COMMONWEALTH OF KENTUCKY

BEFORE THE PUBLIC SERVICE COMMISSION

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COMMISSION

In the Matter of:

ADJUSTMENT OF GAS AND ELECTRIC)
RATES, TERMS AND CONDITIONS OF) CASE NO. 2003-00433
AND CONDITIONS OF LOUISVILLE)
GAS AND ELECTRIC COMPANY)

In the Matter of:

ADJUSTMENT OF THE ELECTRIC)
RATES, TERMS AND CONDITIONS OF) CASE NO. 2003-00434
KENTUCKY UTILITIES COMPANY)

REBUTTAL TESTIMONY

OF

ROBERT G. ROSENBERG

EDGEWOOD CONSULTING, INC.

April 26 2004

Filed: April 26, 2004

I. INTRODUCTION

Q. Are you the same Robert G. Rosenberg who previously submitted testimony in this proceeding?

A. Yes, I am.

Q. What is the purpose of this testimony?

A. The purpose of my testimony is to rebut the return on equity testimonies of Attorney General witness Dr. Carl Weaver, Department of Defense witness Kenneth Kincel and KIUC witness Richard Baudino. In particular, I will rebut their proposals concerning a recommended return on equity in this proceeding for Louisville Gas and Electric Company and Kentucky Utilities Company (hereinafter referred to as LG&E and KU, respectively, or the Companies). I will also respond to those witnesses' criticisms of my cost of equity determination.

Q. Have you prepared an exhibit in conjunction with your testimony?

A. Yes. In support of my testimony I have prepared RGR Rebuttal Exhibit 1, consisting of 4 schedules.

Q. Were these schedules prepared by you or under your supervision?

A. Yes, they were.

Q. Please summarize what allowed returns on equity these witnesses are recommending.

A. For the electric operations of LG&E and KU, both Dr. Weaver and Mr. Kincel recommend a return of 10.0 percent, while Mr. Baudino recommends a return of only 8.7 percent. For the gas operations of LG&E, Dr. Weaver recommends a return of 10.35 percent, Mr. Kincel a return of 10.50 percent and Mr. Baudino of only 8.9 percent. In the rebuttal testimony, below, I will provide numerous reasons why these return recommendations are substantially understated.

Q. How do these return recommendations compare with recent returns allowed by regulators in the U.S.?

A. These return recommendations are well below the general level of allowed returns for U.S. utilities. According to the April 5, 2004 *Major Rate Case Decisions* of Regulatory Research Associates, average allowed returns for electric and gas utilities in 2003 were both at the 11.0 percent level. In the first quarter of 2004, the average allowed return for electric companies was 11.0 percent and for gas companies it was 11.1 percent. I am including this information not to recommend that the Kentucky Commission merely "follow the others." I think this Commission should decide the allowed return on the record of these proceedings. However, I do think that this information shows that the general level of allowed returns is higher than what is being recommended by the three other witnesses in this proceeding.

Q. How will the remainder of your rebuttal testimony be organized?

A. I will give a brief description of the cost of equity approach of each of the three witnesses. Along with that description I will provide some general commentary on why their recommendations are understated. I then continue on and discuss methodological issues wherein I find problems in their approaches. Along with that analysis, I will discuss why certain criticisms those witnesses made of my approach are unfounded.

Q. Would you begin by briefly describing Dr. Weaver's cost of equity approach?

A. Dr. Weaver employs three equity costing methods on proxy groups of electric and gas companies in order to reach his recommendations. In Dr. Weaver's DCF analysis, he employs both constant-growth and multi-stage growth approaches. Dr. Weaver also conducts a CAPM analysis using various inputs for the risk-free rate (proxied by a 10-year Treasury security) and two estimates for the market risk premium. Dr. Weaver's third approach is a risk premium analysis, calculated over the most recent eleven years for his proxy groups.[1] Because Dr. Weaver believed that interest rates and the cost of equity are increasing at the current time, he performed an economic adjustment of 95 basis points to his two DCF methods to account for the prospective increase in the cost of money. Based on these analyses, Dr. Weaver determined that the cost of equity for electric operations of LG&E and KU lies in the range of 9.75-10.25 percent with a midpoint of 10.0 percent. For the gas operations of LG&E, Dr. Weaver obtained a cost of equity range of 10.10-10.60 percent, with a midpoint of 10.35 percent.

Q. Do you have any preliminary points to raise about Dr. Weaver's testimony?

A. Yes, I do. First, Dr. Weaver's cost of equity recommendation for LG&E is inexplicably different than his recommendation in his very recent ESM testimony filed in December 2003 in Case No. 2003-00335. In that proceeding, Dr. Weaver found a cost of equity range for LG&E of 10.25-11.25 percent. In his rate case testimony, Dr. Weaver's determination declines to 9.75-10.25 percent, which is a

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[1] Although Dr. Weaver obtained an 11.99 percent risk premium result for his gas proxy group, he judgmentally lowered this figure to 11.0 percent in his further analyses.

drop of 50 to 100 basis points in just a three-month period. In response to the Company's Data Request No. 32, Dr. Weaver indicated that the risk of LG&E had changed very little between the filing of his ESM testimony and the filing of his rate case testimony. Furthermore, the yield on 10-year Treasury securities is down only about 2 basis points between the pricing period employed in his ESM testimony (approximately July-October 2003) and the time period used in his rate case testimony (approximately September 2003-February 2004). A-rated public utility bonds and the public utility composite bond yield are only down 27 and 22 basis points, respectively, between these two time periods. While changes in the cost of equity do not directly track changes in interest rates on a 1-for-1 basis, to have such a drastic change in the recommended cost of equity over such a short time period should give pause concerning the stability and reliability of Dr. Weaver's analyses.

Second, Dr. Weaver relied extensively on projections of the 10-year Treasury Note yield in his various analyses. In particular, he employed it in his CAPM analysis as the risk-free rate, in the risk premium analysis as the interest rate to which the risk premium was added and as the economic adjustment factor for his DCF analysis. However, he has, in my opinion, understated the projected 10-year Treasury Note yield. Although Dr. Weaver cites a 4.9 percent forecast for the 10-year Treasury Note from the Office of Management and Budget (OMB),[2] that forecast is from almost eight months ago. The more recent forecast from OMB

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[2] Dr. Weaver originally indicated that source #3 on Schedule 39 was the Congressional Budget Office; in an errata sheet he corrected the source to be the OMB.

dated February 2, 2004, indicates that the projected yield on 10-year Treasury Notes over the 2005-2009 period is about 5.5 percent. Furthermore, although Dr. Weaver cited a Value Line projection dated November 28, 2003, a more recent Value Line projection dated February 27, 2004 shows that the projected yield on the 10-year Treasury Note over the 2004-2008 period is 5.44 percent.[3] The Congressional Budget Office (CBO), one of the sources cited by Dr. Weaver, shows a 5.5 percent forecast for the 10-year Treasury Note in every year over the 2006-2014 period. Mr. Majoros, another witness on behalf of the Attorney General, cited projections for the 10-year Treasury Note from Macroeconomic Advisors *Long-Term Economic Outlook*, December 9, 2003. Those projections indicated an average forecast yield of 5.6 percent over the 2004-2009 period and 5.8 percent over the 2004-2012 period. Finally, *Blue Chip Economic Indicators* for March 10, 2004 projects that over the 2006-2010 period, Treasury Notes will yield 5.6 percent. Based on these data, using a forecasted 10-year Treasury yield of 5.5 percent would be reasonable. Using this forecast rate would raise Dr. Weaver's results for all three of his methods.

Q. Please briefly summarize Mr. Kincel's method of estimating the cost of equity in this proceeding.

A. Mr. Kincel employed three methods to estimate the cost of equity in this proceeding. He used a constant-growth DCF method, employing various projections of growth. For the CAPM method, Mr. Kincel used two estimates of

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[3] Value Line also forecasts that the yield on long-term Treasury bonds will average 6.1 percent over the 2004-2008 period. This is 66 basis points higher than the projection for the 10-year Treasury Note.

the market risk premium and then added a size premium to his results. For the risk premium approach, Mr. Kincel used a historic average risk premium spanning many years. For his electric proxy group, Mr. Kincel determined a cost of equity range of 9.2-10.2 percent[4] and, in the interests of "gradualism," he recommended a return of 10.0 percent for the electric operations. For his gas proxy group, Mr. Kincel obtained a range of 9.6-10.75 percent and recommended a 10.5 percent return for LG&E's gas operations.

Q. Would you briefly summarize Mr. Baudino's analysis?

A. Standing alone among all the rate of return witnesses in this proceeding, Mr. Baudino uses only one method—the DCF approach—to reach his recommended return on equity. Mr. Baudino conducted a constant-growth DCF approach using various projections. Based on his analysis, he recommends an 8.7 percent return on equity for electric operations and an 8.9 percent return on equity for gas operations in this proceeding. Mr. Baudino also conducted a CAPM analysis, but indicates that he did not rely upon it in reaching his recommendation.[5]

Mr. Baudino's return recommendations are clearly understated. They are more than 200 basis points below recent allowed returns of other utilities. Many of the individual-company DCF results are below the level of the cost of debt and one

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[4] Mr. Kincel's electric range actually reached up to 11.0 percent, but he chose to use an upper-end figure of only 10.2 percent.

[5] In regard to Baudino's non-use of the CAPM method, I note that Dr. Weaver indicated in his response to Company Data Request No. 13 in the ESM proceeding that the CAPM was as widely used as the DCF method by participants in the capital market and that a great deal of the financial literature that deals with cost of equity analysis deals with the CAPM model. Mr. Baudino, himself, in response No. 12 to the Company's Data Request in this proceeding, noted that: "The CAPM is a widely used method of estimating the cost of equity...."

of the four average DCF results that Mr. Baudino uses to derive his DCF recommendation for LG&E's gas operations is only 6.01 percent—below the recent level of bond yields, too. Furthermore, Mr. Baudino has testified in a past proceeding[6] that cost of equity estimates that were not more than 170 basis points above the utility bond yield should be regarded as unreasonable and discarded. The recent average yield on A-rated bonds has been about at the 6.3 percent level. Taking consideration of Mr. Baudino's admonition, cost of equity estimates below the level of 8 percent would be regarded as unreasonable and should be discarded, which would include many of Mr. Baudino's own DCF estimates in this proceeding. Furthermore, the fact that Mr. Baudino is recommending returns on equity in this proceeding as little as 70 basis points above a return level which, in the past, he has regarded as unreasonable, should raise further questions about the reasonableness of his cost of equity analyses in this proceeding.

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[6] Testimony regarding Cincinnati Gas & Electric, Case No. 92-1464-EL-AIR, April 1993.

II. PROXY GROUP SELECTION

Q. Please comment on the various proxy groups used in this proceeding.

A. In my direct testimony, I selected proxy groups consisting of thirteen electric companies and six gas companies. Both Mr. Kincel and Mr. Baudino indicated that they found my proxy companies reasonable and employed them in their analyses.[7] However, Dr. Weaver criticized my electric proxy group and suggested that I should not have included three companies. Although I disagree with Dr. Weaver's contention, deleting those three companies would have no effect on my recommendation.

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[7] Mr. Kincel did delete one company from my electric proxy group and added one company to my gas proxy group.

III. THE DCF APPROACH

Q. Would you comment on Dr. Weaver's multi-stage DCF model?

A. Dr. Weaver's calculations are shown on Schedules 37 and 64. There are several calculational and theoretical deficiencies that understate the cost of equity using this approach. I will enumerate these below.

First, Dr. Weaver's present value of a dividend perpetuity in 2018 is calculated incorrectly for two different reasons:[8]

(1) The cash flow going to an investor in the final year she or he owns the stock consists of a dividend and the proceeds from the sale of the stock. Dr. Weaver has not included a dividend in 2018.

(2) Dr. Weaver has calculated a potential sale price for the Year 2017, **not** 2018, and yet he discounts this assumed cash flow as if it were received in 2018.

Q. Have you made a revision to Dr. Weaver's DCF analysis which corrects this problem?

A. Yes, I have. On page 1 of Schedule 1 (for the electric proxy group) and page 1 of Schedule 2 (for the gas proxy group), I correct the calculational error of Dr. Weaver described above. The results shown on those schedules do not correct for any additional errors I have found in Dr. Weaver's analysis, but only for the error associated with the calculation of the present value of the dividend perpetuity.

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[8] In response to Company Information Request No. 22 in the ESM proceeding, Dr. Weaver referenced the text *Financial Management* by Brigham et al. in order to demonstrate the calculations to be performed in a multi-stage DCF analysis. Pages 340-341 of that text clearly show that Dr. Weaver's calculation of the present value of the perpetuity was done incorrectly.

Q. Would you describe the next error you found with Dr. Weaver's multi-stage DCF analysis?

A. In Dr. Weaver's constant-growth DCF analysis, he used a multi-month average price. He commented at page 59, line 10 of his testimony that a four-month time frame encompasses a sufficient period to wash out any abnormalities in the data.[9] However, for some unexplained reason, Dr. Weaver employs a spot market price on February 17, 2004 in his multi-stage DCF calculation.[10] The use of this spot price causes the DCF results to be lower than had Dr. Weaver used the same average price that he used in his constant-growth DCF calculation. On page 2 of Schedule 1 and page 2 of Schedule 2, I show Dr. Weaver's multi-stage DCF model with two corrections—(1) correcting the present value of the perpetuity and (2) using the average price, rather than the spot price.

Q. Do you have any comment on the near-term growth of Dr. Weaver's multi-stage DCF calculation?

A. Yes, I do. Dr. Weaver starts with the recent growth in dividends and converges that growth rate to the near-term analysts' growth projection—assuming that the beginning growth rate he employs converges to the analysts' growth rate in the Year 2007. Dr. Weaver opined at page 57 that with the advent of deregulation,

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[9] I note that while Dr. Weaver discusses a four-month pricing period in his testimony, he actually uses a five-month period in his analysis. In my testimony, I employed a six-month pricing period and noted that the pricing period should be not so short as to merely represent "the luck of the draw" and should be long enough to smooth the effects of any temporary market fluctuations. Thus, my notion about not using a short pricing period match the comments of Dr. Weaver on page 59 of his testimony, cited above.

[10] Dr. Weaver used an average price, rather than a spot price, in his two-stage DCF analysis in his testimony in the LG&E gas rate proceeding, Case No. 2000-080.

dividend growth was much less certain. Yet Dr. Weaver uses an uncertain estimate of dividend growth, based on just one year's change in the dividend as the basis for determining his near-term growth for the multi-stage DCF analysis. The growth rate that Dr. Weaver assumes for the first five years in his multi-stage DCF analysis is in fact about 150 basis points (for the electric group) and almost 250 basis points (for the gas group) **below** the growth that analysts estimate over the next five years. Based on these considerations, I believe that Dr. Weaver is understating the multi-stage DCF cost of equity estimate. Dr. Weaver, himself, provides an alternative to using the type of two-stage analysis he shows on his Schedules 37 and 64.

Q. What is that alternative?

A. Dr. Weaver indicates in his Appendix II at page 12 that he would employ a two-stage approach where analysts' projections are used as the first stage and an Ibbotson-based growth calculation is used as the second stage. In fact, Dr. Weaver used that very approach in his testimony in the LG&E gas rate proceeding, Case No. 2000-080. However, he does not use that approach in his testimony in this proceeding, even though his Appendix states he would do so. On Schedule 3, page 1 and Schedule 4, page 1, I show Dr. Weaver's methodology from the LG&E gas rate case for the multi-stage DCF approach. The first five years employ the analysts' projected growth rates. The long-term projected growth is based on the compounded historic return for large-company stocks reported by Ibbotson Associates with the dividend yields of the comparison companies subtracted from that. The Ibbotson historic return for large company stocks is 10.4 percent. Subtracting the 4.85 percent dividend yield for the electric comparison group and the 4.02 percent dividend yield for the gas comparison group produces long-term growth estimates of 5.55 percent and 6.38 percent, respectively, for the two groups.

On page 2 of Schedule 3 and page 2 of Schedule 4, I make one modification to Dr. Weaver's gas rate case multi-stage DCF methodology. Note that the second-stage growth is estimated using the return for large-company stocks reported in Ibbotson. However, the companies in Dr. Weaver's comparison groups are not all large companies. According to the criteria reported by Ibbotson, three of the companies in Dr. Weaver's electric comparison group are low-cap stocks that have a compounded historic return of 11.7 percent, per Ibbotson. Thus, the weighted average compound historic return for companies similar in size to the companies included in Dr. Weaver's comparison groups is 10.83 percent. Per the Ibbotson criteria, four of Dr. Weaver's gas proxy companies are mid-cap (an 11.3 percent historic return), three are low cap (an 11.7 percent return) and one is micro-cap (a 12.7 percent return)—producing a weighted average compound historic return for that group of 11.62 percent. Following Dr. Weaver's approach and subtracting the 4.85 and 4.02 percent respective dividend yields for the two groups, the projected growth for the second stage of the DCF calculation is 5.98 percent (10.83 – 4.85) for the electric group and 7.60 (11.62-4.02) for the gas group. Using these second-stage growth rates and the other inputs for the two-stage DCF calculation, the cost of equity results are shown on page 2 of Schedule 3 and page 2 of Schedule 4.

Q. Would you review the results of your corrections and adjustments to Dr. Weaver's multi-stage DCF analysis?

A. Below, I summarize the changes that I have described above relating to Dr. Weaver's multi-stage DCF analysis:

SUMMARY OF MULTI-STAGE DCF REVISIONS

	Electric Group	Gas Group
Correcting for PV of perpetuity and average price	9.20 %	9.26 %
Dr. Weaver's Ibbotson approach	10.43	10.45
Dr. Weaver's Ibbotson approach adjusted for size	10.79	11.51

Based on the above results, it is clear that Dr. Weaver's multi-stage DCF results for his electric proxy group (8.79 percent) and for his gas proxy group (8.92 percent) are substantially understated.

Q. Would you comment on Mr. Kincel's claim on page 7 of his testimony that the constant-growth model is simpler to use than your two-stage DCF approach because it does not require an analyst to deal with expectations beyond the next few years?

A. While Mr. Kincel would like to assume away investor expectations beyond the next few years, the DCF model does not. As Mr. Kincel, himself, indicates on page 10 of his testimony, the DCF model assumes that the price of a share of common stock is equal to the present value of the expected future cash flows from an investment.

The way the constant-growth DCF model is derived from the more general model of discounted cash flows is by assuming constant growth to infinity. I have constructed a simple hypothetical example to show the pitfall in ignoring growth beyond five years. Let us assume a company has a price of $10.00, an expected dividend of $0.45 and, thus, a dividend yield of 4.5 percent. Let us further assume that the expected growth for this company into the indefinite future is 6.0 percent. Thus the indicated cost of equity would be about 10.5 percent. If we discount the expected future cash flows only out five years, the cumulative present value of the first five years of cash flows would be only $1.88—less than 20 percent of the current price. Thus, growth after five years has a very significant impact on the DCF estimate of required return and should not be merely assumed away in order to supposedly simplify a calculation.

Q. Would you comment on Mr. Baudino's contention that you should not have used the growth in earnings in the first stage of your DCF analysis?

A. In my direct testimony, I noted that utilities have been changing their payout policy recently and any projections of dividend growth are a reflection of potential payout policy changes, rather than the underlying growth of the company.[11] Mr. Baudino, himself, uses four growth forecasts and notes on page 37 that the dividend growth forecast is much lower than the three earnings growth forecasts that he, himself, uses. In Mr. Baudino's rebuttal testimony in the PBR proceeding, he stated at page 38, line 23 that:

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[11] I note that Dr. Weaver states at page 57 of his testimony that "with the advent of deregulation, constant dividend income is less certain."

