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UTILITY MERGERS AND THE COST OF CAPITAL

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INTRODUCTION

Much work has been done on the impact of mergers and acquisitions on the shareholders of both acquiring and target firms (see Asquith *et al.* [1983], Bradley *et al.*[1988], Jarrell and Poulsen [1989], Jensen and Ruback [1983], and Travlos [1987]). Those studies generally indicate favorable stock price responses for target firms, and slight, to no, stock price response for acquiring firms. Recent interest has been focussed on utility mergers and impacts on share prices, with similar conclusions obtained (see Bartunek *et al.*[1993], Ray and Thompson [1990]). Bartunek *et al* found that acquirers experience wealth losses, while targets experience gains, and that the results are not as favorable as for either as compared with non-utility acquisitions.[1] Ray and Thompson examined four electric utility mergers and found that three of them exhibited positive wealth gains for both acquirer and target shareholders.

There are two significant differences in mergers between non-utility firms and mergers between utility firms. First, utility mergers are subjected to a much a higher level of regulatory scrutiny, at both the state and federal levels. Second, merger-induced efficiency gains and/or cost savings are generally passed on to customers rather than retained by shareholders (see Bartunek *et al.* [1993], Ray and Thompson [1990], Norris [1990], Studness [1989], and Studness [1996] for discussion of these two points).[2] Because of this second point it is not surprising that utility shareholders do not gain as much as non-utility shareholders. Additionally, utility shareholders lose flexibility in terms of their portfolio allocations between the two pre-merger utility stocks, and have, in essence, forced portfolio allocations, based on the relative sizes of the two utility companies. This can result in an increase in the cost of equity, and cost of capital, of the merged utility, which in a regulated environment is ultimately flowed through to the customers (see Bonbright *et al.* [1988] and Morin [1994] for a discussion of cost of capital methods employed by regulators). Thus, in utility mergers, although there may be significant gains in operating efficiencies and cost savings inuring to the benefit of customers, consideration should be made of the offsetting increase in the cost of capital, which ratepayers ultimately pay for.

This paper considers two different models for examining the theoretical increase in the merged utility's cost of capital because of the loss in portfolio allocation flexibility. This is done from the perspective of a hypothetical investor with appropriate portfolio efficiency frontiers and risk-return indifference curves. In Section II, we consider a model (Model 1) where the portfolio consists of just two utility stocks. Section III examines a model (Model 2) where one of the utility stocks is not included in the pre-merger portfolio. In both models it is demonstrated that the utility merger will increase the merged utility's cost of equity.

A MODEL WITH TWO UTILITY STOCKS IN THE PORTFOLIO (MODEL 1)

Assume an investor with a stock investment portfolio composed of the stocks of two utilities, Utility 1 and Utility 2 and that the two utilities announce an impending merger. Let k_1 and k_2 be this investor's required returns on his equity investment's in Utilities 1 and 2, respectively, where $k_1 < k_2$. Finally, let σ_1^2, σ_2^2, and σ_{12} represent this investor's perceptions with regard to variance of return on Utility 1's common stock, the variance of return on Utility 2's common stock, and the covariance of returns on Utilities 1 and 2 common stock, respectively.

The variance, σ_0^2, for any given portfolio allocations to Utility 1 stock, b_1, and Utility 2 stock, $b_2=1-b_1$, is given as:

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Equation 1

$$\sigma_0^2 = b_1^2\sigma_1^2 + b_2^2\sigma_2^2 + 2b_1b_2\sigma_{12}$$

For any given level of risk, or portfolio variance, it can be shown that the optimal values of b_1 and b_2 are:

Equation 2

$$b_1^* = ([\sigma_2^2-\sigma_{12}]-[\sigma_{12}^2-\sigma_2^2\sigma_1^2+\sigma_0^2(\sigma_1^2+\sigma_2^2-2\sigma_{12})]^{½}) / (\sigma_1^2+\sigma_2^2-2\sigma_{12})$$

