia in the period following TMI.

In order to differentiate between null hypothesis (2) and null hypothesis (3), we estimated a model including all of the control variables and all of the test variables. PERCENT1 and PERCENT2 were not significant, suggesting that the existence, not the extent, of nuclear capacity is important in determining the risk premium. Hence, our expanded results favor acceptance of null hypothesis (3) but rejection of null hypothesis (2).

Concern over the performance of other Babcock and Wilcox reactors might have led investors to demand yet another differential risk premium for the bonds of Babcock and Wilcox utilities after TMI. In columns 2 and 3 of Table I, the coefficients of both Babcock and Wilcox variables are significantly positive—bonds issued by firms with Babcock and Wilcox reactors carried a greater net risk premium than all other bonds before and after the accident. The difference between the coefficients is not statistically significant, however. Thus our results do not allow the rejection of null hypothesis (4).[9]

In summary, the evidence of columns 1 to 3 in Table I supports the following conclusions:

1. The accident at TMI appears to have caused an increase in the risk premia attached to all electric utility bonds.
2. Firms possessing nuclear-generating capacity had a larger increase in risk premia following TMI than did non-nuclear firms.
3. The presence, not the proportion, of committed nuclear-generating capacity appears to be responsible for a larger risk premium.
4. Firms that employed Babcock and Wilcox reactors consistently suffered larger risk premia than did other nuclear firms, but the accident at TMI did not create a differential brand effect.

IV. General Interpretation of the Results

This study concurs with previous findings that there was an industry-wide effect, resulting from TMI, on risk premia that is independent of nuclear power generation. Also, firms with nuclear-generating facilities experienced significant relative increases in risk premia following TMI. Our results indicate that the nuclear effect on risk premia was a function of the existence, not the extent, of a firm's commitment to nuclear power, however. Lastly, while Babcock and Wilcox firms paid a larger risk premium, both before and after TMI, the size of that additional risk premium may have declined by a slight and statistically insignificant amount after TMI.

[9] Only 5 of the 33 utilities sampled had BW reactors. These companies are dispersed throughout the geographic distribution of the sample. In addition, our sample utilities are located throughout the United States.

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