> With respect to dividend payouts, I agree that utilities are adopting more conservative payout policies. This is shown by forecasted dividend growth rates that are lower than expected earnings growth. This is why for the purpose of my analysis, I concentrated on higher earnings growth forecasts as a proxy for long-term dividend growth.

In fact, in the PBR proceeding, Mr. Baudino relied only on earnings growth rates in deriving his recommendation; he considered projected dividend growth as being below the reasonable range of investor expectations. Use of very low near-term dividend growth forecasts would reflect only a pessimistic view of investor growth and cash flow expectations and would thus be understated. Therefore, Mr. Baudino's calculations on Schedules 11 and 12 of his exhibit, which attempt to revise my analysis, produce understated estimates of the investor-required return.[12]

Q. Do you agree with Dr. Weaver's contention on page 8, line 21 of his testimony that you made "two fatal errors" in calculating the projected GDP growth for the second stage of one of your DCF analyses?

A. No, I do not. Dr. Weaver is wrong on both counts. First, Dr. Weaver contended that I should not have used the Consumer Price Index (CPI) as a measure of inflation in that calculation. The CPI is a very widely used measure of inflation and it is certainly reasonable to assume that investors use it as such. Ibbotson Associates, the source from which both I and Mr. Kincel took some of our data, uses the CPI as its measure of inflation. The Conference Board, one of the sources used by Dr. Weaver, shows projections of real GDP and the CPI in its summary of

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[12] As indicated in my earlier discussion, when Mr. Baudino relies on dividend growth rates in his own analysis in this proceeding, the result is often cost of equity estimates either below, or insufficiently above, bond yields.

the economic forecast. Furthermore, Dr. Weaver, himself, in his review of the current and prospective economic conditions looked at the real rate of change in GDP and at "**the inflation rate as measured by the Consumer Price Index**" (Dr. Weaver's testimony, page 32 and Schedules 2-3). Thus it is reasonable to assume that investors, in general, would consider the CPI as an important measure of inflation, as clearly does Dr. Weaver.

The second supposed "fatal error" cited by Dr. Weaver was that I should have multiplied the projected growth in GDP by the projected inflation growth, rather than adding. However, I **did**, in fact, multiply those two factors; Dr. Weaver is incorrect in his contention that I added them.

I note in passing that Mr. Baudino claimed that I should have used forecasted industry retention growth rather than GDP growth in my analysis. However, Mr. Baudino apparently ignored the fact that I did include projected industry sustainable growth in my analysis and that that growth rate was close to my projected growth in GDP.

Q. Would you comment on Mr. Baudino's criticism of the inclusion of an "sv" component for your sustainable growth calculation?

A. Mr. Baudino claims that estimating such a component is problematic. However, in my estimation of the "sv" component, I used Value Line projections—the same source for most of the projections that he used in his analysis. Mr. Baudino also claims that I used the current "high" level of price-book ratios and assumed that these would hold into the future, while he thought that those price-book ratios

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would fall to the 1.0 level. I note at the outset that this is a surprising criticism from Mr. Baudino, given that his constant-growth DCF analysis is predicated on the notion that investors expect company financial parameters (i.e., growth in earnings, dividends, book value and price) to all grow at the same rate in the future. If investors actually did expect that the market price would fall from its current level down to the level of book value, then this would imply that investors expected **negative** growth in price, but **positive** growth in book value—expectations that would vitiate the assumption of constant expected growth underlying the sole equity costing method in this proceeding upon which Mr. Baudino relies. Furthermore, Value Line projects that the future price-book ratio, several years out, is just about equal to the current level of the price-book ratio—contrary to Mr. Baudino's contention that the price-book ratio could be expected to fall. Finally, using a hypothetical, but representative example, I have calculated that if Mr. Baudino was correct that investors were expecting the price to fall from the current level of about 1.6 to the level of 1.0, then the implied investor-required return would be less than 2 percent—clearly a meaningless figure.

IV. THE CAPM APPROACH

Q. **Would you comment on the issue of the risk-free rate component of the CAPM analysis?**

A. As indicated on pages 28-29 of my direct testimony, because common stock is a long-term investment, the choice of the risk-free rate should match the long horizon of common stock. Mr. Kincel used the yield on 20-year Treasury securities as the risk-free rate, while Dr. Weaver used the yield on 10-year securities and Mr. Baudino used the yield on 5- and 20-year securities. I believe that in addition to using the 10-year Treasury Note yield in his CAPM analysis,[13] Dr. Weaver should also have used longer-term Treasury security yields. Over Dr. Weaver's pricing period the average yield on 20-year and long-term Treasury securities was about 90 basis points higher than the yield on 10-year Treasury securities. Projections show that long-term Treasury bonds will be yielding about 50 basis points higher than the 10-year Treasury Note. Thus, had Dr. Weaver included these longer-term Treasury bond yields in his analysis, his CAPM cost of equity estimate would have been higher than the one he calculated.[14]

In my opinion, Mr. Baudino should not have used the 5-year Treasury security yield as the risk-free rate in his analysis—it is too short a term to match the long-term prospects of common stock. In fact, Mr. Baudino, himself, did not seem to have much confidence in the use of a 5-year Treasury Note as the risk-free

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[13] Recall that earlier in this testimony I showed that even the yields on 10-year Treasury Notes employed by Dr. Weaver were understated.

[14] Had Dr. Weaver employed yields on longer-term Treasury securities in his analyses, his risk premium cost of equity estimate and the economic adjustment to the DCF estimate would have been substantially higher.

rate—he did employ it on his Exhibit___(RAB-9), but did not employ it on Exhibit___(RAB-8).

Q. Would you provide an overview of the market risk premium component of the CAPM approach?

A. This component reflects the market risk premium that investors expect for the stock market as a whole. Two general approaches were employed by the return on equity witnesses in this proceeding to estimate this component. Both Mr. Kincel and I used an estimate based on historic risk premium data from Ibbotson Associates. All of the witnesses used an estimate of the expected market risk premium based on a DCF analysis for some stock market aggregate, such as the S&P 500.

Q. Do you agree with Mr. Kincel's use of the Ibbotson risk premium?

A. Yes, in general, I do. However, Mr. Kincel only used the Ibbotson figures through 2002, while data through 2003 are available. Mr. Kincel used an Ibbotson market risk premium of 7 percent on his Exhibits___(KLK-10 and KLK-16). The updated Ibbotson risk premium, through 2003 is 7.2 percent. Use of this updated figure raises Mr. Kincel's CAPM results by about 14 basis points.

Q. Please comment on Mr. Baudino's criticism of your use of the Ibbotson historic average risk premium.

A. Mr. Baudino attacks the use of the Ibbotson risk premium because he believes that investors would not expect that the risk premium experienced over the past would be used as an expectation by investors for the future. We do not know exactly how investors determine their expected risk premiums. I followed two different but complementary approaches, one of which assumed a constant risk premium (using the Ibbotson historic data) and one considering the prospect that risk premiums might vary and therefore using the current level of risk premium (my DCF analysis for the S&P 500 group). Using the historic risk premium from Ibbotson can be justified on several accounts. Investors may actually expect a constant risk premium (i.e., they might expect that the price of risk will change little, if at all, over time). This is because investors know that they, or their successor investors, will hold their stock over varying economic conditions, including peaks, valleys and more "normal" conditions. Thus they might regard the expected risk premium as being some type of average of the risk premiums that might prevail over various economic conditions. Alternatively, they might expect that the risk premium varies, but they are uncertain about future economic and financial conditions and thus use the historic average as a proxy for the future. Finally, investors may expect that the risk premium does, in fact, vary, but that it returns to a mean value. In fact, Ibbotson Associates has tested the risk premium for serial correlation and found that there was no pattern in movements of the risk premium over time. Ibbotson stated at page 75 of its *2003 Yearbook* that:

> The best estimate of the expected value of a variable that has behaved randomly in the past is the average (or arithmetic mean) of its past values.

Q. Did any of the witnesses have criticism of your use of the arithmetic mean in your Ibbotson risk premium analysis?

A. Yes. Both Mr. Baudino and Dr. Weaver criticized use of the arithmetic mean and suggested that the geometric mean should be used in its place. In contrast, both Mr. Kincel and I employ the arithmetic mean. Mr. Baudino suggested that mutual funds cite geometric means in calculating **past** returns. Dr. Weaver cited two examples comparing the arithmetic and geometric means on pages 26-27 of his testimony, but these examples also dealt with **past** returns. Dr. Weaver, himself, acknowledged at page 6 of his Appendix II that:

> Past returns to a security are known with certainty and there is no risk associated with their measurement.

In my direct testimony, I presented two examples—one involving a simple coin flip exercise and the other a more extended analysis—as to why the geometric mean was inappropriate to use for the purpose of estimating the expected future risk premium. It is appropriate to use the geometric mean <u>when looking backward</u> where we know achieved results <u>with certainty</u>. However, as prospective returns are not known with certainty, but, instead, are reflected by a probability distribution, it is appropriate to use the arithmetic mean in forming expectations.[15]

This point is supported in the Ibbotson *Yearbook*, which states:

> For use as the expected equity risk premium in the CAPM, the *arithmetic* or *simple difference* of the *arithmetic means* of stock market returns and riskless rates is the relevant number....The expected equity risk premium should always be calculated using the arithmetic mean. The arithmetic mean is the rate of return which, when compounded over multiple periods, gives the mean of the probability distribution of ending

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[15] This concept is supported by the Latane and Tuttle text Dr. Weaver cited at page 28 of his testimony as supposedly supporting the use of the geometric mean. On page 223 of that test, the authors state:

> ...future money payments are usually uncertain. Therefore, the analyst cannot assume a definite future payment. Rather, he must set up a probability distribution of future payments and estimate the likelihood of each.

That is exactly what I did in Appendix B of my direct testimony which demonstrated the propriety of using the arithmetic mean rather than the geometric mean.

> wealth values....This makes the arithmetic mean return appropriate for computing the cost of capital....Stated another way, the arithmetic mean is correct because an investment with uncertain returns will have a higher expected ending wealth value than an investment that earns, with certainty, its compound or geometric rate of return every year....In other words, more money is gained by higher-than-expected returns than is lost by lower-than-expected returns. **Therefore, in the investment markets, where returns are described by a probability distribution, the arithmetic mean is the measure that accounts for uncertainty, and is the appropriate one for estimating discount rates and the cost of capital.** [Emphasis added.]

Dr. Roger Morin in his book *Regulatory Finance: Utilities' Cost of Capital* provided similar reasoning in support of the arithmetic, rather than geometric mean:

> Only arithmetic means are correct for forecasting purposes and for estimating the cost of capital.... In capital markets where returns are a probability distribution, the answer that takes account of uncertainty, the arithmetic mean, is the correct one for estimating discount rates and the cost of capital....Looking forward, the expected return is the arithmetic mean. Looking backward, the historical achieved return is a geometric average. When looking at the future, the arithmetic mean is relevant. When examining the past, the geometric mean is relevant. In statistical parlance, the arithmetic average is the unbiased measure of the expected value of repeated observations of a random variable, not the geometric mean.

Clearly, the arithmetic mean is the appropriate figure to use in the Ibbotson historic risk premium analysis, not the geometric mean.

Q. Did Mr. Baudino criticize your second risk premium analysis which involves a DCF calculation for the S&P 500?

A. Yes, he did. Mr. Baudino thought that the 13 percent earnings growth rate used in my calculation was unsustainable.[16] Instead, Mr. Baudino proposed two alternatives to my growth rate: (1) the 9.91 percent average growth rate he obtained by averaging forecast earnings, book value and dividend projections from Value Line and (2) a 9.46 percent growth rate obtained by averaging the earnings growth rate I used with a GDP growth projection.[17] The unreasonableness of Mr. Baudino's suggestions can be discerned by looking at their end result. He obtains an estimated required return on the market for both approaches in the 11.1-11.2 percent range—just about at the allowed return for electric utilities recently. Since the beta of the market is higher than the beta for electric utilities, the required return for the market should be substantially higher than that for electric utilities, but this is not true for Mr. Baudino's estimates.[18]

Furthermore, as can be seen on Exhibit___(RAB-7), Mr. Baudino employs a 6.68 percent projected growth in dividends in his market return calculation. I do not believe that investors would take this low dividend projection as a reasonable proxy for expected long-term growth for the market as a whole. In the Value Line

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[16] Mr. Baudino's own data, taken from Value Line, indicated a projected earnings growth rate of 14.03 percent.

[17] Mr. Baudino calculated the estimated market return from this second approach incorrectly. Using the correct calculation would produce an estimated required return for the market of only 8.41 percent—below even Mr. Baudino's recommendation for LG&E and KU in this proceeding.

[18] It is my understanding that Mr. Baudino may revise the figures referenced above somewhat, but the point I make still holds.

universe, about 43 percent of the companies do not currently pay a dividend. Thus, these are companies that have a dividend yield of zero and for whom Value Line projects no 5-year growth in dividends. It is my opinion that a DCF calculation which includes a zero dividend yield and a projection of no growth for a large number of non-dividend-paying companies, clearly biases the DCF result downward. Therefore, Mr. Baudino's estimate of the required market return is unreasonably low and should be disregarded in this proceeding.

Q. Would you comment on Dr. Weaver's calculation of the expected market risk premium using a Value Line estimate?

A. In half of Dr. Weaver's CAPM calculations he uses a market return estimate based on a price appreciation projection from Value Line which he then adds to the average dividend yield for the Value Line universe. However, Dr. Weaver has calculated the price appreciation in an understated manner for two reasons. First, Dr. Weaver used a spot estimate of Value Line's projection of price appreciation. However, I have calculated that over Dr. Weaver's pricing period, the average Value Line price appreciation estimate was 43 percent, rather than the 40 percent figure Dr. Weaver used. Second, Dr. Weaver used a four-year period to calculate price appreciation, whereas Value Line considers the projection to be for three and one-half years. Making this modification to Dr. Weaver's CAPM calculations raised the result for the electric and gas groups by about 135 basis points for those calculations.

Q. Did any of the witnesses question the size premium that you used in your CAPM analysis?

A. Mr. Baudino and Dr. Weaver questioned the inclusion of a size premium. Mr. Kincel, in contrast, employed the same type of size premium that I used in my analysis. The Ibbotson *Yearbook* indicates that the size premium is applicable to small companies, in general, and does not carve out an exception for electric utilities. While Dr. Weaver claims that the size premium should not exist, the research performed by Ibbotson Associates suggests that small companies have earned higher returns than would be estimated by the CAPM approach and they thus conclude that the CAPM is not capturing a systematic risk factor reflected in smaller companies. Put simply, this means that, even controlling for the level of risk (beta), smaller companies have earned (required) higher returns in the past than have larger companies. Mr. Kincel, who uses the Ibbotson size premium adjustment states at page 14 of his testimony that:

> The size adjustment simply means that small companies require a larger ROE because they are inherently more risky than accounted for by the statistical beta.

I agree with Mr. Kincel's evaluation of this issue.

Q. Does Dr. Weaver question your use of the empirical CAPM formulation?

A. Yes, he does. Dr. Weaver claims that the traditional CAPM is a form of regression equation that suffers from multicollinearity and that the empirical CAPM formulation that I use increases multicollinearity. Dr. Weaver is incorrect in his contentions. The traditional CAPM is **not** a regression equation—it is an equilibrium model. Neither I nor Dr. Weaver conduct any type of regression analysis in calculating the cost of equity using the CAPM approach.[19] The CAPM approach that I employ is an equation, not a regression equation.[20] Multicollinearity is a statistical phenomenon where two independent variables in a regression analysis are correlated with each other. My analysis does not reflect any situation where there are two independent variables, so therefore there cannot be any multicollinearity.

Q. Do you agree with Dr. Weaver's contention that the empirical CAPM approach double counts adjustments to beta?

A. No, I do not. Value Line's beta adjustment is not related to the empirical formulation of the CAPM. Value Line adjusts the raw beta in order to reduce the measurement error associated with approximating the real, unobserved beta. That adjustment to beta results in the published beta that Value Line carries in *The Value Line Investment Survey*. All rate of return witnesses in this proceeding use that adjusted beta in their CAPM calculations. In contrast, the empirical CAPM formulation accounts for the fact that research has shown that the Security Market Line[21] is flatter than indicated by CAPM theory. Thus, the empirical CAPM formulation serves to use evidence from the capital markets themselves as to the appropriate risk-return relationship for a stock.

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[19] Although Value Line does perform a regression analysis in order to calculate beta, that regression analysis does not at all involve the risk-free rate, the factor whose presence Dr. Weaver claims causes multicollinearity.

[20] Similarly, the formula for the constant-growth DCF model is: $k = D/P + g$. That is an equation, not a regression equation.

[21] The Security Market Line is a plotting of risk versus return—in particular, risk (as proxied by beta) is measured on the horizontal axis and return (i.e., market return) is measured on the vertical axis.

V. THE RISK PREMIUM APPROACH

Q. Did you find any deficiencies in Dr. Weaver's risk premium analysis?

A. Yes, I did. Dr. Weaver has calculated average risk premiums of 4.61 percent and 6.81 percent for his electric and gas groups, respectively. However, in my opinion, Dr. Weaver has calculated the average risk premium in a non-intuitive way (i.e., that is an approach that would not likely be employed by investors). In calculating the average risk premium, Dr. Weaver weights returns that occurred in the early part of his period much more substantially than the returns that have occurred more recently. For example, the return achieved over the 1992-1993 period is given **eleven times the weight** compared with the return achieved in the 2002-2003 period. I see no reason why investors would use such an unusual weighting scheme in trying to estimate the expected risk premium.

Two alternatives to Dr. Weaver's averaging approach make much more sense. First, investors might well simply average the eleven yearly average risk premiums.[22] Averaging in this manner produces average risk premiums for the electric and gas groups of 5.1 percent and 7.3 percent, respectively. The second alternative averaging approach that would likely be more intuitive to investors than Dr. Weaver's method would be to take an average of the nine returns for investment periods ending in 2003 (e.g., one average return starts in 1992 and ends in 2003, the next average return starts in 1993 and ends in 2003, up to the average

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[22] These yearly average risk premiums are found on page 3 of Dr. Weaver's Schedule 40 and Schedule 66 for the electric and gas groups, respectively. The figures are shown on the line that Dr. Weaver labels "Average HPY Risk Premium." The yearly average risk premiums are shown in decimal form and must be multiplied by 100 to convert to percentage form.

return starting in 2002 and ending in 2003).[23] The average risk premium calculated in this manner is 5.5 percent for the electric group and 8.6 percent for the gas group.

Q. What is the result of your modifications to Dr. Weaver's risk premium analysis?

A. Using averaging processes that I think would be more intuitive to investors than Dr. Weaver's approach, I calculated two alternative average risk premiums for the electric proxy group of 5.1 percent and 5.5 percent which average 5.3 percent. The two alternative risk premiums for the gas proxy group were 7.3 percent and 8.6 percent and average 7.9 percent. Adding the 5.18 percent Treasury yield employed by Dr. Weaver in his risk premium analysis, produces a modified risk premium result of 10.5 percent and 13.1 percent for the electric and gas proxy groups, respectively.

Q. Do you have any comments concerning Mr. Kincel's risk premium analysis?

A. Yes, I do. Mr. Kincel calculated that the risk premium over Government bond income returns for his electric proxy group was 4.27 percent. His analysis covered the period 1954-2002. Updating that analysis through 2003 produces an average risk premium of 4.57 percent—an increase of 30 basis points. Furthermore, Mr. Kincel started his analysis in 1954, even though he had a substantial amount of data available prior to that point. As I indicated on pages 33-34 of my direct testimony,

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[23] These figures are shown on page 4 of Dr. Weaver's Schedules 40 and 66 for the electric and gas groups, respectively. The average of the eleven returns ending in 2003 is shown at the bottom of the 2003 column in the row labeled "Average." To get the average return in percent, one simply subtracts 1 from the figure that Dr. Weaver reports and multiplies the result by 100 in order to express this average in percentage terms.

using historic risk premium data, the full period of data availability should be used, rather than the analyst selecting only a sub-period.[24] Extending Mr. Kincel's risk premium analysis for the full period of data availability, the risk premium is 5.42 percent—well above the 4.27 percent figure calculated by Mr. Kincel.