Equation 3

$$b_2^* = ([\sigma_1^2-\sigma_{12}]+[\sigma_{12}^2-\sigma_2^2\sigma_1^2+\sigma_0^2(\sigma_1^2+\sigma_2^2-2\sigma_{12})]^{½}) / (\sigma_1^2+\sigma_2^2-2\sigma_{12})$$

and the optimizing portfolio return is:

Equation 4

$$k_0 = b_1^*k_1 + b_2^*k_2 = ([k_1\sigma_2^2 + k_2\sigma_1^2] - \sigma_{12}[k_1+k_2] + [k_2-k_1][\sigma_{12}^2-\sigma_2^2\sigma_1^2+\sigma_0^2(\sigma_1^2+\sigma_2^2-2\sigma_{12})]^{½}) / (\sigma_1^2+\sigma_2^2-2\sigma_{12})$$

The relationship in equation 4 represents the efficient frontier for this investor with investments in the common stock of Utilities 1 and 2.[3]

If there is a risk-free investment, with an interest rate of r_o, then we can obtain a capital market line for this investor.[4] The investor will maximize utility by allocating his portfolio between the risk-free investment and an optimal combination of Utility Stocks 1 and 2. It can be shown that the optimizing values of b_1 and b_2 are:

Equation 5

$$\beta_1^* = ([\sigma_2^2-\sigma_{12}]-[k_1-k_2][\sigma_{12}^2-\sigma_1^2\sigma_2^2]/[k_1\sigma_2^2+k_2\sigma_1^2-(k_1+k_2) \sigma_{12}-r_0(\sigma_1^2+\sigma_2^2-2\sigma_{12})])/(\sigma_1^2+\sigma_2^2-2\sigma_{12})$$

Equation 6

$$\beta_2^* = 1 - \beta_1^*$$

The optimizing portfolio variance is given as:

Equation 7

$$(\sigma_P^*)^2 = (\beta_1^*)^2\sigma_1^2 + (\beta_2^*)^2\sigma_2^2 + 2\beta_1\beta_2\sigma_{12}$$

Furthermore, the slope of the capital market line is:

Equation 8

$$\gamma = \sigma_P^*[k_1\sigma_2^2+k_2\sigma_1^2-(k_1+k_2) \sigma_{12}-r_0(\sigma_1^2+\sigma_2^2-2\sigma_{12})]/[\sigma_1^2\sigma_2^2-\sigma_{12}^2]$$

and the capital market line is:

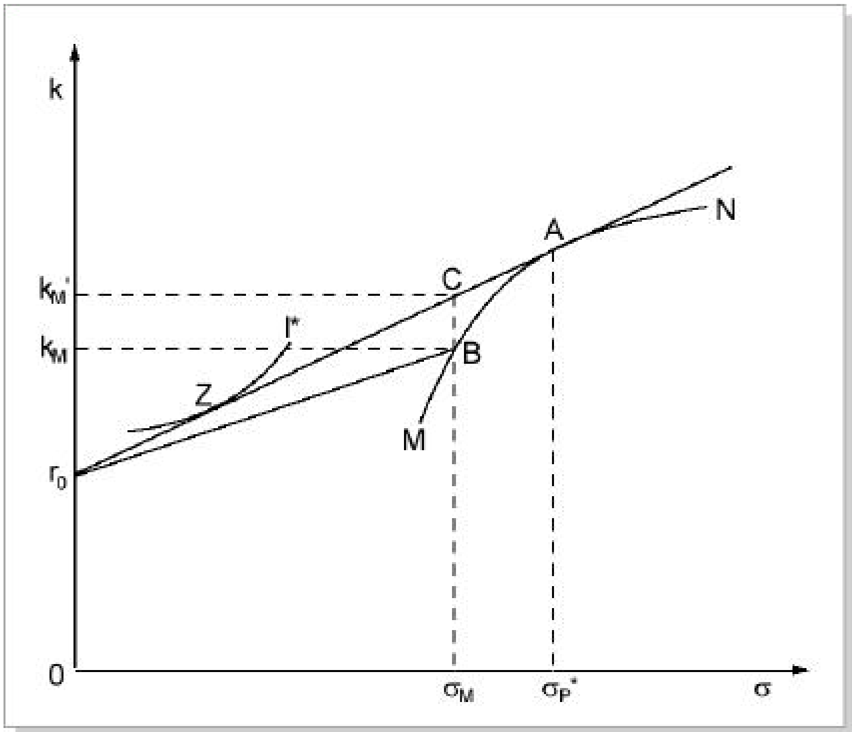
Equation 9

$$k_P = r_0 + \gamma\sigma_P^*$$

This is illustrated in Figure 1. The capital market line is shown as r_0A, where A is the point on the efficient frontier, MN, that corresponds to the optimal allocation reflected in equations (5) and (6). The investor maximizes his utility through an appropriate linear combination of the risk-free investment and his portfolio investment in

Utilities 1 and 2 (explicitly determined by equations (5) and (6)) to achieve the highest indifference curve, I*, at point Z in Figure 1.

FIGURE 1



Note that the optimal allocations between the stocks of Utility 1 and Utility 2, shown in equations (5) and (6), are dependent upon the individual investor's estimates of individual stock variances, covariance, and expected returns. The individual's variance and covariance estimates are unlikely to correspond to the average market estimates of variances and covariance. In the regulated utility environment those expected returns, k_1 and k_2, are in essence equal to the regulators' allowed returns, which are generally equal to the market- required costs of equity.[5] Note that this is in sharp contrast to unregulated markets where the expected return may deviate, significantly, from the market-required cost of equity.

If Utilities 1 and 2 merge, the individual investor no longer has the flexibility to select the allocations between the two utilities. Those allocations are fixed by the relative sizes of the common equity in each of the two firms. For example, assume that a hypothetical investor chooses to hold a 50%/50% allocation between Utility Stocks 1 and 2 in the pre-merger situation. If the two utilities merge, and Utility 1 has a common equity amount of $12 billion and Utility 2 has a common equity amount of $4 billion, then an investor in the new merged stock is now investing with a *forced* allocation ratio of 75%/25%.

Thus, if α_1 and $\alpha_2 = 1\text{-}\alpha_1$ represent the new post-merger *forced* portfolio allocation ratios, the post-merger portfolio return for the individual investor will be:

Equation 10

$$k_M = \alpha_1 k_1 + \alpha_2 k_2$$

and the post-merger portfolio variance for the individual investor will be:

Equation 11

$$\alpha_M^2 = \alpha_1^2 \sigma_1^2 + \alpha_2^2 \sigma_2^2 + 2\alpha_1 \alpha_2 \sigma_{12}.$$

This corresponds to a point on the efficient frontier shown in equation (4) and is illustrated as point B in Figure 1.[6] Note that that *forced* allocation point will necessarily be below the capital market line (unless the forced portfolio allocation happens to be equal to the individual investor's optimizing allocations embodied in equations (5) and (6)).

As can be easily seen from the figure, the post-merger capital market line is given as r_0B, which is everywhere below the pre-merger capital market line r_0A. Consequently, absent any changes in the expected returns, the individual investor will be worse off. In contrast with mergers of unregulated firms, where merger-induced gains in operating and managerial efficiencies enhance the bottom line to the benefit of shareholders, in regulated industries those savings are flowed through to the customers, with little, if any, of the benefits flowing through to customers.[7] To maintain the same level of utility (at I* in Figure 1), the investor will necessarily require an increase in the return on equity. In a regulated utility environment this will necessarily result in an increase in the merged utility's cost of equity, k_M' so that $k_M' > k_M$. This increase in the merged utility's cost of equity continues until the capital market line rotates up to r_0C, so that the individual investor can reach the same indifference curve as in the pre-merger case. Note that point C corresponds to σ_M from equation (11) and k_M', derived from the pre-merger capital market line.

Examples of the magnitude of this cost of equity impact, $k_M' - k_M$, are shown in Tables 1-3. In those three tables, $k_1 = 11\%$, $\sigma_1^2 = .01\%$, $\sigma_2^2 = .015\%$, and $r_0 = 7\%$. The only differences in the tables are that k_2 is set equal to 11.5%, 12%, and 12.5% for Tables 1, 2, and 3, respectively. The "offset" term refers to the amount by which the forced merger portfolio allocation for Utility 1, a_1, exceeds the unconstrained pre-merger portfolio allocation for Utility 1, b_1^*, from equation (5). A positive (negative) offset indicates that the forced Utility 1 portfolio allocation is greater (less) than the unconstrained allocation.

Several implications emerge from those tables. First, the greater the degree of offset, the greater the required increase in the cost of equity. Thus, if the merged allocation ratios are significantly different those that which the investor employed in the pre-merger situation, there will be a greater increase in the cost of equity. Second, the greater the covariance between the stocks of the two merged utilities, the smaller will be the required increase in the cost of equity. Intuitively, this can be explained by noting that the curvature of the efficient frontier, MN, decreases as σ_{12} increases, which implies that $k_M' - k_M$ decreases as well. Third, there is no appreciable effect on the cost of capital impact as the difference between the two utilities' respective costs of equity increases. This can be seen by comparing corresponding elements in Tables 1, 2, and 3. Fourth, the incremental cost of capital impacts are not *de minimis*. For example, in a merged utility with \$5 billion in assets and a 50% common equity ratio, a 20 basis point impact represents \$7.5 million annually in increased rates to customers, and a 100 basis point impact represents \$37.5 million annually in increased rates to customers.[8]

A MODEL WITH ONE UTILITY STOCK AND A NON-MERGER STOCK IN THE PORTFOLIO (MODEL 2)

In this model assume that the individual investor has two stocks in his portfolio: one of the pre-merger utility stocks (Utility 1) and a stock for a company not included in the merger (with expected return $k_3 > k_1, k_2$, and variance σ_3^2). The other utility stock (Utility 2) is not included in his portfolio because of the investor's assumption that the variance of return on Utility Stock 2 is so high that any combination of Utility Stock 2 in the portfolio would be inside the efficient frontier (shown as XY in Figure 2) composed of just Utility Stock 1 and the non-merger stock.

For example, if the expected return on Utility Stock 2 is equivalent to the expected return on Utility Stock 1, and if Utility Stock 2's variance is perceived by the individual investor to be relatively high, then any combination of Utility Stock 1 and Utility Stock 2, results in a new combined Utility Stock M with a standard deviation given as:

Equation 12

$$s_1 = (\alpha_1^2\sigma_1^2 + (1-\alpha_1)^2\sigma_2^2 + 2\alpha_1(1-\alpha_1)\,\sigma_{12})^{1/2}$$

and a covariance with the non-merger stock given as:

Equation 13

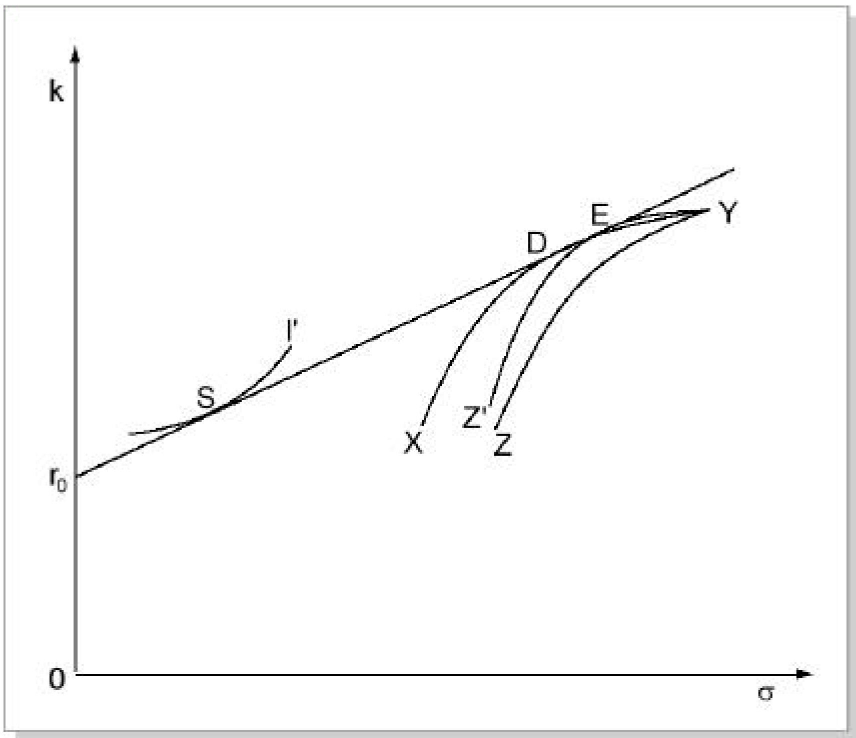
$$s_{13} = \alpha_1\sigma_{13} + (1-\alpha_1)\,\sigma_{23}$$

where $s_1 > \sigma_1$ (given large enough σ_2), α_1 is the proportion allocated to Utility Stock 1 (relative to just Utility Stocks 1 and 2), σ_{13} is the covariance of Utility Stock 1 with the non-merger stock, and σ_{23} is the covariance of

Utility Stock 2 with the non-merger stock. Let us further assume that $\sigma_{13} = \sigma_{23}$, which implies that $s_{13} = \sigma_{13} = \sigma_{23}$. It can be shown that the efficiency frontier of Utility Stock M and the non-merger stock is shown as ZY in Figure 2, and is everywhere below XY[9]. If $s_1 > \sigma_1$, for all α_1, then regardless of the value of α_1, ZY will be below XY and the investor would not include Utility Stock 2 in his portfolio.

The capital market line associated with efficiency frontier XY is shown in Figure 2 as r_0D (with a slope of γ_0), which is tangent to the highest indifference curve, I', achievable at point S. If Utilities 1 and 2 merge with a forced merger portfolio allocations α_1 and $\alpha_2 = 1 - \alpha_1$ for Utility Stocks 1 and 2, respectively, then the investor's efficient frontier will be ZY, the corresponding capital market line will be below r_0D, and tangency with the highest indifference curve will correspond to a lower level of utility.

FIGURE 2



As discussed earlier, the investor will require an increased return on equity in order to maintain the same level of utility (I' in Figure 2). This will result in the cost of equity of the merged utility increasing, which will cause the efficient frontier to shift up, to Z'EY shown in Figure 2, until it is just tangent to the original capital market line r_0D at point E. Note that this new efficient frontier, Z'EY, will *not* necessarily be the same as XDY, and will result in a different portfolio allocation to the non-merger stock.

Let k_1' be the new merged utility's cost of equity, where $k_1' > \alpha_1 k_1 + \alpha_2 k_2$, b be the proportion of the portfolio invested in the merged utility's stock, and 1-b be the proportion of the portfolio invested in the non-merger stock. The efficient frontier, ZY, has to shift out to Z'EY in such a way that k_1' and b satisfy two conditions : (1) the slope of the capital market line, r_0D, is equal to the slope of Z'EY at the optimal value of b (at point E), and (2) at the optimizing value of b (at point E), $k_P = bk_1' + (1-b)k_3$ and $\sigma' = (b^2 s_1^2 + (1-b)^2\sigma_3^2 + 2b(1-b)s_{13})^{½}$ lie on both Z'EY and r_0DE.