Q. Did Mr. Baudino and Mr. Kincel criticize your historic risk premium analysis based on Moody's data?

A. Yes, they did. They questioned whether investors might expect a constant risk premium based on the data that I use.[25] Earlier in this rebuttal testimony, in connection with the Ibbotson risk premium, I indicated why investors might use historic risk premium data as a proxy for future expectations. Those points hold also for my Moody's risk premium analysis. I note that while Mr. Baudino thinks that investors would not expect a constant risk premium, the data in my analysis show no trend and thus it is reasonable to use the average of historic data as a proxy for the future.

Q. Did Dr. Weaver contend that the high R^2 that was obtained from your second risk premium analysis involving a regression was due to a statistical problem called autocorrelation?

A. Yes, he did, but he is incorrect. When a regression is conducted, the residuals[26] are assumed to be statistically independent—i.e., there should be no serial

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[24] Recall that Mr. Kincel, himself, uses Ibbotson data from 1926-2002.

[25] I note that Mr. Kincel, himself, uses an historic risk premium analysis wherein he assumed a constant risk premium. Mr. Kincel employed the Moody's 24 Stock Index, but used a different bond yield in his analysis than I did.

[26] After a regression equation is derived, actual values of the independent variable can be inserted into the equation in order to calculate predicted values of the dependent variable. Subtracting a predicted value of the dependent variable from an actual value of the

correlation among the residuals of the regression. If there is serial correlation present, then autocorrelation is said to exist.[27] Even in the presence of autocorrelation, the regression coefficients obtained are unbiased. Dr. Weaver contends that the high R^2 of 0.78 that was obtained in my second risk premium analysis was due to autocorrelation.[28] Although Dr. Weaver claims that my second risk premium analysis suffers from autocorrelation, he, himself, performed no tests to see the effects of any such autocorrelation. However, in response to Dr. Weaver's contentions, I have examined the autocorrelation issue and found that using a standard statistical technique to eliminate any effect of autocorrelation, the adjusted R^2 that I obtain is exactly equal to the adjusted R^2 obtained for the original model reported in my testimony and the calculated risk premium is virtually identical (within one basis point) to that reported in my testimony. Thus, contrary to Dr. Weaver's assertion, autocorrelation causes no problem with using or interpreting my second risk premium regression.

Q. Did Dr. Weaver also criticize your second risk premium analysis for showing an inverse relationship between the level of interest rates and risk premiums?

A. Yes, he did, but he was incorrect on this point too. The way I read Dr. Weaver's testimony is that he is of the belief that when interest rates are high, the risk

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dependent variable produces what is known in statistics as the residual.

[27] Note that autocorrelation is a characteristic of the residuals of a regression, not the independent variable of a regression as Dr. Weaver claimed on pages 22-23 of his testimony.

[28] R^2 is also known as the coefficient of determination and measures the proportion of variation in the dependent variable explained by variation in the independent variable. R^2 can vary between zero (which indicates no explanatory value) and 1.0 (which indicates perfect explanatory value).

premium should widen and vice versa. He claims, specifically, on page 22 of his testimony that it is nearly universally agreed that when interest rates are high, investors are more risk adverse and vice versa. However, while Dr. Weaver may have only common stock investors in mind in making this statement, bondholders are investors too. When interest rates are high, they too become more risk adverse. While Dr. Weaver might contend that there **should** be a direct relationship between interest rates and the risk premium, that is not what the data in my regression analysis show. Importantly, that is not what Dr. Weaver's own risk premium analysis shows also! I have performed a correlation between 1-year and 10-year Treasury security yields and the annual risk premiums in Dr. Weaver's electric and gas company risk premium analyses. The correlation between the level of interest rates and risk premiums is negative indicating, as was found in my data, that there is an inverse relationship between interest rates and risk premiums—i.e., the lower the level of interest rates, the higher the risk premium and vice versa.

Furthermore, there is other evidence from Dr. Weaver's own analyses that indicates his contention is incorrect. When Dr. Weaver testified in LG&E's gas rate proceeding (Case No. 2000-080) in testimony filed June 21, 2000, he combined an interest rate of about 6 percent with a risk premium of 4.71 percent to reach his risk premium result. In this proceeding, however, Dr. Weaver combines an interest rate of 5.18 percent with a risk premium of 6.81 percent to reach his preliminary gas risk premium result.[29] Note that in comparing these risk premium

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[29] Dr. Weaver did judgmentally lower this 6.81 percent risk premium to 5.82 percent for further use in his analysis. The point I make also holds even with this adjusted risk premium figure.

analyses, the interest rate used in this proceeding is lower than Dr. Weaver used in the gas case four years ago. According to Dr. Weaver's hypothesis, the risk premium should therefore now be lower than it was four years ago, but it is not—it is higher! Thus, once again, Dr. Weaver's own data do not support the hypothesis he has advanced.

Q. Does this conclude your rebuttal testimony?

A. Yes, it does.

VERIFICATION

STATE OF New York)
) SS:
COUNTY OF Schoharie)

The undersigned, **Robert G. Rosenberg**, being duly sworn, deposes and says he is Principal of Edgewood Consulting, Inc., that he has personal knowledge of the matters set forth in the foregoing testimony, and the answers contained therein are true and correct to the best of his information, knowledge and belief.

Robert G. Rosenberg
ROBERT G. ROSENBERG

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 21 day of April 2004.

Wanda J King (SEAL)
Notary Public

My Commission Expires:

WANDA J. KING
Notary Public, State of New York #01KI4608325
Residing in Schoharie County
My Commission Expires Jan. 31, 20 07

RGR Rebuttal Exhibit 1

Schedule 1

MULTI-STAGE DCF MODEL
WEAVER ELECTRIC PROXY GROUP
Using Spot Price and Correcting PV of Perpetuity

Company	Ameren	Cinergy	DTE Energy	Empire District	FPL Group	MGE Energy	PNM Res.	Progress Energy	Southern Company
Price	$46.50	$38.92	$39.88	$23.23	$65.45	$31.50	$31.74	$46.35	$29.91
L-T Pr. Growth	2.95 %	3.55 %	4.85 %	4.83 %	4.64 %	6.00 %	5.00 %	3.77 %	5.07 %
Internal Rate of Return	8.24 %	8.29 %	9.74 %	10.00 %	8.24 %	10.02 %	7.92 %	8.77 %	9.57 %

AVERAGE INTERNAL RATE OF RETURN = 8.98%

		Cash Flow								
		Ameren	Cinergy	DTE Energy	Empire District	FPL Group	MGE Energy	PNM Res.	Progress Energy	Southern Company
	Price	-46.50	-38.92	-39.88	-23.23	-65.45	-31.50	-31.74	-46.35	-29.91
Year	1	2.56	1.88	2.08	1.28	2.40	1.36	0.92	2.32	1.40
	2	2.58	1.93	2.11	1.30	2.49	1.39	0.97	2.41	1.44
	3	2.62	1.98	2.16	1.33	2.59	1.43	1.02	2.50	1.49
	4	2.68	2.05	2.23	1.37	2.70	1.50	1.08	2.59	1.56
	5	2.75	2.12	2.34	1.44	2.83	1.59	1.13	2.69	1.64
	6	2.84	2.19	2.46	1.51	2.96	1.69	1.19	2.79	1.72
	7	2.92	2.27	2.58	1.58	3.09	1.79	1.25	2.89	1.81
	8	3.01	2.35	2.70	1.66	3.24	1.90	1.31	3.00	1.90
	9	3.09	2.44	2.83	1.74	3.39	2.01	1.37	3.12	2.00
	10	3.19	2.52	2.97	1.82	3.55	2.13	1.44	3.23	2.10
	11	3.28	2.61	3.11	1.91	3.71	2.26	1.52	3.36	2.20
	12	3.38	2.71	3.26	2.01	3.88	2.39	1.59	3.48	2.31
	13	3.48	2.80	3.42	2.10	4.06	2.54	1.67	3.61	2.43
	14	3.58	2.90	3.59	2.20	4.25	2.69	1.75	3.75	2.56
Calculation	15	3.68	3.00	3.76	2.31	4.45	2.85	1.84	3.89	2.68
Continues	16	3.79	3.11	3.94	2.42	4.66	3.02	1.93	4.04	2.82
on through	17	3.90	3.22	4.14	2.54	4.87	3.20	2.03	4.19	2.96
Year 200	18	4.02	3.34	4.34	2.66	5.10	3.39	2.13	4.35	3.11
↓	19	4.14	3.45	4.55	2.79	5.33	3.60	2.24	4.51	3.27
	20	4.26	3.58	4.77	2.92	5.58	3.81	2.35	4.68	3.44

RGR Rebuttal Exhibit 1

Schedule 1
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MULTI-STAGE DCF MODEL
WEAVER ELECTRIC PROXY GROUP
Using Average Price and Correcting PV of Perpetuity

Company	Ameren	Cinergy	DTE Energy	Empire District	FPL Group	MGE Energy	PNM Res.	Progress Energy	Southern Company
Price	$44.62	$36.84	$37.46	$21.68	$64.05	$31.47	$28.53	$43.81	$29.25
L-T Pr. Growth	2.95 %	3.55 %	4.85 %	4.83 %	4.64 %	6.00 %	5.00 %	3.77 %	5.07 %
Internal Rate of Return	8.46 %	8.56 %	10.05 %	10.37 %	8.32 %	10.02 %	8.25 %	9.06 %	9.67 %

AVERAGE INTERNAL RATE OF RETURN = 9.20%

		Cash Flow								
		Ameren	Cinergy	DTE Energy	Empire District	FPL Group	MGE Energy	PNM Res.	Progress Energy	Southern Company
	Price	-44.62	-36.84	-37.46	-21.68	-64.05	-31.47	-28.53	-43.81	-29.25
Year	1	2.56	1.88	2.08	1.28	2.40	1.36	0.92	2.32	1.40
	2	2.58	1.93	2.11	1.30	2.49	1.39	0.97	2.41	1.44
	3	2.62	1.98	2.16	1.33	2.59	1.43	1.02	2.50	1.49
	4	2.68	2.05	2.23	1.37	2.70	1.50	1.08	2.59	1.56
	5	2.75	2.12	2.34	1.44	2.83	1.59	1.13	2.69	1.64
	6	2.84	2.19	2.46	1.51	2.96	1.69	1.19	2.79	1.72
	7	2.92	2.27	2.58	1.58	3.09	1.79	1.25	2.89	1.81
	8	3.01	2.35	2.70	1.66	3.24	1.90	1.31	3.00	1.90
	9	3.09	2.44	2.83	1.74	3.39	2.01	1.37	3.12	2.00
	10	3.19	2.52	2.97	1.82	3.55	2.13	1.44	3.23	2.10
	11	3.28	2.61	3.11	1.91	3.71	2.26	1.52	3.36	2.20
	12	3.38	2.71	3.26	2.01	3.88	2.39	1.59	3.48	2.31
	13	3.48	2.80	3.42	2.10	4.06	2.54	1.67	3.61	2.43
	14	3.58	2.90	3.59	2.20	4.25	2.69	1.75	3.75	2.56
Calculation	15	3.68	3.00	3.76	2.31	4.45	2.85	1.84	3.89	2.68
Continues	16	3.79	3.11	3.94	2.42	4.66	3.02	1.93	4.04	2.82
on through	17	3.90	3.22	4.14	2.54	4.87	3.20	2.03	4.19	2.96
Year 200	18	4.02	3.34	4.34	2.66	5.10	3.39	2.13	4.35	3.11
↓	19	4.14	3.45	4.55	2.79	5.33	3.60	2.24	4.51	3.27
	20	4.26	3.58	4.77	2.92	5.58	3.81	2.35	4.68	3.44

RGR Rebuttal Exhibit 1

Schedule 2
Page 1 of 2

MULTI-STAGE DCF MODEL
WEAVER GAS PROXY GROUP
Using Spot Price and Correcting PV of Perpetuity

Company	AGL Resources	Atmos Energy	Cascade Natural Gas	Energen	New Jersey Resources	Northwest Natural Gas	Peoples Energy	South Jersey Ind.
Price	$28.30	$26.44	$22.23	$42.41	$39.45	$31.28	$43.30	$41.85
L-T Pr. Growth	5.38 %	6.08 %	4.50 %	7.07 %	6.33 %	4.65 %	4.58 %	5.13 %
Internal Rate of Return	8.93 %	10.36 %	8.56 %	8.57 %	9.40 %	8.53 %	9.33 %	8.86 %

AVERAGE INTERNAL RATE OF RETURN = 9.07%

		Cash Flow							
		AGL Resources	Atmos Energy	Cascade Natural Gas	Energen	New Jersey Resources	Northwest Natural Gas	Peoples Energy	South Jersey Ind.
	Price	-28.30	-26.44	-22.23	-42.41	-39.45	-31.28	-43.30	-41.85
Year	1	1.12	1.20	0.96	0.72	1.28	1.28	2.12	1.60
	2	1.13	1.23	0.97	0.75	1.32	1.30	2.18	1.66
	3	1.14	1.28	0.99	0.78	1.38	1.34	2.26	1.73
	4	1.17	1.35	1.03	0.83	1.46	1.39	2.35	1.81
	5	1.23	1.43	1.07	0.89	1.55	1.45	2.46	1.90
	6	1.30	1.51	1.12	0.95	1.65	1.52	2.57	2.00
	7	1.37	1.61	1.17	1.02	1.75	1.59	2.69	2.10
	8	1.44	1.70	1.22	1.09	1.86	1.66	2.81	2.21
	9	1.52	1.81	1.28	1.17	1.98	1.74	2.94	2.33
	10	1.60	1.92	1.34	1.25	2.11	1.82	3.07	2.44
	11	1.69	2.03	1.40	1.34	2.24	1.91	3.21	2.57
	12	1.78	2.16	1.46	1.44	2.38	2.00	3.36	2.70
	13	1.88	2.29	1.52	1.54	2.53	2.09	3.52	2.84
	14	1.98	2.43	1.59	1.65	2.69	2.19	3.68	2.99
Calculation	15	2.08	2.58	1.67	1.76	2.86	2.29	3.85	3.14
Continues	16	2.20	2.73	1.74	1.89	3.04	2.39	4.02	3.30
on through	17	2.31	2.90	1.82	2.02	3.24	2.51	4.21	3.47
Year 200	18	2.44	3.07	1.90	2.16	3.44	2.62	4.40	3.65
↓	19	2.57	3.26	1.99	2.32	3.66	2.74	4.60	3.84
	20	2.71	3.46	2.08	2.48	3.89	2.87	4.81	4.03

RGR Rebuttal Exhibit 1

Schedule 2
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MULTI-STAGE DCF MODEL
WEAVER GAS PROXY GROUP
Using Average Price and Correcting PV of Perpetuity

Company	AGL Resources	Atmos Energy	Cascade Natural Gas	Energen	New Jersey Resources	Northwest Natural Gas	Peoples Energy	South Jersey Ind.
Price	$28.27	$24.65	$20.60	$39.53	$37.89	$29.91	$41.23	$39.53
L-T Pr. Growth	5.38 %	6.08 %	4.50 %	7.07 %	6.33 %	4.65 %	4.58 %	5.13 %
Internal Rate of Return	8.94 %	10.67 %	8.88 %	8.70 %	9.53 %	8.71 %	9.57 %	9.08 %

AVERAGE INTERNAL RATE OF RETURN = 9.26%

		Cash Flow							
		AGL Resources	Atmos Energy	Cascade Natural Gas	Energen	New Jersey Resources	Northwest Natural Gas	Peoples Energy	South Jersey Ind.
	Price	-28.27	-24.65	-20.60	-39.53	-37.89	-29.91	-41.23	-39.53
Year	1	1.12	1.20	0.96	0.72	1.28	1.28	2.12	1.60
	2	1.13	1.23	0.97	0.75	1.32	1.30	2.18	1.66
	3	1.14	1.28	0.99	0.78	1.38	1.34	2.26	1.73
	4	1.17	1.35	1.03	0.83	1.46	1.39	2.35	1.81
	5	1.23	1.43	1.07	0.89	1.55	1.45	2.46	1.90
	6	1.30	1.51	1.12	0.95	1.65	1.52	2.57	2.00
	7	1.37	1.61	1.17	1.02	1.75	1.59	2.69	2.10
	8	1.44	1.70	1.22	1.09	1.86	1.66	2.81	2.21
	9	1.52	1.81	1.28	1.17	1.98	1.74	2.94	2.33
	10	1.60	1.92	1.34	1.25	2.11	1.82	3.07	2.44
	11	1.69	2.03	1.40	1.34	2.24	1.91	3.21	2.57
	12	1.78	2.16	1.46	1.44	2.38	2.00	3.36	2.70
	13	1.88	2.29	1.52	1.54	2.53	2.09	3.52	2.84
	14	1.98	2.43	1.59	1.65	2.69	2.19	3.68	2.99
Calculation	15	2.08	2.58	1.67	1.76	2.86	2.29	3.85	3.14
Continues	16	2.20	2.73	1.74	1.89	3.04	2.39	4.02	3.30
on through	17	2.31	2.90	1.82	2.02	3.24	2.51	4.21	3.47
Year 200	18	2.44	3.07	1.90	2.16	3.44	2.62	4.40	3.65
↓	19	2.57	3.26	1.99	2.32	3.66	2.74	4.60	3.84
	20	2.71	3.46	2.08	2.48	3.89	2.87	4.81	4.03

RGR Rebuttal Exhibit 1

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MULTI-STAGE DCF MODEL
WEAVER ELECTRIC PROXY GROUP
Employing Dr. Weaver's Methodology from the 2000 LG&E Gas Rate Case

Company	Ameren	Cinergy	DTE Energy	Empire District	FPL Group	MGE Energy	PNM Res.	Progress Energy	Southern Company
Average Price	$44.62	$36.84	$37.46	$21.68	$64.05	$31.47	$28.53	$43.81	$29.25
Indicated Dividend	$2.56	$1.88	$2.08	$1.28	$2.40	$1.36	$0.92	$2.32	$1.40
5-Yr Pr. Growth	2.95 %	3.55 %	4.85 %	4.83 %	4.64 %	6.00 %	5.00 %	3.77 %	5.07 %
L-T Pr. Growth	5.55 %	5.55 %	5.55 %	5.55 %	5.55 %	5.55 %	5.55 %	5.55 %	5.55 %
Internal Rate of Return	10.96 %	10.49 %	11.24 %	11.59 %	9.35 %	10.20 %	8.86 %	10.72 %	10.50 %

AVERAGE INTERNAL RATE OF RETURN = 10.43 %

		Cash Flow								
		Ameren	Cinergy	DTE Energy	Empire District	FPL Group	MGE Energy	PNM Res.	Progress Energy	Southern Company
	Price	-44.62	-36.84	-37.46	-21.68	-64.05	-31.47	-28.53	-43.81	-29.25
Year	1	2.64	1.95	2.18	1.34	2.51	1.44	0.97	2.41	1.47
	2	2.71	2.02	2.29	1.41	2.63	1.53	1.01	2.50	1.55
	3	2.79	2.09	2.40	1.47	2.75	1.62	1.07	2.59	1.62
	4	2.88	2.16	2.51	1.55	2.88	1.72	1.12	2.69	1.71
	5	2.96	2.24	2.64	1.62	3.01	1.82	1.17	2.79	1.79
	6	3.12	2.36	2.78	1.71	3.18	1.92	1.24	2.95	1.89
	7	3.30	2.49	2.94	1.81	3.35	2.03	1.31	3.11	2.00
	8	3.48	2.63	3.10	1.91	3.54	2.14	1.38	3.28	2.11
	9	3.67	2.78	3.27	2.01	3.74	2.26	1.46	3.46	2.23
	10	3.88	2.93	3.45	2.12	3.94	2.38	1.54	3.66	2.35
	11	4.09	3.09	3.64	2.24	4.16	2.52	1.62	3.86	2.48
	12	4.32	3.27	3.85	2.37	4.39	2.66	1.71	4.07	2.62
	13	4.56	3.45	4.06	2.50	4.64	2.80	1.81	4.30	2.76
	14	4.81	3.64	4.29	2.63	4.90	2.96	1.91	4.54	2.92
Calculation	15	5.08	3.84	4.52	2.78	5.17	3.12	2.02	4.79	3.08
Continues	16	5.36	4.05	4.77	2.94	5.45	3.30	2.13	5.06	3.25
on through	17	5.66	4.28	5.04	3.10	5.76	3.48	2.25	5.34	3.43
Year 200	18	5.97	4.52	5.32	3.27	6.08	3.67	2.37	5.63	3.62
↓	19	6.31	4.77	5.61	3.45	6.41	3.88	2.50	5.95	3.82
	20	6.66	5.03	5.93	3.64	6.77	4.09	2.64	6.28	4.03

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MULTI-STAGE DCF MODEL
WEAVER ELECTRIC PROXY GROUP
Employing Dr. Weaver's Methodology from the 2000 LG&E Gas Rate Case
With Adjustment for Small Stocks

Company	Ameren	Cinergy	DTE Energy	Empire District	FPL Group	MGE Energy	PNM Res.	Progress Energy	Southern Company
Average Price	$44.62	$36.84	$37.46	$21.68	$64.05	$31.47	$28.53	$43.81	$29.25
Indicated Dividend	$2.56	$1.88	$2.08	$1.28	$2.40	$1.36	$0.92	$2.32	$1.40
5-Yr Pr. Growth	2.95 %	3.55 %	4.85 %	4.83 %	4.64 %	6.00 %	5.00 %	3.77 %	5.07 %
L-T Pr. Growth	5.98 %	5.98 %	5.98 %	5.98 %	5.98 %	5.98 %	5.98 %	5.98 %	5.98 %
Internal Rate of Return	11.31 %	10.84 %	11.59 %	11.94 %	9.72 %	10.56 %	9.24 %	11.08 %	10.86 %

AVERAGE INTERNAL RATE OF RETURN = 10.79 %

		Cash Flow								
		Ameren	Cinergy	DTE Energy	Empire District	FPL Group	MGE Energy	PNM Res.	Progress Energy	Southern Company
	Price	-44.62	-36.84	-37.46	-21.68	-64.05	-31.47	-28.53	-43.81	-29.25
Year	1	2.64	1.95	2.18	1.34	2.51	1.44	0.97	2.41	1.47
	2	2.71	2.02	2.29	1.41	2.63	1.53	1.01	2.50	1.55
	3	2.79	2.09	2.40	1.47	2.75	1.62	1.07	2.59	1.62
	4	2.88	2.16	2.51	1.55	2.88	1.72	1.12	2.69	1.71
	5	2.96	2.24	2.64	1.62	3.01	1.82	1.17	2.79	1.79
	6	3.14	2.37	2.79	1.72	3.19	1.93	1.24	2.96	1.90
	7	3.33	2.51	2.96	1.82	3.38	2.04	1.32	3.14	2.01
	8	3.52	2.66	3.14	1.93	3.58	2.17	1.40	3.32	2.13
	9	3.73	2.82	3.33	2.04	3.80	2.30	1.48	3.52	2.26
	10	3.96	2.99	3.52	2.17	4.03	2.43	1.57	3.73	2.40
	11	4.19	3.17	3.73	2.30	4.27	2.58	1.66	3.96	2.54
	12	4.45	3.36	3.96	2.43	4.52	2.73	1.76	4.19	2.69
	13	4.71	3.56	4.19	2.58	4.79	2.90	1.87	4.44	2.85
	14	4.99	3.78	4.45	2.73	5.08	3.07	1.98	4.71	3.02
Calculation	15	5.29	4.00	4.71	2.90	5.38	3.25	2.10	4.99	3.20
Continues	16	5.61	4.24	4.99	3.07	5.70	3.45	2.22	5.29	3.40
on through	17	5.94	4.49	5.29	3.25	6.04	3.65	2.36	5.60	3.60
Year 200	18	6.30	4.76	5.61	3.45	6.41	3.87	2.50	5.94	3.81
↓	19	6.68	5.05	5.94	3.65	6.79	4.10	2.65	6.29	4.04
	20	7.08	5.35	6.30	3.87	7.20	4.35	2.81	6.67	4.28

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MULTI-STAGE DCF MODEL
WEAVER GAS PROXY GROUP
Employing Dr. Weaver's Methodology from the 2000 LG&E Gas Rate Case

Company	AGL Resources	Atmos Energy	Cascade Natural Gas	Energen	New Jersey Resources	Northwest Natural Gas	Peoples Energy	South Jersey Ind.
Average Price	$28.27	$24.65	$20.60	$39.53	$37.89	$29.91	$41.23	$39.53
Indicated Dividend	$1.12	$1.20	$0.96	$0.72	$1.28	$1.28	$2.12	$1.60
5-Yr Pr. Growth	5.38 %	6.08 %	4.50 %	7.07 %	6.33 %	4.65 %	4.58 %	5.13 %
L-T Pr. Growth	6.38 %	6.38 %	6.38 %	6.38 %	6.38 %	6.38 %	6.38 %	6.38 %
Internal Rate of Return	10.41 %	11.49 %	10.95 %	8.33 %	9.96 %	10.60 %	11.44 %	10.45 %

AVERAGE INTERNAL RATE OF RETURN = 10.45 %

		Cash Flow							
		AGL Resources	Atmos Energy	Cascade Natural Gas	Energen	New Jersey Resources	Northwest Natural Gas	Peoples Energy	South Jersey Ind.
	Price	-28.27	-24.65	-20.60	-39.53	-37.89	-29.91	-41.23	-39.53
Year	1	1.18	1.27	1.00	0.77	1.36	1.34	2.22	1.68
	2	1.24	1.35	1.05	0.83	1.45	1.40	2.32	1.77
	3	1.31	1.43	1.10	0.88	1.54	1.47	2.42	1.86
	4	1.38	1.52	1.14	0.95	1.64	1.54	2.54	1.95
	5	1.46	1.61	1.20	1.01	1.74	1.61	2.65	2.05
	6	1.55	1.71	1.27	1.08	1.85	1.71	2.82	2.19
	7	1.65	1.82	1.35	1.15	1.97	1.82	3.00	2.33
	8	1.75	1.94	1.44	1.22	2.09	1.93	3.19	2.47
	9	1.86	2.06	1.53	1.30	2.23	2.06	3.40	2.63
	10	1.98	2.20	1.63	1.38	2.37	2.19	3.61	2.80
	11	2.11	2.34	1.73	1.47	2.52	2.33	3.84	2.98
	12	2.24	2.49	1.84	1.56	2.68	2.48	4.09	3.17
	13	2.39	2.64	1.96	1.66	2.85	2.64	4.35	3.37
	14	2.54	2.81	2.09	1.77	3.04	2.80	4.63	3.59
Calculation	15	2.70	2.99	2.22	1.88	3.23	2.98	4.92	3.81
Continues	16	2.87	3.18	2.36	2.00	3.44	3.17	5.24	4.06
on through	17	3.06	3.39	2.51	2.13	3.65	3.37	5.57	4.32
Year 200	18	3.25	3.60	2.67	2.26	3.89	3.59	5.93	4.59
↓	19	3.46	3.83	2.84	2.41	4.14	3.82	6.30	4.88
	20	3.68	4.08	3.03	2.56	4.40	4.06	6.71	5.20

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MULTI-STAGE DCF MODEL
WEAVER GAS PROXY GROUP
Employing Dr. Weaver's Methodology from the 2000 LG&E Gas Rate Case
With Adjustment for Small Stocks

Company	AGL Resources	Atmos Energy	Cascade Natural Gas	Energen	New Jersey Resources	Northwest Natural Gas	Peoples Energy	South Jersey Ind.
Average Price	$28.27	$24.65	$20.60	$39.53	$37.89	$29.91	$41.23	$39.53
Indicated Dividend	$1.12	$1.20	$0.96	$0.72	$1.28	$1.28	$2.12	$1.60
5-Yr Pr. Growth	5.38 %	6.08 %	4.50 %	7.07 %	6.33 %	4.65 %	4.58 %	5.13 %
L-T Pr. Growth	7.60 %	7.60 %	7.60 %	7.60 %	7.60 %	7.60 %	7.60 %	7.60 %
Internal Rate of Return	11.47 %	12.51 %	11.98 %	9.45 %	11.03 %	11.65 %	12.46 %	11.51 %

AVERAGE INTERNAL RATE OF RETURN = 11.51 %

		Cash Flow							
		AGL Resources	Atmos Energy	Cascade Natural Gas	Energen	New Jersey Resources	Northwest Natural Gas	Peoples Energy	South Jersey Ind.
	Price	-28.27	-24.65	-20.60	-39.53	-37.89	-29.91	-41.23	-39.53
Year	1	1.18	1.27	1.00	0.77	1.36	1.34	2.22	1.68
	2	1.24	1.35	1.05	0.83	1.45	1.40	2.32	1.77
	3	1.31	1.43	1.10	0.88	1.54	1.47	2.42	1.86
	4	1.38	1.52	1.14	0.95	1.64	1.54	2.54	1.95
	5	1.46	1.61	1.20	1.01	1.74	1.61	2.65	2.05
	6	1.57	1.73	1.29	1.09	1.87	1.73	2.85	2.21
	7	1.69	1.87	1.39	1.17	2.01	1.86	3.07	2.38
	8	1.81	2.01	1.49	1.26	2.17	2.00	3.30	2.56
	9	1.95	2.16	1.60	1.36	2.33	2.15	3.55	2.75
	10	2.10	2.32	1.73	1.46	2.51	2.32	3.83	2.96
	11	2.26	2.50	1.86	1.57	2.70	2.49	4.12	3.19
	12	2.43	2.69	2.00	1.69	2.91	2.68	4.43	3.43
	13	2.62	2.90	2.15	1.82	3.13	2.89	4.77	3.69
	14	2.81	3.12	2.31	1.96	3.36	3.11	5.13	3.97
Calculation	15	3.03	3.35	2.49	2.11	3.62	3.34	5.52	4.27
Continues	16	3.26	3.61	2.68	2.27	3.89	3.60	5.94	4.60
on through	17	3.51	3.88	2.88	2.44	4.19	3.87	6.39	4.95
Year 200	18	3.77	4.18	3.10	2.63	4.51	4.16	6.87	5.32
↓	19	4.06	4.49	3.34	2.83	4.85	4.48	7.40	5.73
	20	4.37	4.84	3.59	3.04	5.22	4.82	7.96	6.17

WORKPAPERS

of

Robert Rosenberg
Edgewood Consulting, Inc.

for

REBUTTAL TESTIMONY

Louisville Gas and Electric Company
Case No. 2003-00433

Kentucky Utilities Company
Case No. 2003-00434

May 2004

Regulatory Study
April 5, 2004

MAJOR RATE CASE DECISIONS–JANUARY-MARCH 2004

For the first three months of 2004, the average electric equity return authorization by state commissions was 11% (three determinations), virtually identical to the 10.97% average in calendar-2003. The average gas equity return authorization for the first quarter of 2004 was 11.1% (four determinations), up slightly from the 10.99% average in calendar-2003. During the first quarter of 2004, there was one (10%) telecommunications equity return authorization.

In recent years there have been relatively few equity return determinations. The reasons include: industry restructuring/intensifying competition; more efficient utility operations; technological improvements; relatively low inflation and interest rates; accelerated depreciation/amortization programs; the increased utilization of "black box" settlements; and, the growing use of performance, or price-based, regulation. As the number of equity return determinations has declined, the average authorized return now has less of a relationship to the return that the typical electric, gas, or telecommunications company has an opportunity to earn. In addition, electric industry restructuring in many states has led to the unbundling of rates, with commissions authorizing return and revenue requirement parameters for distribution operations only, which further complicates data comparability. The tables included in this study are extensions of those contained in the January 22, 2004 Regulatory Study entitled *Major Rate Case Decisions–January 2002-December 2003--Supplemental Study*. Refer to that report for information concerning individual rate case decisions that were rendered in 2002 and 2003.

The table on page 2 shows annual average equity returns authorized since 1994, and by quarter since 1998, in major electric, gas, and telecommunications rate decisions, followed by the number of determinations during each period. The tables on page 3 present the composite industry data for items in the chronology of this and earlier reports, summarized annually since 1994, and quarterly for the most recent nine quarters. The individual electric, gas, and telecommunications cases decided in the first three months of 2004 are listed on page 4, with the decision date shown first, followed by the company name, the abbreviation for the state issuing the decision, the authorized rate of return (ROR), return on equity (ROE), and percentage of common equity in the adopted capital structure. Next we show the month and year in which the adopted test year ended, whether the commission utilized an average or a year-end rate base, and the amount of the permanent rate change authorized. The dollar amounts represent the permanent rate change ordered at the time decisions were rendered. A case is generally considered "major" if the rate change initially requested was $5 million or greater, or the authorized rate change was at least $3 million. Gas rate requests that are considered in conjunction with major electric requests are recorded and reported as individual cases, regardless of size.

Average Equity Returns Authorized January 1994 - March 2004

(Return Percent - No. of Observations)

	Period	Electric Utilities	Gas Utilities	Telephone Utilities
1994	Full Year	11.34 (31)	11.35 (28)	11.81 (11)
1995	Full Year	11.55 (33)	11.43 (16)	12.08 (8)
1996	Full Year	11.39 (22)	11.19 (20)	11.74 (4)
1997	Full Year	11.40 (11)	11.29 (13)	11.56 (5)
1998	1st Quarter	11.31 (4)	— (0)	11.30 (1)
	2nd Quarter	12.20 (1)	11.37 (3)	— (0)
	3rd Quarter	11.80 (2)	11.41 (3)	— (0)
	4th Quarter	11.83 (3)	11.69 (4)	— (0)
1998	Full Year	11.66 (10)	11.51 (10)	11.30 (1)
1999	1st Quarter	10.58 (4)	10.82 (3)	13.00 (1)
	2nd Quarter	10.94 (4)	10.82 (3)	— (0)
	3rd Quarter	10.63 (8)	— (0)	— (0)
	4th Quarter	11.08 (4)	10.33 (3)	— (0)
1999	Full Year	10.77 (20)	10.66 (9)	13.00 (1)
2000	1st Quarter	11.06 (5)	10.71 (1)	11.50 (1)
	2nd Quarter	11.11 (2)	11.08 (4)	— (0)
	3rd Quarter	11.68 (2)	11.33 (5)	11.25 (1)
	4th Quarter	12.08 (3)	12.50 (2)	— (0)
2000	Full Year	11.43 (12)	11.39 (12)	11.38 (2)
2001	1st Quarter	11.38 (2)	11.16 (4)	— (0)
	2nd Quarter	10.88 (2)	10.75 (1)	— (0)
	3rd Quarter	10.78 (8)	— (0)	— (0)
	4th Quarter	11.50 (6)	10.65 (2)	— (0)
2001	Full Year	11.09 (18)	10.95 (7)	— (0)
2002	1st Quarter	10.87 (5)	10.67 (3)	— (0)
	2nd Quarter	11.41 (6)	11.64 (4)	— (0)
	3rd Quarter	11.06 (4)	11.50 (3)	— (0)
	4th Quarter	11.20 (7)	10.78 (11)	— (0)
2002	Full Year	11.16 (22)	11.03 (21)	— (0)
2003	1st Quarter	11.47 (7)	11.38 (5)	— (0)
	2nd Quarter	11.16 (4)	11.36 (4)	— (0)
	3rd Quarter	9.95 (5)	10.61 (5)	— (0)
	4th Quarter	11.09 (6)	10.84 (11)	— (0)
2003	Full Year	10.97 (22)	10.99 (25)	— (0)
2004	1st Quarter	11.00 (3)	11.10 (4)	10.00 (1)

Attorney General's Response to
The Requests for Information of
Louisville Gas & Electric Company
Case No. 2003-00433

Witness Responding: Carl G. K. Weaver

32. In Dr. Weaver's opinion, has the risk of LG&E or KU changed since the filing of his ESM testimony in December 2003. If so, explain in detail how.

Answer:

From a stock market perspective, the risk of LG&E or KU relative to the risk of other stocks in the equity market has changed very little since December 2003. Financial risk is somewhat higher due to the higher interest payments required as a result of the cancellation of the accounts receivable securitization program and replacing it with higher interest debt. This higher financial risk has been offset by higher stock prices which have reduced the cost of equity in the overall market as additional information confirms the economic recovery.

INTEREST RATES

	Treasury Bond Yields			Moody's Bond Yields			
	10-Year (1)	20-Year (2)	Long-Term* (3)	Aa (4)	A (5)	Baa (6)	Public Utility (7)
2003 July	3.98	4.92	5.00	6.37	6.57	6.67	6.54
August	4.45	5.39	5.41	6.48	6.78	7.08	6.78
September	4.27	5.21	5.23	6.30	6.56	6.87	6.58
October	4.29	5.21	5.24	6.28	6.43	6.79	6.50
November	4.30	5.17	5.20	6.25	6.36	6.68	6.43
December	4.27	5.11	5.15	6.18	6.27	6.61	6.36
January	4.15	5.01	5.05	6.06	6.15	6.47	6.23
February	4.08	4.94	4.99	6.10	6.15	6.28	6.17
Average:							
Jul-Oct 2003	4.25	5.18	5.22	6.36	6.59	6.85	6.60
Sep'03-Feb'04	4.23	5.11	5.14	6.20	6.32	6.62	6.38
Difference	-0.02	-0.07	-0.08	-0.16	-0.27	-0.24	-0.22

* The *Federal Reserve Statistical Release* reported the yield on 30-year Treausry bonds through January 2002, after which point the series was discontinued and a new series of long-term Treasury bond yields (with at least 25 years or more remaining until maturity) was commenced starting in February 2002.

Source: Federal Reserve Statistical Release; Mergent (formerly Moody's) Bond Record; and Moody's website.