The slope of the efficient frontier, for given k_1' and b, can be shown to be equal to:

Equation 14

$$(k_3 - k_1')\sigma'/(s_{13}^2 - s_1^2\sigma_3^2 + (\sigma')^2(s_1^2 + \sigma_3^2 - 2s_{13}))^{½}$$

The denominator of the expression in equation (14) can be shown to be equal to: $| bs_1^2 - (1\text{-}b)\sigma_3^2 + (1\text{-}2b)s_{13} |$. Substituting this into equation (14) and setting this slope equal to the slope of r_0D, γ_0, yields:

Equation 15

$$(k_3 - k_1')\sigma' / | bs_1^2 - (1\text{-}b)\sigma_3^2 + (1\text{-}2b)s_{13} | = \gamma_0.$$

Isolation of k_1' on the left-hand side produces:

Equation 16

$$k_1' = k_3 - \gamma_0 | bs_1^2 - (1\text{-}b)\sigma_3^2 + (1\text{-}2b)s_{13} | / \sigma'.$$

The second required condition is that:

Equation 17

$$r_0 + \gamma_0 s' = bk_1' + (1\text{-}b)k_3.$$

Substitution of k_1', from equation (16) and $\sigma' = (b^2s_1^2 + (1\text{-}b)^2\sigma_3^2 + 2b(1\text{-}b)s_{13})^{1/2}$ into equation (17) yields:

Equation 18

$$r_0 + \gamma_0(b^2s_1^2 + (1\text{-}b)^2\sigma_3^2 + 2b(1\text{-}b)s_{13})^{1/2} =$$
$$k_3 - b\gamma_0 | bs_1^2 - (1\text{-}b)\sigma_3^2 + (1\text{-}2b)s_{13} | / (b^2s_1^2 + (1\text{-}b)^2\sigma_3^2 + 2b(1\text{-}b)s_{13})^{1/2}$$

This equation can then be solved for the optimal value of b, which can then be substituted back into equation (16) to obtain k_1'.[10]

Examples of the cost of equity impact, $k_1' - (\alpha_1k_1 + \alpha_2k_2)$ are shown in Tables 4 -6. In those tables $k_1 = k_2 = 11\%$, $k_3 = 18\%$, $\sigma_1^2 = .01\%$, $\sigma_2^3 = .025\%$, $\sigma_3^2 = .018\%$, and $r_0 = 7\%$. Each table considers a range of covariances (0% to .001%) between Utility Stocks 1 and 2 and the non-merger stock.

Some of the implications here are similar to those derived from Tables 1 - 3. First, the smaller the value of α_1, the greater the required increase in the cost of equity. In this model, $\alpha_1 = 100\%$ in the pre-merger situation, so that the degree of offset increases as we decrease α_1 in the merged utility. Second, the greater the covariance between the stocks of the two merged utilities, the greater will be the required increase in the cost of equity, a result which is in sharp contrast to that obtained in Tables 1 - 3. In Model 2 the intuitive explanation for this phenomenon is that as σ_{12} increases, s_1^2 increases which causes ZY to be that much lower than XY. Intuitively, k_1' must then be that much greater in order to obtain a new Z'Y tangent to r_0D. Third, as $\sigma_{13} = \sigma_{23}$ increases, the cost of capital impact increases. This can be seen by comparing corresponding elements in Tables 4, 5, and 6. Fourth, the incremental cost of capital impacts are not *de minimis* as was discussed in the earlier model.

CONCLUSIONS

When utilities merge, because of the loss in portfolio allocation flexibility and because very little, if any, of the merger-induced cost savings inure to the benefit of the shareholder, the merged utilities' cost of capital will increase.[11] This has a detrimental impact on the customers of the utility and is not small given the capital-intensive nature of utilities. It was demonstrated in both Models that the greater the extent to which the investor's post-merger forced portfolio allocation deviates from the pre-merger portfolio allocation, the greater the required increase in the cost of equity. A corollary of this is that the more diverse are the stockholders of the merging utilities, the greater the likelihood that the pre-merger portfolio allocations are diverse, the greater the degree of "forced portfolio allocation" associated with the merger, and the larger is the impact on the cost of equity.

We also found, in Model 1, that increases in differences in risk, and the costs of equity, between the two utility firms, pre-merger, has practically no effect on the cost of equity impact.