Table 4. ECONOMIC ASSUMPTIONS [1]
(Calendar years; dollar amounts in billions)

	2002 Actual	Projections					
		2003	2004	2005	2006	2007	2008
Gross Domestic Product (GDP):							
Levels, dollar amounts in billions:							
Current dollars	10,446	10,863	11,405	11,972	12,563	13,183	13,837
Real, chained (1996) dollars	9,440	9,661	10,018	10,378	10,733	11,079	11,427
Chained price index (1996 = 100), annual average	110.7	112.4	113.8	115.3	117.0	119.0	121.0
Percent change, fourth quarter over fourth quarter:							
Current dollars	4.3	4.4	5.1	4.9	4.9	5.0	4.9
Real, chained (1996) dollars	2.9	2.8	3.7	3.5	3.3	3.2	3.1
Chained price index (1996 = 100)	1.3	1.5	1.3	1.4	1.6	1.7	1.8
Percent change, year over year:							
Current dollars	3.6	4.0	5.0	5.0	4.9	4.9	5.0
Real, chained (1996) dollars	2.4	2.3	3.7	3.6	3.4	3.2	3.1
Chained price index (1996 = 100)	1.1	1.6	1.2	1.3	1.5	1.7	1.8
Incomes, billions of current dollars:							
Corporate profits before tax	665	708	671	1,151	1,142	1,135	1,154
Wages and salaries	5,004	5,162	5,438	5,740	6,060	6,373	6,689
Other taxable income [2]	2,411	2,479	2,615	2,662	2,706	2,767	2,851
Consumer Price Index (all urban): [3]							
Level (1982–84 = 100), annual average	179.9	184.0	187.0	190.4	194.2	198.6	203.1
Percent change, fourth quarter over fourth quarter	2.2	1.9	1.8	1.9	2.1	2.3	2.3
Percent change, year over year	1.6	2.3	1.7	1.8	2.0	2.2	2.3
Unemployment rate, civilian, percent:							
Fourth quarter level	5.9	5.8	5.5	5.3	5.2	5.1	5.1
Annual average	5.8	5.9	5.6	5.4	5.2	5.1	5.1
Federal pay raises, January, percent:							
Military [4]	6.9	4.7	4	NA	NA	NA	NA
Civilian [5]	4.6	4.1	5	NA	NA	NA	NA
Interest rates, percent:							
91-day Treasury bills [6]	1.6	1.2	2.0	2.8	3.6	4.2	4.3
10-year Treasury notes	4.6	3.7	4.1	4.5	4.8	5.1	5.3

Avg
4.9

The economic assumptions for the Mid-Session Review, summarized in Table 4, differ from those used in the Administration's 2004 Budget in that they incorporate the fiscal, monetary, and economic developments discussed above.

During the second half of this year and into 2004 and 2005 growth is now projected to be somewhat stronger than anticipated in the February Budget, while inflation and interest rates are now projected to be lower. The unemployment rate is slightly higher in the near term, reflecting the higher current level.

3.45

OMB
2/2/04

ANALYTICAL PERSPECTIVES

BUDGET OF THE UNITED STATES GOVERNMENT

Fiscal Year 2005

Table 11–1. ECONOMIC ASSUMPTIONS [1]

(Calendar years; dollar amounts in billions)

	Actual 2002	Projections						
		2003	2004	2005	2006	2007	2008	2009
Gross Domestic Product (GDP):								
Levels, dollar amounts in billions:								
Current dollars	10,446	10,939	11,566	12,139	12,746	13,396	14,096	14,831
Real, chained (1996) dollars	9,440	9,730	10,163	10,528	10,886	11,248	11,607	11,969
Chained price index (1996=100), annual average	110.7	112.4	113.8	115.3	117.1	119.1	121.4	123.9
Percent change, fourth quarter over fourth quarter:								
Current dollars	4.3	5.8	5.2	4.9	5.0	5.2	5.2	5.2
Real, chained (1996) dollars	2.9	4.2	4.0	3.4	3.3	3.3	3.1	3.1
Chained price index (1996=100)	1.3	1.5	1.2	1.4	1.6	1.8	2.0	2.0
Percent change, year over year:								
Current dollars	3.6	4.7	5.7	4.9	5.0	5.1	5.2	5.2
Real, chained (1996) dollars	2.4	3.1	4.4	3.6	3.4	3.3	3.2	3.1
Chained price index (1996=100)	1.1	1.6	1.2	1.3	1.5	1.7	2.0	2.0
Incomes, billions of current dollars:								
Corporate profits before tax	665	756	891	1,181	1,134	1,134	1,175	1,222
Wages and salaries	4,996	5,101	5,356	5,686	6,008	6,347	6,687	7,030
Other taxable income [2]	2,411	2,487	2,609	2,681	2,727	2,791	2,888	3,016
Consumer Price Index: [3]								
Level (1982–84=100), annual average	179.9	184.0	186.6	189.4	192.8	196.8	201.5	206.6
Percent change, fourth quarter over fourth quarter	2.2	2.0	1.4	1.6	1.9	2.2	2.5	2.5
Percent change, year over year	1.6	2.3	1.4	1.5	1.8	2.1	2.4	2.5
Unemployment rate, civilian, percent:								
Fourth quarter level	5.9	5.9	5.5	5.3	5.2	5.1	5.1	5.1
Annual average	5.8	6.0	5.6	5.4	5.2	5.1	5.1	5.1
Federal pay raises, January, percent:								
Military [4]	6.9	4.7	4.15	3.5	NA	NA	NA	NA
Civilian [5]	4.6	4.1	4.1	1.5	NA	NA	NA	NA
Interest rates, percent:								
91-day Treasury bills [6]	1.6	1.0	1.3	2.4	3.3	4.0	4.3	4.4
10-year Treasury notes	4.6	4.0	4.6	5.0	5.4	5.6	5.8	5.8
ADDENDUM: [7]								
Gross Domestic Product (GDP), revised:								
Levels, dollar amounts in billions:								
Current dollars	10,481	10,984	11,612	12,187	12,796	13,449	14,151	14,890
Real, chained (2000) dollars	10,083	10,397	10,858	11,248	11,630	12,017	12,401	12,788
Chained price index (2000=100), annual average	103.9	105.7	107.0	108.4	110.0	111.9	114.1	116.4
Percent change, fourth quarter over fourth quarter:								
Current dollars	4.2	5.9	5.2	4.9	5.0	5.2	5.2	5.2
Real, chained (2000) dollars	2.8	4.3	4.0	3.4	3.3	3.3	3.1	3.1
Chained price index (2000=100)	1.4	1.5	1.2	1.4	1.6	1.8	2.0	2.0
Percent change, year over year:								
Current dollars	3.8	4.8	5.7	4.9	5.0	5.1	5.2	5.2
Real, chained (2000) dollars	2.2	3.1	4.4	3.6	3.4	3.3	3.2	3.1
Chained price index (2000=100)	1.5	1.6	1.2	1.3	1.5	1.7	2.0	2.0
Incomes, billions of current dollars, revised:								
Corporate profits before tax	745	845	992	1,313	1,261	1,262	1,307	1,359
Wages and salaries	4,975	5,092	5,352	5,682	6,004	6,342	6,682	7,025
Other taxable income [2]	2,349	2,401	2,515	2,587	2,634	2,701	2,796	2,923

NA = Not Available.

[1] Based on information available as of late November 2003.

[2] Dividends, rent, interest and proprietors' income components of personal income.

[3] Seasonally adjusted CPI for all urban consumers.

[4] Percentages apply to basic pay only; 2002, 2003, and 2004 figures are averages of various rank- and longevity- specific adjustments; percentages to be proposed for years after 2005 have not yet been determined.

[5] Overall average increase, including locality pay adjustments. Percentages to be proposed for years after 2005 have not yet been determined.

[6] Average rate, secondary market (bank discount basis).

[7] Assumptions adjusted to reflect comprehensive revisions to GDP and incomes released by the Bureau of Economic Analysis in December 2003.

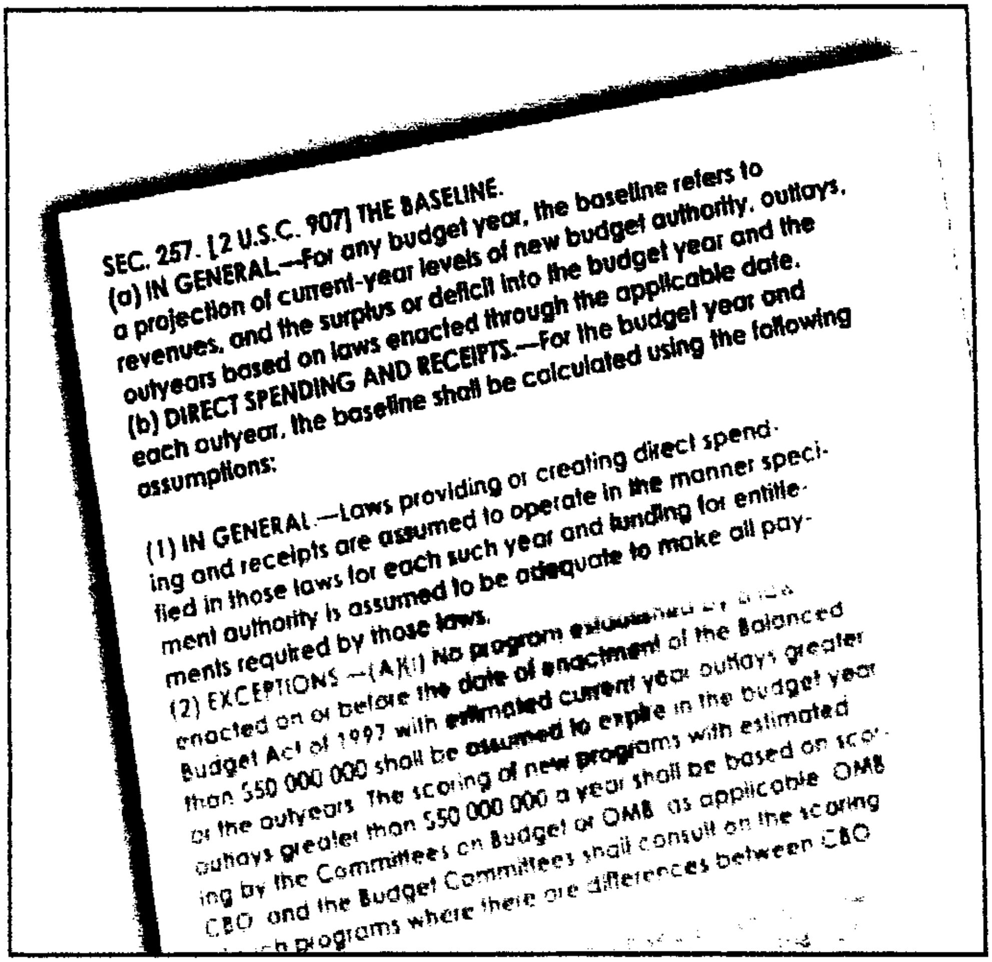
FE

Value Line Forecast for the U.S. Economy

	ACTUAL				ESTIMATED					
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
GROSS DOMESTIC PRODUCT AND ITS COMPONENTS (2000 CHAIN WEIGHTED $) BILLIONS OF DOLLARS										
Final Sales	9404	9760	9901	10077	*10395*	*10840*	*11219*	*11634*	*12041*	*12487*
Total Consumption	6439	6739	6905	7140	*7362*	*7625*	*7892*	*8160*	*8421*	*8691*
Nonresidential Fixed Investment	1133	1232	1177	1093	*1123*	*1226*	*1337*	*1430*	*1530*	*1637*
Construction	293	313	305	249	*237*	*237*	*256*	*272*	*291*	*314*
Equipment & Software	840	919	871	847	*891*	*991*	*1081*	*1156*	*1249*	*1361*
Residential Fixed Investment	444	447	448	470	*506*	*538*	*528*	*533*	*544*	*560*
Exports	1008	1096	1039	1014	*1034*	*1154*	*1292*	*1421*	*1535*	*1666*
Imports	1304	1476	1437	1485	*1539*	*1664*	*1781*	*1870*	*1972*	*2091*
Federal Government	574	579	600	648	*704*	*749*	*761*	*764*	*771*	*778*
State & Local Governments	1113	1143	1168	1189	*1196*	*1209*	*1221*	*1245*	*1270*	*1296*
Gross Domestic Product	9268	9817	10101	10481	*10984*	*11674*	*13124*	*13853*	*14654*	*15210*
Real GDP (2000 Chain Weighted $)	9470	9817	9867	10083	*10397*	*10881*	*11283*	*11690*	*12122*	*12583*
PRICES AND WAGES-ANNUAL RATES OF CHANGE										
GDP Deflator	1.4	2.2	2.4	1.5	*1.6*	*1.3*	*1.5*	*2.0*	*2.2*	*2.4*
CPI-All Urban Consumers	2.2	3.4	2.8	1.6	*2.3*	*1.8*	*2.1*	*2.3*	*2.4*	*2.5*
PPI-Finished Goods	1.8	3.7	2.0	-1.3	*3.2*	*1.5*	*1.5*	*1.3*	*1.5*	*1.8*
Employment Cost Index—Total Comp.	3.2	4.6	4.1	3.8	*3.9*	*3.7*	*3.6*	*3.5*	*3.7*	*4.0*
Productivity	2.8	2.7	2.2	4.9	*4.2*	*3.0*	*2.0*	*2.0*	*2.3*	*2.5*
PRODUCTION AND OTHER KEY MEASURES										
Industrial Prod. (% Change)	4.4	4.4	-3.4	-0.6	*0.3*	*5.6*	*5.3*	*5.0*	*4.7*	*4.5*
Factory Operating Rate (%)	81.4	81.1	75.4	73.9	*73.4*	*76.3*	*78.0*	*79.0*	*80.0*	*81.0*
Nonfarm Inven. Chg. (2000 Chain Weighted $)	71.5	57.8	-36.3	9.3	*0.4*	*40.0*	*53.0*	*40.0*	*55.0*	*50.0*
Housing Starts (Mill. Units)	1.65	1.57	1.60	1.71	*1.85*	*1.89*	*1.73*	*1.72*	*1.73*	*1.75*
Existing House Sales (Mill. Units)	5.19	5.16	5.29	5.60	*6.10*	*6.16*	*6.05*	*6.02*	*6.02*	*6.05*
Total Light Vehicle Sales (Mill. Units)	16.9	17.4	17.1	16.8	*16.6*	*17.1*	*17.4*	*17.3*	*17.4*	*17.5*
National Unemployment Rate (%)	4.2	4.0	4.8	5.8	*6.0*	*5.6*	*5.5*	*5.4*	*5.3*	*5.2*
Federal Budget Surplus (Unified, FY, $Bill)	124.4	236.9	127.3	-158.5	*-374.2*	*-475.0*	*-425.0*	*-350.0*	*-250.0*	*-200.0*
Price of Oil ($Bbl., U.S. Refiners' Cost)	17.42	28.21	22.95	24.00	*28.62*	*28.50*	*28.00*	*27.50*	*27.00*	*26.00*
MONEY AND INTEREST RATES										
3-Month Treasury Bill Rate (%)	4.6	5.8	3.4	1.6	*1.0*	*1.3*	*2.4*	*2.5*	*2.7*	*3.0*
Federal Funds Rate (%)	5.0	6.2	3.9	1.7	*1.1*	*1.1*	*2.3*	*2.5*	*3.0*	*3.5*
10-Year Treasury Note Rate (%)	5.6	6.0	5.0	4.6	*4.0*	*4.5*	*5.3*	*5.6*	*5.8*	*6.0*
Long-Term Treasury Bond Rate (%)	5.9	5.9	5.5	5.4	*5.0*	*5.2*	*5.9*	*6.2*	*6.5*	*6.7*
AAA Corporate Bond Rate (%)	7.0	7.6	7.1	6.5	*5.7*	*5.8*	*6.7*	*6.9*	*7.0*	*7.2*
Prime Rate (%)	8.0	9.2	6.9	4.7	*4.1*	*4.1*	*5.2*	*5.5*	*6.0*	*6.5*
INCOMES										
Personal Income (% Change)	5.1	8.0	3.4	2.3	*3.1*	*4.8*	*5.5*	*5.5*	*5.6*	*5.7*
Real Disp. Inc. (% Change)	3.0	4.8	1.8	3.8	*2.5*	*3.8*	*3.1*	*3.2*	*3.0*	*3.0*
Personal Savings Rate (%)	2.4	2.4	1.7	2.3	*2.0*	*1.6*	*2.0*	*2.0*	*2.3*	*2.5*
Pretax Corporate Profits ($Bill)	776.0	773.0	694.0	665.0	*843.0*	*1082.0*	*1244.0*	*1393.0*	*1532.0*	*1686.0*
Aftertax Corporate Profits ($Bill)	517.0	508.0	496.0	550.0	*619.0*	*703.0*	*808.0*	*905.0*	*996.0*	*1096.0*
Yr-to-Yr % Change	10.1	-1.7	-2.5	11.0	*12.5*	*13.6*	*15.0*	*12.0*	*10.0*	*10.0*
COMPOSITION OF REAL GDP-ANNUAL RATES OF CHANGE										
Gross Domestic Product	4.4	3.7	0.5	2.2	*3.1*	*4.7*	*3.7*	*3.6*	*3.7*	*3.8*
Final Sales	4.5	3.8	1.4	1.8	*3.2*	*4.3*	*3.5*	*3.7*	*3.5*	*3.7*
Total Consumption	5.1	4.7	2.5	3.4	*3.1*	*3.6*	*3.5*	*3.4*	*3.2*	*3.2*
Nonresidential Fixed Investment	9.2	8.7	-4.5	-7.1	*2.7*	*9.2*	*9.0*	*7.0*	*7.0*	*7.0*
Construction	-0.4	6.8	-2.6	-18.4	*-4.8*	*0.1*	*8.0*	*6.0*	*7.0*	*8.0*
Equipment & Software	12.7	9.4	-5.2	-2.8	*5.2*	*11.3*	*9.0*	*7.0*	*8.0*	*9.0*
Residential Fixed Investment	6.0	0.7	0.2	4.9	*7.7*	*6.4*	*-2.0*	*1.0*	*2.0*	*3.0*
Exports	4.3	8.7	-5.2	-2.4	*2.0*	*11.6*	*12.0*	*10.0*	*8.0*	*8.5*
Imports	11.5	13.2	-2.6	3.3	*3.6*	*8.1*	*7.0*	*5.0*	*5.5*	*6.0*
Federal Government	2.2	0.9	3.6	8.0	*8.6*	*6.4*	*1.5*	*0.5*	*0.8*	*1.0*
State & Local Governments	4.7	2.7	2.2	1.8	*0.6*	*1.1*	*1.0*	*2.0*	*2.0*	*2.0*

The Budget and Economic Outlook:
Fiscal Years 2005 to 2014

January 2004



SEC. 257. [2 U.S.C. 907] THE BASELINE.
(a) IN GENERAL.—For any budget year, the baseline refers to a projection of current-year levels of new budget authority, outlays, revenues, and the surplus or deficit into the budget year and the outyears based on laws enacted through the applicable date.
(b) DIRECT SPENDING AND RECEIPTS.—For the budget year and each outyear, the baseline shall be calculated using the following assumptions:

(1) IN GENERAL.—Laws providing or creating direct spending and receipts are assumed to operate in the manner specified in those laws for each such year and funding for entitlement authority is assumed to be adequate to make all payments required by those laws.
(2) EXCEPTIONS.—(A)(i) No program established by a law enacted on or before the date of enactment of the Balanced Budget Act of 1997 with estimated current year outlays greater than $50 000 000 shall be assumed to expire in the budget year or the outyears The scoring of new programs with estimated outlays greater than $50 000 000 a year shall be based on scoring by the Committees on Budget or OMB as applicable OMB CBO and the Budget Committees shall consult on the scoring
h programs where there are differences between CBO

APPENDIX

E

CBO's Economic Projections for 2004 Through 2014

Year-by-year economic projections for 2004 through 2014 are shown in the accompanying tables *(by calendar year in Table E-1 and by fiscal year in Table E-2).* The Congressional Budget Office did not try to explicitly incorporate cyclical fluctuations into its projections for years after 2005. Instead, the projected values shown here for 2006 through 2014 reflect CBO's assessment of average values for that period—which take into account potential ups and downs in the business cycle.

Table E-1.

CBO's Year-by-Year Forecast and Projections for Calendar Years 2004 Through 2014

	Estimated	Forecast		Projected								
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Nominal GDP (Billions of dollars)	10,980	11,629	12,243	12,814	13,389	14,023	14,686	15,354	16,034	16,743	17,490	18,266
Nominal GDP (Percentage change)	4.8	5.9	5.3	4.7	4.5	4.7	4.7	4.5	4.4	4.4	4.5	4.4
Real GDP (Percentage change)	3.2	4.8	4.2	3.2	2.7	2.8	2.8	2.6	2.5	2.5	2.5	2.5
GDP Price Index (Percentage change)	1.6	1.1	1.1	1.5	1.8	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Consumer Price Index[a] (Percentage change)	2.3	1.6	1.7	2.0	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Employment Cost Index[b] (Percentage change)	2.9	2.4	2.5	2.7	3.2	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Unemployment Rate (Percent)	6.0	5.8	5.3	5.0	5.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2
Three-Month Treasury Bill Rate (Percent)	1.0	1.3	3.0	4.0	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6
Ten-Year Treasury Note Rate (Percent)	4.0	4.6	5.4	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Tax Bases (Billions of dollars)												
Corporate book profits	844	948	1,319	1,358	1,356	1,356	1,359	1,393	1,451	1,516	1,587	1,670
Wages and salaries	5,087	5,333	5,639	5,926	6,208	6,511	6,823	7,134	7,449	7,777	8,120	8,476
Tax Bases (Percentage of GDP)												
Corporate book profits	7.7	8.1	10.8	10.6	10.1	9.7	9.3	9.1	9.0	9.1	9.1	9.1
Wages and salaries	46.3	45.9	46.1	46.2	46.4	46.4	46.5	46.5	46.5	46.4	46.4	46.4

Sources: Congressional Budget Office; Department of Commerce, Bureau of Economic Analysis; Department of Labor, Bureau of Labor Statistics; Federal Reserve Board.

Note: Percentage change is year over year.

a. The consumer price index for all urban consumers.

b. The employment cost index for wages and salaries only, private-industry workers.

Table E-2.

CBO's Year-by-Year Forecast and Projections for Fiscal Years 2004 Through 2014

	Estimated	Forecast		Projected								
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Nominal GDP (Billions of dollars)	10,829	11,469	12,091	12,682	13,236	13,862	14,519	15,187	15,862	16,562	17,301	18,070
Nominal GDP (Percentage change)	4.4	5.9	5.4	4.9	4.4	4.7	4.7	4.6	4.4	4.4	4.5	4.4
Real GDP (Percentage change)	2.8	4.7	4.3	3.5	2.6	2.8	2.8	2.7	2.5	2.5	2.5	2.5
GDP Price Index (Percentage change)	1.5	1.2	1.1	1.3	1.7	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Consumer Price Index[a] (Percentage change)	2.4	1.7	1.6	2.0	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Employment Cost Index[b] (Percentage change)	2.8	2.5	2.5	2.6	3.1	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Unemployment Rate (Percent)	6.0	5.9	5.4	5.0	5.1	5.2	5.2	5.2	5.2	5.2	5.2	5.2
Three-Month Treasury Bill Rate (Percent)	1.1	1.1	2.6	3.8	4.5	4.6	4.6	4.6	4.6	4.6	4.6	4.6
Ten-Year Treasury Note Rate (Percent)	3.9	4.5	5.3	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
Tax Bases (Billions of dollars)												
Corporate book profits	819	938	1,215	1,353	1,354	1,358	1,357	1,382	1,435	1,500	1,569	1,645
Wages and salaries	5,051	5,257	5,563	5,859	6,134	6,435	6,744	7,057	7,370	7,693	8,033	8,386
Tax Bases (Percentage of GDP)												
Corporate book profits	7.6	8.2	10.0	10.7	10.2	9.8	9.3	9.1	9.0	9.1	9.1	9.1
Wages and salaries	46.6	45.8	46	46.2	46.3	46.4	46.5	46.5	46.5	46.5	46.4	46.4

Sources: Congressional Budget Office; Department of Commerce, Bureau of Economic Analysis; Department of Labor, Bureau of Labor Statistics; Federal Reserve Board.

Note: Percentage change is year over year.

a. The consumer price index for all urban consumers.

b. The employment cost index for wages and salaries only, private-industry workers.

COMMONWEALTH OF KENTUCKY

BEFORE THE PUBLIC SERVICE COMMISSION

In the Matter of:

AN ADJUSTMENT OF THE ELECTRIC)
RATES, TERMS AND CONDITIONS OF) CASE NO. 2003-00434
KENTUCKY UTILITIES COMPANY)

DIRECT TESTIMONY AND EXHIBITS OF MICHAEL J. MAJOROS, JR.

(REVENUE REQUIREMENTS)

On Behalf of the Office Of Rate Intervention Of The
Attorney General Of The Commonwealth Of Kentucky

March 23, 2004

Q. WHY DOES THE ASSET VALUE OF THE PENSION AND OPEB FUNDS CREATE VOLATILITY IN THESE COSTS?

A. The change in the asset value is reflected in the return on the assets because part of that return is capital gain or loss. This return is a direct offset to all of the other pension costs. Also, changes in the asset value of the pension fund affect the differential between that value and the present value of the ABO. If the asset value falls, that differential increases.

Q. WHAT IS THE LIKELY FUTURE TREND IN INTEREST RATES?

A. Interest rates on high-grade corporate bonds are currently at a 37-year low.[4] Given the size of both the Federal budget deficit and the national trade deficit, it is unlikely that these very low interest rates can continue indefinitely into the future. On December 9, 2003, the economic research firm Macroeconomic Advisors released its 10-year forecasts of national product, income, inflation and interest rates. It forecasts a slow but steady increase in interest rates throughout the coming decade, as follows:[5]

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[4] See http://www.federalreserve.gov/releases/h15/data/m/aaa.txt

[5] Macroeconomic Advisers, LLC, "Long-Term Economic Outlook", December 9, 2003.

		Bond Yields
Bonds	10-year Treasury Bonds	Aaa Corporate
2003	4.01%	5.66%
2004	4.56%	5.74%
2005	5.27%	6.36%
2006	5.75%	6.84%
2007	5.86%	6.95%
2008	5.97%	7.06%
2009	6.01%	7.10%
2010	6.09%	7.18%
2011	6.11%	7.20%
2012	6.14%	7.23%

Q. WHAT IS THE LIKELY TREND IN THE VALUE OF KU'S PENSION AND OPEB FUND ASSETS?

A. During the coming years, that value will probably increase. That is because most companies do not fully revalue their pension assets each year. Rather, they use a "smoothing" technique in which only one-third of each year's gain or loss is recognized in calculating the capital gains or losses in the funds' asset values. The remaining two-thirds are amortized into the revaluation over the next two years.

As everyone knows, returns on both equity and debt investments were poor during the years 2001 and 2002. If KU uses the three-year smoothing technique, then the poor returns of those years will be recognized in the return calculations only over the next two years. If the markets continue to improve, as they have over the past year, then the asset value of KU's pension funds should increase, which will increase the returns and narrow the gap between those funds' values and the ABOs.

Attorney General's Response to
The Requests for Information of
Louisville Gas & Electric Company
Case No. 2003-00433

WITNESS RESPONSIBLE:
Michael J. Majoros, Jr.

3. **Please provide a copy of the entire Macroeconomic Advisors Report cited in footnote 5 on page 13 of the Testimony of Michael J. Majoros.**

Response:

There is no reference to this document in the testimony Mr. Majoros has filed in Case No. 2003-00433. However, Mr. Majoros does reference the document in his testimony regarding Case No. 2003-00434. This document is protected under copyright and as such cannot be provided as requested. The CD labeled Majoros Attachments contains a folder labeled Response to LG&E 3 containing the page on which the referenced figures appears, with the remainder of the page redacted.

Table 1

MA Long-Term Forecast, 2003 Fourth Quarter: 2003-2012

The Long-Term Forecast in Summary

	YEAR OVER YEAR % CHANGE OR ANNUAL AVERAGE												AVERAGE
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2003-2012
– INDICATORS OF REAL ACTIVITY													
Real Chain-Type GDP													
Utilization Rate in Mfg (%)													
Unemployment Rate (%)													
GDP Chain-Type Price Index													
Consumer Price Index													
35 Country Exchange Rate (Index)													
Price of Imported Oil ($/b)													
Compensation per Hour													
Output per Hour													
Money Stock: M1													
Prime Lending Rate (%)													
90-Day T-Bill Rate (%)													
Yield on 10-Year T-Notes (%)	5.0	4.6	4.0	4.6	5.3	5.8	5.9	6.0	6.0	6.1	6.1	6.1	5.6
Yield on AAA Corp Bonds (%)	7.1	6.5	5.7	5.7	6.4	6.8	7.0	7.1	7.1	7.2	7.2	7.2	6.7
Expected Inflation (%)													
Real Disposable Personal Income													
Corporate Profits After Tax													
Federal Surplus/Deficit (FY-UNI, Bil)													
Potential GDP, Total Economy													
Potential GDP, Pvt Nonfarm Business													
= Contribution of TFP													
+ Contribution of Labor Inputs													
+ Conribution of Capital Inputs													

BLUE CHIP ECONOMIC INDICATORS

Top Analysts' Forecasts of the U.S. Economic Outlook For The Year Ahead

Vol. 29, No. 3 March 10, 2004

ASPEN

Long-Range Consensus U.S. Economic Projections

I. The table below shows the latest U.S. Blue Chip Consensus[1] projections by years for 2006 through 2010, an average for the five-year perio 2006-2010, and an average for the next five-year period 2011-2015. There are also Top 10 and Bottom 10 averages for each variable. Apply these projections cautiously. The vast majority of economic and political forces cannot be evaluated over such a long time span.

		YEAR					**Five-Year Averages**	
ECONOMIC VARIABLE		**2006**	**2007**	**2008**	**2009**	**2010**	**2006-10**	**2011-15**
		Percent Change, Full Year-Over-Prior Year						
1. Real GDP (chained, 2000 dollars)	**CONSENSUS**	**3.4**	**3.2**	**3.1**	**3.1**	**3.2**	**3.2**	**3:1**
	Top 10 Avg.	3.9	3.8	3.6	3.6	3.7	3.7	3.4
	Bottom 10 Avg.	2.7	2.5	2.6	2.6	2.8	2.6	2.7
2. GDP Chained Price Index	**CONSENSUS**	**1.9**	**1.9**	**2.0**	**2.1**	**2.2**	**2.0**	**2.2**
	Top 10 Avg.	2.5	2.4	2.5	2.5	2.7	2.5	2.7
	Bottom 10 Avg.	1.4	1.5	1.6	1.6	1.7	1.5	1.9
3. Nominal GDP (current dollars)	**CONSENSUS**	**5.3**	**5.2**	**5.2**	**5.2**	**5.4**	**5.3**	**5.4**
	Top 10 Avg.	5.9	5.9	6.0	6.0	6.2	6.0	6.1
	Bottom 10 Avg.	4.7	4.5	4.4	4.5	4.8	4.6	4.8
4. Consumer Price Index (for all urban consumers)	**CONSENSUS**	**2.2**	**2.3**	**2.3**	**2.4**	**2.4**	**2.3**	**2.5**
	Top 10 Avg.	2.9	2.8	3.0	3.1	3.1	3.0	3.1
	Bottom 10 Avg.	1.5	1.7	1.7	1.8	1.9	1.7	2.0
5. Industrial Production (total)	**CONSENSUS**	**4.0**	**3.7**	**3.6**	**3.5**	**3.7**	**3.7**	**3.6**
	Top 10 Avg.	5.2	4.7	4.4	4.3	4.5	4.6	4.2
	Bottom 10 Avg.	2.8	2.6	2.8	2.6	3.0	2.8	2.9
6. Disposable Personal Income (chained, 2000 dollars)	**CONSENSUS**	**3.4**	**3.3**	**3.2**	**3.2**	**3.2**	**3.3**	**3.4**
	Top 10 Avg.	4.2	4.1	3.9	4.0	4.0	4.0	4.6
	Bottom 10 Avg.	2.8	2.5	2.5	2.6	2.5	2.6	2.6
7. Personal Consumption Expenditures (chained, 2000 dollars)	**CONSENSUS**	**3.1**	**3.0**	**2.9**	**3.0**	**3.0**	**3.0**	**2.9**
	Top 10 Avg.	3.5	3.4	3.2	3.4	3.5	3.4	3.3
	Bottom 10 Avg.	2.6	2.5	2.4	2.5	2.5	2.5	2.5
8. Non-Residential Fixed Investment (chained, 2000 dollars)	**CONSENSUS**	**6.6**	**6.0**	**5.4**	**5.2**	**5.7**	**5.8**	**5.5**
	Top 10 Avg.	8.9	8.1	7.8	7.7	8.1	8.1	7.6
	Bottom 10 Avg.	4.2	3.5	2.6	2.6	3.7	3.3	3.6
9. Corporate Profits. Pretax (current dollars)	**CONSENSUS**	**7.3**	**6.8**	**5.7**	**5.7**	**6.8**	**6.4**	**6.7**
	Top 10 Avg.	11.7	10.5	9.8	8.8	9.8	10.1	8.7
	Bottom 10 Avg.	3.9	4.0	0.4	1.4	3.5	2.6	5.0
		Annual Average						
10. Treasury Bills, 3-Month (percent per annum)	**CONSENSUS**	**3.4**	**3.7**	**3.9**	**4.1**	**4.3**	**3.9**	**4.3**
	Top 10 Avg.	4.3	4.6	4.9	5.2	5.4	4.9	5.2
	Bottom 10 Avg.	2.5	2.7	2.8	2.8	3.1	2.8	3.3
11. Treasury Notes, 10-Year (yield per annum)	**CONSENSUS**	**5.5**	**5.5**	**5.4**	**5.7**	**5.7**	**5.6**	**5.7**
	Top 10 Avg.	6.2	6.2	6.3	6.5	6.5	6.3	6.5
	Bottom 10 Avg.	4.9	4.9	4.5	4.9	4.9	4.8	5.0
12. Unemployment Rate (% of civilian labor force)	**CONSENSUS**	**5.2**	**5.2**	**5.2**	**5.2**	**5.2**	**5.2**	**5.1**
	Top 10 Avg.	5.6	5.7	5.6	5.7	5.7	5.7	5.6
	Bottom 10 Avg.	4.9	4.8	4.7	4.7	4.7	4.7	4.7
		Total Units, Millions						
13. Housing Starts (millions of units)	**CONSENSUS**	**1.67**	**1.66**	**1.68**	**1.66**	**1.70**	**1.67**	**1.70**
	Top 10 Avg.	1.84	1.85	1.85	1.85	1.86	1.85	1.88
	Bottom 10 Avg.	1.55	1.44	1.52	1.46	1.59	1.51	1.58
14. Total Auto & Truck Sales (millions of units)	**CONSENSUS**	**16.9**	**16.9**	**17.0**	**17.1**	**17.2**	**17.0**	**17.4**
	Top 10 Avg.	17.8	17.9	18.0	18.1	18.3	18.0	18.6
	Bottom 10 Avg.	16.1	16.0	16.0	16.1	16.1	16.1	16.2
		Billions of Chained, 1996 Dollars						
15. Net Exports (billions of chained, 2000 dollars)	**CONSENSUS**	**-472.8**	**-454.1**	**-432.2**	**-418.8**	**-401.3**	**-435.8**	**-390.4**
	Top 10 Avg.	-407.0	-373.2	-323.4	-284.5	-255.3	-328.7	-208.6
	Bottom 10 Avg.	-542.2	-532.8	-541.6	-550.5	-547.3	-542.9	-546.2

COMMONWEALTH OF KENTUCKY

BEFORE THE PUBLIC SERVICE COMMISSION

In the Matter of:

AN ADJUSTMENT OF THE GAS AND ELECTRIC)
RATES, TERMS, AND CONDITIONS OF) CASE NO.
LOUISVILLE GAS AND ELECTRIC COMPANY) 2003-00433

KENTUCKY INDUSTRIAL UTILITY CUSTOMERS, INC.
RESPONSE TO
COMMISSION STAFF'S FIRST DATA REQUEST

12. Refer to the Baudino Testimony, page 11. Mr. Baudino states that he performed a Capital Asset Pricing Model ("CAPM") analysis, but did not incorporate the results into his recommendation. Explain why Mr. Baudino performed the analysis if he did not use it in his recommendation.

RESPONSE:

Mr. Baudino provided a CAPM analysis to provide additional information on how the cost of equity may be estimated. The CAPM is a widely used method of estimating the cost of equity and can provide general insights on current economic conditions and their impact on the investor-required rate of return. However, Mr. Baudino also believes that the DCF is a better method of estimating the cost of equity at this time.

Responses of the Attorney General's Witness
Carl G. K. Weaver to
Commonwealth of Kentucky PSC Case No. 2003-00334
And Case No. 2003-00335
Louisville Gas and Electric Company's and Kentucky Utilities Company's Initial Requests for Information

13. In reference to Dr. Weaver's statement at page 42, lines 14-16 that the DCF constant growth model has greater use by participants in the capital market than the multi-stage DCF or the bond-yield-risk premium models:

a. Provide all studies, documents, surveys, etc. relied upon by Dr. Weaver in making this statement.

b. Does Dr. Weaver claim that the DCF constant growth model has greater use by participants in the capital market than the CAPM method? If so, provide all studies documents, surveys, etc. relied upon by Dr. Weaver to support this contention.

Answer:

a. I reached this conclusion based upon my experience teaching finance courses in managerial finance and in capital markets analysis. The multi-stage DCF and bond-yield-risk premium models are not covered as well in financial text books as are the constant growth DCF and the CAPM models. A great deal of the financial literature that deals with cost of equity analysis deals with the CAPM model.

b. No.