In Model 1, as the covariances between the two firms increase, perhaps indicating increased similarity in operating characteristics, the merger-induced cost of equity effect decreases. The opposite result occurs in Model 2.

In evaluating utility mergers, and their effects on the customers and the public interest, regulators should look beyond the straightforward estimates of cost savings, generally attributable to improved efficiencies. Regulators should also consider the potential increase in the cost of capital, which, if flowed through to ratepayers, would offset any alleged efficiency gains. Furthermore, there is a possibility, that in mergers of utilities that are similarly situated, in terms of geography, customer mix, fuel mix, or regulation, this detrimental cost of capital impact may be even greater.

ENDNOTES

1. They also found that for the combined firms there was a relative decrease in stock price from one to ten days after the announcement.
2. Christensen and Greene (1976) and Tirello and Worms found selected opportunities for cost savings in electric utilities.
3. See Brigham and Gapenski [1993, pp. 59-60] for discussion of the efficient frontier.
4. See Brigham and Gapenski [1993, pp.77-79] for discussion of the capital market line.
5. The discounted cash flow (DCF) and risk premium methods are generally used by regulators, with significant preference given to the DCF method. See Bonbright, Danielsen, and Kamerschen [1988] and Morin [1994] for discussion of these methods.
6. It could lie to the right of point A instead of to the left as shown in Figure 1, but there is no loss in generality in our assumption.
7. Two recent examples of this were the merger of Entergy Corp. with Gulf States Utilities (Federal Energy Regulatory Commission Docket Nos. EC92-21-000 and ER92-806-000) and the proposed merger of Central and Southwest Corp. with El Paso Electric Company (Federal Energy Regulatory Commission Docket Nos. EL94-7-000 and ER94-898-000) where, in both cases, hundred of millions of dollars in merger-related benefits were alleged by the Applicant utilities, which benefits would be flowed through in the form of lower rates to customers. According to claims made by utility executives in *The Wall Street Journal* (various editions), the following proposed mergers will result in significant merger related savings flowing through to customers:

   Western Resources, Inc. - Kansas City Power and Light Co.; Public Service Co. of Colorado - Southwestern Public Service Co.; Texas Utilities - Enserch Corp.; PECO Energy Co. - PP&L Resources, Inc.

   See Studness [1996] for discussion of the flowing through of merger benefits to customers.
8. This includes the effects of associated increased income taxes, which are included in the rates paid by customers. The "tax multiplier" is estimated at 1.5, which corresponds to the current level of corporate federal income tax rates.
9. Let b be the proportion of the portfolio allocated to Utility Stock 1, and Utility Stock M, and "1-b" be the proportion of the portfolio allocated to the non-merger stock. $(b^2s_1^2 + (1\text{-}b)^2 \;{}_3^2 + 2b(1\text{-}b)s_{13})^{½} > (b^2 \;{}_1^2 + (1\text{-}b)^2 \;{}_3^2 + 2b(1\text{-}b) \;{}_{13})^{½}$, since $s_{13} = \;{}_{13}$ and $s_1 > \;{}_1$. The term on the left hand side of the inequality is the portfolio standard deviation on ZY for given k, while the term on the right-hand side of the inequality is the portfolio standard deviation on XY for the same value of k. Hence, ZY lies to the right (or below) XY.
10. Although multiple solutions of b are obtained, we utilized the value of b that corresponded closest to the pre-merger portfolio allocations of Utility Stock 1 and the non-merger stock.
11. Of course, to the extent that individual subsidiaries or divisions of the merged utility continue to be recognized separately for regulatory purposes, different division-specific or subsidiary-specific costs of equity can be calculated as well (see Gordon and Halpern [1974]) for an example of such methodology). Those individual costs of equity will also be higher.

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TABLE 1
Cost Of Capital Impact In Model 1
(k_2 = 11.5%)

	Offset					
σ_{12}	**0.4**	**0.2**	**0.1**	**-0.1**	**-0.2**	**-0.4**
0.0000%	1.27%	0.34%	0.08%	0.09%	0.33%	1.18%
0.0010%	1.10%	0.29%	0.07%	0.07%	0.28%	1.02%
0.0025%	0.88%	0.23%	0.06%	0.06%	0.22%	0.81%
0.0050%	0.58%	0.15%	0.04%	0.04%	0.14%	0.54%
0.0075%	NA	0.09%	0.02%	0.02%	0.08%	0.32%
0.0100%	NA	0.04%	0.01%	0.01%	0.04%	0.15%

Note: NA implies a post-merger portfolio allocation outside the range (0,1)

TABLE 2
Cost Of Capital Impact In Model 1
(k_2 = 12%)

	Offset					
σ_{12}	**0.4**	**0.2**	**0.1**	**-0.1**	**-0.2**	**-0.4**
0.0000%	1.36%	0.36%	0.09%	0.09%	0.33%	1.18%
0.0010%	1.18%	0.31%	0.08%	0.07%	0.28%	1.02%
0.0025%	0.94%	0.24%	0.06%	0.06%	0.22%	0.81%
0.0050%	0.62%	0.16%	0.04%	0.04%	0.14%	0.53%
0.0075%	0.36%	0.09%	0.02%	0.02%	0.08%	0.31%
0.0100%	0.15%	0.04%	0.01%	0.01%	0.03%	0.13%

TABLE 3
Cost Of Capital Impact In Model 1
(k_2 = 12.5%)

	Offset					
σ_{12}	**0.4**	**0.2**	**0.1**	**-0.1**	**-0.2**	**-0.4**
0.0000%	1.46%	0.38%	0.10%	0.09%	0.34%	1.19%
0.0010%	1.26%	0.33%	0.08%	0.08%	0.29%	1.02%
0.0025%	1.00%	0.25%	0.06%	0.06%	0.22%	0.81%
0.0050%	0.65%	0.16%	0.04%	0.04%	0.14%	0.52%
0.0075%	0.37%	0.09%	0.02%	0.02%	0.08%	0.29%
0.0100%	0.14%	0.03%	0.01%	0.01%	0.02%	NA

Note: NA implies a post-merger portfolio allocation outside the range (0,1)

TABLE 4
Cost Of Capital Impact In Model 2
($\sigma_{13} = \sigma_{23} = 0\%$)

σ_{12}	α_1 0.9	0.7	0.5	0.3	0.1
0.0100%	0.03%	0.26%	0.69%	1.27%	1.95%
0.0110%	0.07%	0.34%	0.77%	1.33%	1.98%
0.0120%	0.10%	0.42%	0.86%	1.39%	2.00%
0.0130%	0.14%	0.49%	0.94%	1.46%	2.03%
0.0140%	0.17%	0.57%	1.02%	1.52%	2.05%

TABLE 5
Cost Of Capital Impact In Model 2
($\sigma_{13} = \sigma_{23} = .001\%$)

σ_{12}	α_1 0.9	0.7	0.5	0.3	0.1
0.0100%	0.03%	0.22%	0.59%	1.08%	1.66%
0.0110%	0.06%	0.29%	0.66%	1.13%	1.68%
0.0120%	0.09%	0.35%	0.73%	1.19%	1.70%
0.0130%	0.12%	0.42%	0.80%	1.24%	1.72%
0.0140%	0.15%	0.48%	0.87%	1.29%	1.74%

TABLE 6
Cost Of Capital Impact In Model 2
($\sigma_{13} = \sigma_{23} = .0025\%$)

σ_{12}	α_1 0.9	0.7	0.5	0.3	0.1
0.0100%	0.02%	0.17%	0.44%	0.81%	1.24%
0.0110%	0.04%	0.22%	0.49%	0.85%	1.26%
0.0120%	0.06%	0.27%	0.55%	0.89%	1.27%
0.0130%	0.09%	0.31%	0.60%	0.93%	1.29%
0.0140%	0.11%	0.36%	0.65%	0.97%	1.30%