							DCF Cost of Equity Using:				
	6-mo div yld avg (1)	VL DPS (2)	VL EPS (3)	Zacks (4)	VL BxR (5)	Avg of All Gr Rates	VL DPS (6)	VL EPS (7)	Zacks (8)	VL BxR (9)	Avg (10)
Alliant Energy	4.16	-9.71	-1.04	5.00	3.13	-0.66	-5.75	3.10	9.26	7.36	3.49
Ameren	5.67	0.62	0.87	3.00	2.27	1.69	6.31	6.56	8.76	8.00	7.41
CH Energy Group	4.77	0.00	0.49	NA	1.82	0.77	4.77	5.27	NA	6.63	5.56
Consolidated Edison	5.41	0.88	-0.04	3.00	2.21	1.51	6.31	5.37	8.49	7.68	6.96
DTE Energy	5.47	0.39	5.49	5.00	5.31	4.05	5.87	11.11	10.61	10.93	9.63
Exelon	3.22	6.25	5.88	5.00	9.39	6.63	9.57	9.19	8.30	12.76	9.96
MGE Energy	4.27	0.59	5.20	NA	4.64	3.48	4.87	9.58	NA	9.01	7.82
NStar	4.58	2.78	3.00	4.00	4.88	3.67	7.42	7.65	8.67	9.57	8.33
Pinnacle West Capital	4.73	5.50	1.09	5.00	3.55	3.79	10.36	5.85	9.85	8.36	8.60
SCANA	4.02	5.22	5.60	4.00	5.43	5.06	9.34	9.73	8.10	9.56	9.18
Southern Company	4.74	3.36	5.18	5.00	4.63	4.54	8.18	10.04	9.86	9.48	9.39
Vectren	4.70	3.49	7.31	6.00	4.38	5.30	8.27	12.18	10.84	9.18	10.12
Wisconsin Energy	2.49	4.56	7.86	7.00	6.36	6.45	7.11	10.45	9.58	8.93	9.02
Average	4.48	1.84	3.61	4.73	4.46	3.56	6.36	8.16	9.30	9.03	8.11
Median	4.70	2.78	5.18	5.00	4.63	3.79	7.11	9.19	9.26	9.01	8.60

Source:

	6-mo div yld avg (1)	VL DPS (2)	VL EPS (3)	Zacks (4)	VL BxR (5)	Avg of All Gr Rates	DCF Cost of Equity Using:				
							VL DPS (6)	VL EPS (7)	Zacks (8)	VL BxR (9)	Avg (10)
AGL Resources	3.92	0.73	6.56	5.00	5.78	4.52	4.66	10.61	9.02	9.81	8.53
Atmos Energy	4.89	2.27	7.22	6.00	4.25	4.94	7.22	12.29	11.04	9.24	9.95
KeySpan	4.99	1.31	7.07	6.00	5.09	4.87	6.33	12.24	11.14	10.21	9.98
Laclede Group	4.68	0.44	5.85	4.00	3.12	3.35	5.13	10.67	8.77	7.87	8.11
Northwest Natural Gas	4.29	1.69	4.90	4.00	4.17	3.69	6.02	9.30	8.38	8.55	8.06
Peoples Energy	5.10	1.59	4.20	4.00	4.74	3.63	6.73	9.41	9.20	9.96	8.83
Average	4.65	1.34	5.97	4.83	4.53	4.17	6.01	10.75	9.59	9.27	8.91
Median	4.79	1.45	6.21	4.50	4.50	4.10	6.17	10.64	9.11	9.53	8.68

Source:

	DCF Medians	
	13 cos	10 cos
GDP	10.77	10.72
Sustain	9.53	10.94
Ind	10.27	10.21
beta	0.65	0.65

LGE ELECTRIC 2003.336/Sch 3 DCF GDP p1

DCF COST OF EQUITY CALCULATION FOR THE COMPARISON GROUP

			Near-Term Projected EPS Growth				
Company	6-Month Average Price	Indicated Dividend	Value Line Projected 5-Year Growth	First Call Projected 5-Year Growth	Average: Value Line and First Call [(3)+(4)]/2	Long-Term Projected Growth in GDP	DCF Cost of Equity Estimate
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Alliant Energy	$19.59	$1.00	5.0 %	4.8 %	4.9 %	5.91 %	11.1 %
Ameren	42.73	2.54	1.0	3.0	2.0	5.91	11.2
CH Energy Group	43.85	2.16	1.5	na	1.5	5.91	10.2
Consolidated Edison	40.82	2.24	1.0	3.0	2.0	5.91	10.8
DTE Energy	38.55	2.06	5.5	5.5	5.5	5.91	11.5
Exelon	57.33	1.92	7.0	5.0	6.0	5.91	9.5
MGE Energy	30.81	1.35	6.0	na	6.0	5.91	10.6
NSTAR	44.82	2.16	3.5	6.0	4.8	5.91	10.8
Pinnacle West	35.35	1.70	0.5	5.0	2.8	5.91	10.4
SCANA	33.20	1.38	5.0	5.0	5.0	5.91	10.1
Southern Company	29.35	1.38	6.5	5.0	5.8	5.91	10.9
Vectren	23.60	1.10	9.0	7.0	8.0	5.91	11.3
Wisconsin Energy	27.95	0.80	8.0	6.5	7.3	5.91	9.1
Median							10.8 %

NA --Not available.

Source: Col. (1) - Schedule 2.
Col. (2) - Derived from data on the MSN Money Central website.
Col. (3) - Derived from data in *The Value Line Investment Survey*.
Col. (4) - First Call website.
Col. (6) - Derived from data in Energy Information Administration Annual Energy Outlook, 2003.
Col. (7) - Derived iteration using an internal rate of return calculation.

LGE ELECTRIC 2003.336/Sch 3 DCF GDP p1

DCF COST OF EQUITY CALCULATION FOR THE COMPARISON GROUP

			Near-Term Projected EPS Growth				
Company	6-Month Average Price	Indicated Dividend	Value Line Projected 5-Year Growth	First Call Projected 5-Year Growth	Average: Value Line and First Call [(3)+(4)]/2	Long-Term Projected Growth in GDP	DCF Cost of Equity Estimate
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Alliant Energy	$19.59	$1.00	5.0 %	4.8 %	4.9 %	5.91 %	11.1 %
Ameren	42.73	2.54	1.0	3.0	2.0	5.91	11.2
DTE Energy	38.56	2.06	5.5	5.5	5.5	5.91	11.5
Exelon	57.33	1.92	7.0	5.0	6.0	5.91	9.5
MGE Energy	30.81	1.35	6.0	na	6.0	5.91	10.6
Pinnacle West	35.35	1.70	0.5	5.0	2.8	5.91	10.4
SCANA	33.20	1.38	5.0	5.0	5.0	5.91	10.1
Southern Company	29.35	1.38	6.5	5.0	5.8	5.91	10.9
Vectren	23.60	1.10	9.0	7.0	8.0	5.91	11.3
Wisconsin Energy	27.95	0.80	8.0	6.5	7.3	5.91	9.1
Median							10.7 %

NA --Not available.

Source: Col. (1) - Schedule 2.
Col. (2) - Derived from data on the MSN Money Central website.
Col. (3) - Derived from data in *The Value Line Investment Survey*.
Col. (4) - First Call website.
Col. (6) - Derived from data in Energy Information Administration Annual Energy Outlook, 2003.
Col. (7) - Derived iteration using an internal rate of return calculation.

LGE Electric 2003.336/Sch 3 DCF Sustainable p2

DCF COST OF EQUITY CALCULATION FOR THE COMPARISON GROUP

			Near-Term Projected EPS Growth				
Company	6-Month Average Price	Indicated Dividend	Value Line Projected 5-Year Growth	First Call Projected 5-Year Growth	Average: Value Line and First Call [(3)+(4)]/2	Long-Term Projected Sustainable Growth	DCF Cost of Equity Estimate
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Alliant Energy	$19.59	$1.00	5.0 %	4.8 %	4.9 %	3.0 %	8.7 %
Ameren	42.73	2.54	1.0	3.0	2.0	3.7	9.4
CH Energy Group	43.85	2.16	1.5	na	1.5	1.9	6.8
Consolidated Edison	40.82	2.24	1.0	3.0	2.0	3.4	8.7
DTE Energy	38.55	2.06	5.5	5.5	5.5	6.3	11.8
Exelon	57.33	1.92	7.0	5.0	6.0	13.0	15.8
MGE Energy	30.81	1.35	6.0	na	6.0	8.6	12.9
NSTAR	44.82	2.16	3.5	6.0	4.8	4.4	9.5
Pinnacle West	35.35	1.70	0.5	5.0	2.8	3.4	8.2
SCANA	33.20	1.38	5.0	5.0	5.0	5.2	9.5
Southern Company	29.35	1.38	6.5	5.0	5.8	7.1	11.9
Vectren	23.60	1.10	9.0	7.0	8.0	6.8	12.0
Wisconsin Energy	27.95	0.80	8.0	6.5	7.3	7.0	10.1

Median	9.5 %
Median excluding CH Energy	9.8 %

NA --Not available.

Source:
Col. (1) - Schedule 2.
Col. (2) - Derived from data on the MSN Money Central website.
Col. (3)&(6) - Derived from data in *The Value Line Investment Survey*.
Col. (4) - First Call website.
Col. (7) - Derived iteration using an internal rate of return calculation.

LGE Electric 2003.336/Sch 3 DCF Sustainable p2

DCF COST OF EQUITY CALCULATION FOR THE COMPARISON GROUP

			Near-Term Projected EPS Growth				
Company	6-Month Average Price	Indicated Dividend	Value Line Projected 5-Year Growth	First Call Projected 5-Year Growth	Average: Value Line and First Call [(3)+(4)]/2	Long-Term Projected Sustainable Growth	DCF Cost of Equity Estimate
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Alliant Energy	$19.59	$1.00	5.0 %	4.8 %	4.9 %	3.0 %	8.7 %
Ameren	42.73	2.54	1.0	3.0	2.0	3.7	9.4
DTE Energy	38.55	2.06	5.5	5.5	5.5	6.3	11.8
Exelon	57.33	1.92	7.0	5.0	6.0	13.0	15.8
MGE Energy	30.81	1.35	6.0	na	6.0	8.6	12.9
Pinnacle West	35.35	1.70	0.5	5.0	2.8	3.4	8.2
SCANA	33.20	1.38	5.0	5.0	5.0	5.2	9.5
Southern Company	29.35	1.38	6.5	5.0	5.8	7.1	11.9
Vectren	23.60	1.10	9.0	7.0	8.0	6.8	12.0
Wisconsin Energy	27.95	0.80	8.0	6.5	7.3	7.0	10.1
Median							10.9 %
Median excluding CH Energy							10.9 %

NA --Not available.

Source:
- Col. (1) - Schedule 2.
- Col. (2) - Derived from data on the MSN Money Central website.
- Col. (3)&(6) - Derived from data in *The Value Line Investment Survey*.
- Col. (4) - First Call website.
- Col. (7) - Derived iteration using an internal rate of return calculation.

LGE Electric 2003.336/Sch DCF Industry p3

DCF COST OF EQUITY CALCULATION FOR THE COMPARISON GROUP

Company	6-Month Average Price	Indicated Dividend	Near-Term Projected EPS Growth: Value Line Projected 5-Year Growth	First Call Projected 5-Year Growth	Average: Value Line and First Call [(3)+(4)]/2	Long-Term Projected Industry Growth	DCF Cost of Equity Estimate
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Alliant Energy	$19.59	$1.00	5.0 %	4.8 %	4.9 %	5.3 %	10.6 %
Ameren	42.73	2.54	1.0	3.0	2.0	5.3	10.7
CH Energy Group	43.85	2.16	1.5	na	1.5	5.3	9.7
Consolidated Edison	40.82	2.24	1.0	3.0	2.0	5.3	10.3
DTE Energy	38.55	2.06	5.5	5.5	5.5	5.3	11.0
Exelon	57.33	1.92	7.0	5.0	6.0	5.3	8.9
MGE Energy	30.81	1.35	6.0	na	6.0	5.3	10.1
NSTAR	44.82	2.16	3.5	6.0	4.8	5.3	10.3
Pinnacle West	35.35	1.70	0.5	5.0	2.8	5.3	9.8
SCANA	33.20	1.38	5.0	5.0	5.0	5.3	9.6
Southern Company	29.35	1.38	6.5	5.0	5.8	5.3	10.4
Vectren	23.60	1.10	9.0	7.0	8.0	5.3	10.8
Wisconsin Energy	27.95	0.80	8.0	6.5	7.3	5.3	8.6
Median							10.3 %

NA --Not available.

Source: Col. (1) - Schedule 2.
Col. (2) - Derived from data on the MSN Money Central website.
Col. (3) - Derived from data in *The Value Line Investment Survey*.
Col. (4) - First Call website.
Col. (6) - See text.
Col. (7) - Derived iteration using an internal rate of return calculation.

LGE Electric 2003.336/Sch DCF Industry p3

DCF COST OF EQUITY CALCULATION FOR THE COMPARISON GROUP

			Near-Term Projected EPS Growth				
Company	6-Month Average Price	Indicated Dividend	Value Line Projected 5-Year Growth	First Call Projected 5-Year Growth	Average: Value Line and First Call [(3)+(4)]/2	Long-Term Projected Industry Growth	DCF Cost of Equity Estimate
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Alliant Energy	$19.59	$1.00	5.0 %	4.8 %	4.9 %	5.3 %	10.6 %
Ameren	42.73	2.54	1.0	3.0	2.0	5.3	10.7
DTE Energy	38.56	2.06	5.5	5.5	5.5	5.3	11.0
Exelon	57.33	1.92	7.0	5.0	6.0	5.3	8.9
MGE Energy	30.81	1.35	6.0	na	6.0	5.3	10.1
Pinnacle West	35.35	1.70	0.5	5.0	2.8	5.3	9.8
SCANA	33.20	1.38	5.0	5.0	5.0	5.3	9.6
Southern Company	29.35	1.38	6.5	5.0	5.8	5.3	10.4
Vectren	23.60	1.10	9.0	7.0	8.0	5.3	10.8
Wisconsin Energy	27.95	0.80	8.0	6.5	7.3	5.3	8.6
Median							10.2 %

NA –Not available.

Source:
Col. (1) - Schedule 2.
Col. (2) - Derived from data on the MSN Money Central website.
Col. (3) - Derived from data in *The Value Line Investment Survey*.
Col. (4) - First Call website.
Col. (6) - See text.
Col. (7) - Derived iteration using an internal rate of return calculation.

	Beta
Alliant Energy	0.70
Ameren	0.65
CH Energy	0.70
Consolidated Edison	0.55
DTE	0.60
Exelon	0.70
MGE Energy	0.55
N Star	0.65
Pinnacle West	0.70
SCANA	0.60
Southern Company	0.65
Vectren	0.75
Wisconsin Energy	0.60
Average	0.65
Median	0.65

VL Aug 15, Jul 4 and Sept 5 2003.

	Beta
Alliant Energy	0.70
Ameren	0.65
DTE	0.60
Exelon	0.70
MGE Energy	0.55
Pinnacle West	0.70
SCANA	0.60
Southern Company	0.65
Vectren	0.75
Wisconsin Energy	0.60
Average	0.65
Median	0.65

VL Aug 15, Jul 4 and Sept 5 2003.

Hypothetical re Present Value of a Perpetuity

	1	1.04				
		Full IRR		Brief IRR		Weaver IRR
	-10	14.4000%	-10	14.400%	-10	14.141%
1	1.04		1.04		1.04	
2	1.0816		1.0816		1.0816	
3	1.124864		1.124864		1.124864	
4	1.169859		1.169859		1.169859	
5	1.216653		1.216653		1.216653	
6	1.265319		1.265319		1.265319	
7	1.315932		1.315932		1.315932	
8	1.368569		1.368569		1.368569	
9	1.423312		1.423312		1.423312	
10	1.480244		1.480244		1.480244	
11	1.539454		1.539454		1.539454	
12	1.601032		1.601032		1.601032	
13	1.665074		1.665074		1.665074	
14	1.731676		1.731676		1.731676	
15	1.800944		1.800944		1.800944	
16	1.872981		1.872981		1.872981	
17	1.9479		1.9479		1.9479	
18	2.025817		2.025817		2.025817	
19	2.106849		2.106849		2.106849	
20	2.191123		24.10235		21.06849	
	2.278768		▲		▲	
	2.369919		Price +		Price only	
	2.464716		Div	P 21.91123	(1 yr too late)	
	2.563304					
	2.665836					

Ninth Edition

FINANCIAL MANAGEMENT

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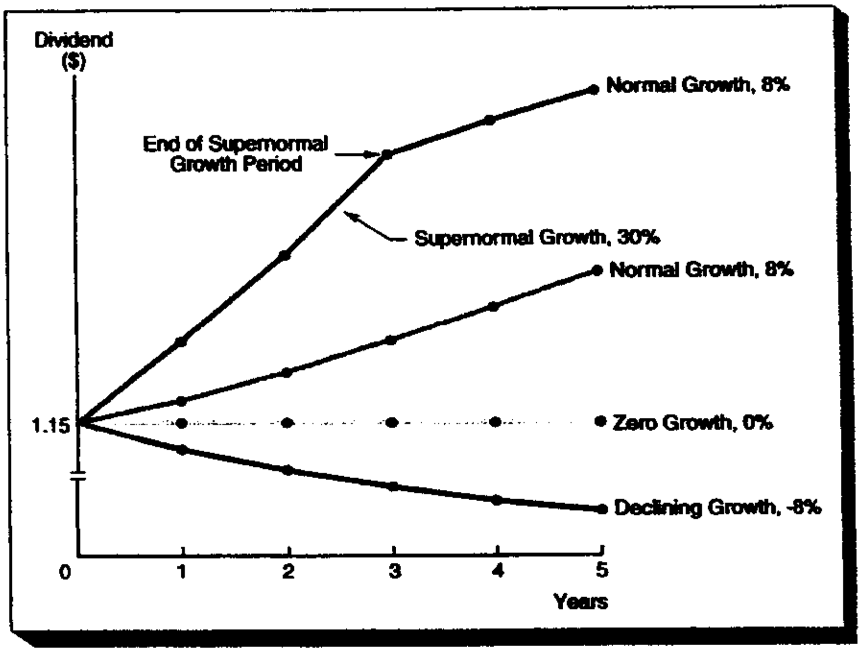
FIGURE 9-3 Illustrative Dividend Growth Rates



In the figure, the dividends of the supernormal growth firm are expected to gro at a 30 percent rate for three years, after which the growth rate is expected to fall t 8 percent, the assumed average for the economy. The value of this firm, like an other, is the present value of its expected future dividends as determined by Equatio 9-1. In the case in which D_t is growing at a constant rate, we simplified Equation 9- to $\hat{P}_0 = D_1/(k_s - g)$. In the supernormal case, however, the expected growth rate is no a constant—it declines at the end of the period of supernormal growth.

To find the value of such a stock, or of any nonconstant growth stock when th growth rate will eventually stabilize, we proceed in three steps:

1. Find the PV of the dividends during the period of nonconstant growth.
2. Find the price of the stock at the end of the nonconstant growth period, at whic point it has become a constant growth stock, and discount this price back to th present.
3. Add these two components to find the intrinsic value of the stock, $\hat{P}_0$.

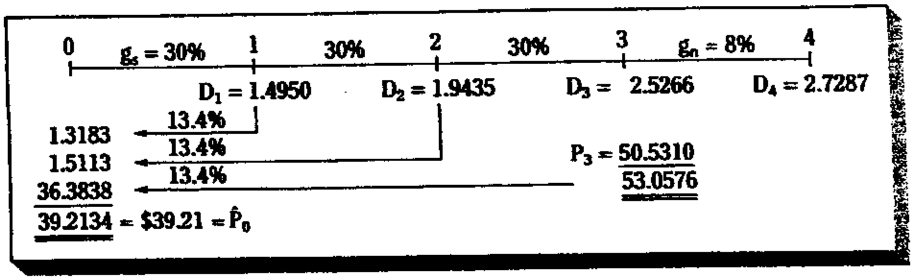
Figure 9-4 can be used to illustrate the process for valuing nonconstant growth stock assuming the following five facts exist:

k_s = stockholders' required rate of return = 13.4%. This rate is used to discount th cash flows.

N = years of supernormal growth = 3.

g_s = rate of growth in both earnings and dividends during the supernormal growt period = 30%. (Note: The growth rate during the supernormal growth perio

FIGURE 9-4 **Process for Finding the Value of a Supernormal Growth Stock**



NOTES TO FIGURE 9-4:

Step 1. Calculate the dividends expected at the end of each year during the supernormal growth period. Calculate the first dividend, $D_1 = D_0(1 + g_s) = \$1.15(1.30) = \$1.4950$. Here g_s is the growth rate during the three-year supernormal growth period, 30 percent. Show the \$1.4950 on the time line as the cash flow at Time 1. Then, calculate $D_2 = D_1(1 + g_s) = \$1.4950(1.30) = \$1.9435$, and then $D_3 = D_2(1 + g_s) = \$1.9435(1.30) = \$2.5266$. Show these values on the time line as the cash flows at Time 2 and Time 3. Note that D_0 is used only to calculate D_1.

Step 2. The price of the stock is the PV of dividends from Time 1 to infinity, so in theory we could project each future dividend, with the normal growth rate, $g_n = 8\%$, used to calculate D_4 and subsequent dividends. However, we know that after D_3 has been paid, which is at Time 3, the stock becomes a constant growth stock. Therefore, we can use the constant growth formula to find $\hat{P}_3$, which is the PV of the dividends from Time 4 to infinity as evaluated at Time 3.

First, we determine $D_4 = \$2.5266(1.08) = \$2.7287$ for use in the formula, and then we calculate $\hat{P}_3$ as follows:

$$\hat{P}_3 = \frac{D_4}{k_s - g_n} = \frac{\$2.7287}{0.134 - 0.08} = \$50.5310.$$

We show this \$50.5310 on the time line as a second cash flow at Time 3. The \$50.5310 is a Time 3 cash flow in the sense that the owner of the stock could sell it for \$50.5310 at Time 3 and also in the sense that \$50.5310 is the present value of the dividend cash flows from Time 4 to infinity. Note that the *total cash flow* at Time 3 consists of the sum of $D_3 + \hat{P}_3 = \$2.5266 + \$50.5310 = \$53.0576$.

Step 3. Now that the cash flows have been placed on the time line, we can discount each cash flow at the required rate of return, $k_s = 13.4\%$. We could discount each flow by dividing by $(1.134)^t$, where t = 1 for Time 1, t = 2 for Time 2, and t = 3 for Time 3. This produces the PVs shown to the left below the time line, and the sum of the PVs is the value of the supernormal growth stock, \$39.21.

With a financial calculator, you can find the PV of the cash flows as shown on the time line with the cash flow (CFLO) register of your calculator. Enter 0 for CF_0 because you get no cash flow at Time 0, $CF_1 = 1.495$, $CF_2 = 1.9435$, and $CF_3 = 2.5266 + 50.531 = 53.0576$. Then enter I = 13.4, and press the NPV key to find the value of the stock, \$39.21.

---

could vary from year to year. Also, there could be several different supernormal growth periods, e.g., 30% for three years, then 20% for three years, and then a constant 8%.) This rate is shown directly on the time line.

g_n = rate of normal, constant growth after the supernormal period = 8%. This rate is also shown on the time line, between Periods 3 and 4.

D_0 = last dividend the company paid = \$1.15.

The valuation process as diagrammed in Figure 9-4 is explained in the steps set forth below the time line. The value of the supernormal growth stock is calculated to be \$39.21.

Attorney General's Response to
The Requests for Information of
Louisville Gas & Electric Company
Case No. 2003-00433

Witness Responding: Carl G. K. Weaver

24. In reference to Schedule 37 and 64:
    a. Provide a computer disk showing all data and calculations underlying the calculation of internal rate of return. (All formulas should be reflected on this computer disk, including those for the calculation of the present value of the perpetuity and the calculation of the internal rate of return.)
    b. Explain how the convergence from current growth to growth in 2007 is derived and provide all assumptions and calculations used.
    c. If different convergent assumptions are used for different companies, explain why this is so.
    d. Explain how the 2002-2003 growth rate is calculated and provide all assumptions and data underlying the calculation.

Answer:

a. See response to question 33.

b. The 2003 growth rate is subtracted from the projected growth rate in the year 2007 (shown in bold type) and the remainder is divided by 4. The quotient is then added to the 2003 rate to obtain the 2004 rate. The same quotient is added to 2004 rate and so forth. The assumption is that the three to five year growth projection will be obtained in four years.

c. As stated in the footnote, the 2003 rate of growth is the dividend growth rate achieved from 2002 to 2003 as provided by Value Line. The assumption is that the growth rate achieved is the most recent growth rate that is available to investors.

COMPARISON OF NEAR-TERM GROWTH IN DR WEAVER'S MULTI-STAGE DCF ANALYSIS

	Weaver Average of Near-Term Growth (1)	Analysts' Projected Near-Term Growth (2)	Difference: Analysts - Weaver (2) - (1) (3)
Electric Group			
Ameren	1.11 %	2.95 %	1.84 %
Cinergy	2.71	3.55	0.84
DTE	1.82	4.85	3.03
Empire	1.81	4.83	3.02
FPL	3.87	4.64	0.77
MGE	2.69	6.00	3.31
PNM	5.50	5.00	-0.50
Progress	3.73	3.77	0.04
Southern	3.28	5.07	1.79
Average	2.95 %	4.52 %	1.57 %
Gas Group			
AGL	1.81 %	5.38 %	3.57 %
Atmos	3.34	6.08	2.74
Cascade	1.69	4.50	2.81
Energen	4.40	7.07	2.67
NJ Res	3.94	6.33	2.39
NW Natural	2.24	4.65	2.41
Peoples	3.22	4.58	1.36
S Jersey	3.99	5.13	1.14
Average	3.08 %	5.47 %	2.39 %

Exhibit ________
Carl G. K. Weaver
Schedule 37

Electric
Multi-stage DCF Model

Company		Ameren Corp.		Cinergy Corp.		DTE Energy		Empire District		FPL Group		MGE Energy		PNM Resources		Progress Energy		Southern Company	
Name:	**Year**	Growth	Div.	Growth	Div.	Growth	Div.	Growth	Div.	Growth	Div.	Growth	Div.	Growth	Div.	Growth	Div.	Growth	Div.
2/17/04	Avg 4 yrs	1.11		2.71		1.82		1.31		3.87		2.69		5.50		3.73		3.28	
Stock Price			-46.50		-38.92		-39.88		-23.23		-65.45		-31.50		-31.74		-46.35		-29.9
	2003	0.00	2.56	2.20%	1.88	0.00	2.08	0.00	1.28	3.40%	2.40	0.70%	1.36	5.80%	0.92	3.70%	2.32	2.20%	1.40
	2004	0.74%	2.58	2.54%	1.93	1.21%	2.11	1.21%	1.30	3.71%	2.49	2.03%	1.39	5.60%	0.97	3.72%	2.41	2.92%	1.44
	2005	1.48%	2.62	2.88%	1.98	2.43%	2.16	2.42%	1.33	4.02%	2.59	3.35%	1.43	5.40%	1.02	3.74%	2.50	3.64%	1.49
	2006	2.22%	2.68	3.21%	2.05	3.64%	2.23	3.62%	1.37	4.33%	2.70	4.68%	1.50	5.20%	1.08	3.75%	2.59	4.35%	1.56
	2007	2.86%	2.75	3.56%	2.12	4.86%	2.34	4.83%	1.44	4.64%	2.83	6.00%	1.59	5.00%	1.13	3.77%	2.69	5.07%	1.64
	2008	2.95%	2.84	3.55%	2.19	4.85%	2.46	4.83%	1.51	4.64%	2.96	6.00%	1.69	5.00%	1.19	3.77%	2.79	5.07%	1.72
	2009	2.95%	2.92	3.55%	2.27	4.85%	2.58	4.83%	1.58	4.64%	3.09	6.00%	1.79	5.00%	1.25	3.77%	2.89	5.07%	1.81
	2010	2.95%	3.01	3.55%	2.35	4.85%	2.70	4.83%	1.66	4.64%	3.24	6.00%	1.90	5.00%	1.31	3.77%	3.00	5.07%	1.90
	2011	2.95%	3.09	3.55%	2.44	4.85%	2.83	4.83%	1.74	4.64%	3.39	6.00%	2.01	5.00%	1.37	3.77%	3.12	5.07%	2.00
	2012	2.95%	3.19	3.55%	2.52	4.85%	2.97	4.83%	1.82	4.64%	3.55	6.00%	2.13	5.00%	1.44	3.77%	3.23	5.07%	2.10
	2013	2.95%	3.28	3.55%	2.61	4.85%	3.11	4.83%	1.91	4.64%	3.71	6.00%	2.26	5.00%	1.52	3.77%	3.36	5.07%	2.20
	2014	2.95%	3.38	3.55%	2.71	4.85%	3.26	4.83%	2.01	4.64%	3.88	6.00%	2.39	5.00%	1.59	3.77%	3.48	5.07%	2.31
	2015	2.95%	3.48	3.55%	2.80	4.85%	3.42	4.83%	2.10	4.64%	4.06	6.00%	2.54	5.00%	1.67	3.77%	3.61	5.07%	2.43
	2016	2.95%	3.58	3.55%	2.90	4.85%	3.59	4.83%	2.20	4.64%	4.25	6.00%	2.69	5.00%	1.75	3.77%	3.75	5.07%	2.56
	2017	2.95%	3.68	3.55%	3.00	4.85%	3.76	4.83%	2.31	4.64%	4.45	6.00%	2.85	5.00%	1.84	3.77%	3.89	5.07%	2.68
PV of dividend perpetuity in 2018:			74.35		66.37		84.84		49.14		134.93		79.49		69.09		84.47		65.91
Internal Rate of Return:			8.1%		8.1%		9.5%		9.8%		8.1%		9.8%		7.6%		8.6%		9.4%
Average Internal Rate of Return:																			8.79%

Notes: The Current Dividend is the latest quarterly dividend times 4 from Schedule 37.

The 2003 rate of growth is the dividend growth rate achieved from 2002-2003 from Value Line.

The 2003 rate of growth converges on the 3-5 year growth forcast (the average of the Zacks, Multex, Thomson, and Value Line EPS for each company) in the year 2007 which is 4 years beyond the forecast date.

The formula for determining the PV of perpetual dividends equals [$D_{(Year)}(1+g)/(k-g)$] where k is the iteratively determined IRR and g is the growth rate.

Exhibit ________
Carl G. K. Weaver
Schedule 64

Gas
Multi-stage DCF Model

Company		AGL Resources		Atmos Energy		Cascade Natural Gas		Energen Corp.		New Jersey Resources		Northwest Natural Gas		Peoples Energy		South Jersey Industries	
Name:	Year	Growth	Div.	Growth	Div.	Growth	Div.	Growth	Div.	Growth	Div.	Growth	Div.	Growth	Div.	Growth	Div.
2/17/04	Avg 4 Yrs	1.81%		3.34%		1.69%		4.40%		3.94%		2.24%		3.22%		3.99%	
Stock Price			-28.30		-26.44		-22.23		-42.41		-39.45		-31.28		-43.30		-41.85
	2003	2.80%	1.12	1.70%	1.20	0.00%	0.96	2.80%	0.72	2.50%	1.28	0.80%	1.28	2.40%	2.12	3.30%	1.60
	2004	0.74%	1.13	2.80%	1.23	1.13%	0.97	3.87%	0.75	3.46%	1.32	1.76%	1.30	2.95%	2.18	3.76%	1.66
	2005	1.48%	1.14	3.89%	1.28	2.25%	0.99	4.94%	0.78	4.42%	1.38	2.73%	1.34	3.49%	2.26	4.22%	1.73
	2006	2.22%	1.17	4.99%	1.35	3.38%	1.03	6.00%	0.83	5.37%	1.46	3.69%	1.39	4.04%	2.35	4.67%	1.81
	2007	**5.38%**	1.23	**6.08%**	1.43	**4.50%**	1.07	**7.07%**	0.89	**6.33%**	1.55	**4.65%**	1.45	**4.58%**	2.46	**5.13%**	1.90
	2008	5.38%	1.30	6.08%	1.51	4.50%	1.12	7.07%	0.95	6.33%	1.65	4.65%	1.52	4.58%	2.57	5.13%	2.00
	2009	5.38%	1.37	6.08%	1.61	4.50%	1.17	7.07%	1.02	6.33%	1.75	4.65%	1.59	4.58%	2.69	5.13%	2.10
	2010	5.38%	1.44	6.08%	1.70	4.50%	1.22	7.07%	1.09	6.33%	1.86	4.65%	1.66	4.58%	2.81	5.13%	2.21
	2011	5.38%	1.52	6.08%	1.81	4.50%	1.28	7.07%	1.17	6.33%	1.98	4.65%	1.74	4.58%	2.94	5.13%	2.33
	2012	5.38%	1.60	6.08%	1.92	4.50%	1.34	7.07%	1.25	6.33%	2.11	4.65%	1.82	4.58%	3.07	5.13%	2.44
	2013	5.38%	1.69	6.08%	2.03	4.50%	1.40	7.07%	1.34	6.33%	2.24	4.65%	1.91	4.58%	3.21	5.13%	2.57
	2014	5.38%	1.78	6.08%	2.16	4.50%	1.46	7.07%	1.44	6.33%	2.38	4.65%	2.00	4.58%	3.36	5.13%	2.70
	2015	5.38%	1.88	6.08%	2.29	4.50%	1.52	7.07%	1.54	6.33%	2.53	4.65%	2.09	4.58%	3.52	5.13%	2.84
	2016	5.38%	1.98	6.08%	2.43	4.50%	1.59	7.07%	1.65	6.33%	2.69	4.65%	2.19	4.58%	3.68	5.13%	2.99
	2017	5.38%	2.08	6.08%	2.58	4.50%	1.67	7.07%	1.76	6.33%	2.86	4.65%	2.29	4.58%	3.85	5.13%	3.14
PV of dividend perpetuity in 2018:			65.13		67.12		45.20		127.59		104.58		64.69		88.58		93.77
Internal Rate of Return:			8.8%		10.1%		8.4%		8.6%		9.2%		8.4%		9.1%		8.7%
Average Internal Rate of Return:																	**8.92%**

Notes: The Current Dividend is the latest quarterly dividend times 4 from Schedule 37.

The 2003 rate of growth is the dividend growth rate achieved from 2002-2003 from Value Line.

The 2003 rate of growth converges on the 3-5 year growth forcast (the average of the Zacks, Multex, Thomson, and Value Line EPS for each company) in the year 2007 which is 4 years beyond the forecast date.

The formula for determining the PV of perpetual dividends equals [$D_{(Year)}(1+g)/(k-g)$] where k is the iteratively determined IRR and g is the growth rate.

Weaver Electric Proxy Group

	Market Capitalization	Ibbotson Category
Ameren	7,400	
Cinergy	6,800	
DTE	6,600	
Empire	500	Low-Cap
FPL	11,700	
MGE Energy	575	Low-Cap
PNM	1,100	Low-Cap
Progress	10,500	
Southern Company	21,200	
Average	7,375	

Source: Value Line November 14, 2003, December 5 2003, and January 2, 2004.

Weaver Gas Proxy Group

	Market Capitalization	Ibbotson Category
AGL	1,900	Mid-Cap
Atmos	1,300	Mid-Cap
Cascade	225	Micro-Cap
Energen	1,400	Mid-Cap
NJ Res.	1,000	Low-Cap
NW Nat.	775	Low-Cap
Peoples	1,500	Mid-Cap
SJ Ind.	525	Low-Cap

Source: Value Line Dec. 19, 2003.

	VLE	FCE	VLFC	VLGRE	VLP	VLD	VLB	2004 Eq Rat
Alliant Energy	5.0	4.8	4.9	3.0	8.3	4.7	0.5	51.5
Ameren	1.0	3.0	2.0	2.5	3.2	0.5	3.5	47.0
CH Energy	1.5	na	1.5	3.0	0.6	0.5	0.5	56.0
Consolidated Edison	1.0	3.0	2.0	2.5	6.1	1.0	3.5	51.5
DTE	5.5	5.5	5.5	5.5	8.6	0.5	4.5	39.5
Exelon	7.0	5.0	6.0	11.5	9.0	3.5	6.0	37.5
MGE Energy	6.0	na	6.0	4.5	-2.8	0.5	7.0	55.0
N Star	3.5	6.0	4.8	5.5	2.9	2.0	3.5	43.5
Pinnacle West	0.5	5.0	2.8	3.5	6.2	5.5	3.0	49.0
SCANA	5.0	5.0	5.0	5.0	5.9	5.5	4.5	46.0
Southern Company	6.5	5.0	5.8	5.0	5.3	3.0	5.0	44.5
Vectren	9.0	7.0	8.0	5.0	6.3	3.5	6.0	50.5
Wisconsin Energy	8.0	6.5	7.3	6.5	4.5	0.0	7.5	43.0
Average	4.6	5.1	4.7	4.8	4.9	2.4	4.2	47.3
Median	5.0	5.0	5.0	5.0	5.9	2.0	4.5	47.0

Assumptions	
Price	10.00
Expected Dividend	0.45
Dividend Yield	4.50
Expected Growth	6.00
DCF Required Return	10.50

Year	Cash Flows	PV @ 10.5%	Cumulative Sum of Present Values
0	-10.00		
1	0.45	0.4072	0.407
2	0.477	0.3907	0.798
3	0.50562	0.3747	1.173
4	0.535957	0.3595	1.532
5	0.568115	0.3448	1.877
6	0.602202	0.3308	2.208
7	0.638334	0.3173	2.525
8	0.676634	0.3044	2.830
9	0.717232	0.2920	3.122
10	0.760266	0.2801	3.402
11	0.805881	0.2687	3.670
12	0.854234	0.2578	3.928
13	0.905488	0.2473	4.175
14	0.959816	0.2372	4.413
15	1.017407	0.2275	4.640
16	1.078451	0.2183	4.858
17	1.143158	0.2094	5.068
18	1.211748	0.2009	5.269
19	1.284453	0.1927	5.461
20	1.36152	0.1848	5.646
21	1.443211	0.1773	5.823
22	1.529804	0.1701	5.994
23	1.621592	0.1632	6.157
24	1.718887	0.1565	6.313
25	1.822021	0.1501	6.463
26	1.931342	0.1440	6.607
27	2.047222	0.1382	6.746
28	2.170056	0.1325	6.878
29	2.300259	0.1271	7.005
30	2.438275	0.1220	7.127
31	2.584571	0.1170	7.244
32	2.739645	0.1122	7.356
33	2.904024	0.1077	7.464
34	3.078265	0.1033	7.567
35	3.262961	0.0991	7.666
36	3.458739	0.0950	7.761
37	3.666263	0.0912	7.853
38	3.886239	0.0875	7.940
39	4.119414	0.0839	8.024
40	4.366578	0.0805	8.104
41	4.628573	0.0772	8.182
42	4.906287	0.0741	8.256
43	5.200965	0.0710	8.327
44	5.512705	0.0681	8.395
45	5.843487	0.0654	8.460
46	6.194075	0.0627	8.523
47	6.565719	0.0602	8.583
48	6.959863	0.0577	8.641
49	7.377242	0.0554	8.696
50	7.819877	0.0531	8.749
51	8.289069	0.0509	8.800
52	8.786414	0.0489	8.849
53	9.313598	0.0469	8.896
54	9.872414	0.0450	8.941
55	10.46476	0.0431	8.984
56	11.09264	0.0414	9.025
57	11.7582	0.0397	9.065
58	12.4637	0.0381	9.103
59	13.21152	0.0365	9.140
60	14.00421	0.0350	9.175
61	14.84446	0.0336	9.208
62	15.73513	0.0322	9.241
63	16.67924	0.0309	9.271
64	17.67999	0.0297	9.301
65	18.74079	0.0285	9.330
66	19.86524	0.0273	9.357
67	21.05715	0.0262	9.383
68	22.32058	0.0251	9.408
69	23.65982	0.0241	9.432
70	25.0794	0.0231	9.455
71	26.58417	0.0222	9.478
72	28.17922	0.0213	9.499
73	29.86997	0.0204	9.519
74	31.66217	0.0196	9.539
75	33.5619	0.0188	9.558
76	35.57561	0.0180	9.576
77	37.71015	0.0173	9.593
78	39.97276	0.0166	9.610
79	42.37113	0.0159	9.625
80	44.91339	0.0153	9.641
81	47.6082	0.0146	9.655
82	50.46469	0.0140	9.669
83	53.49257	0.0135	9.683
84	56.70212	0.0129	9.696
85	60.10425	0.0124	9.708
86	63.71051	0.0119	9.720
87	67.53314	0.0114	9.731
88	71.58513	0.0109	9.742
89	75.88023	0.0105	9.753
90	80.43305	0.0101	9.763
91	85.25903	0.0097	9.773
92	90.37457	0.0093	9.782
93	95.79705	0.0089	9.791
94	101.5449	0.0085	9.799

95	107.6376	0.0082	9.807
96	114.0958	0.0078	9.815
97	120.9416	0.0075	9.823
98	128.1961	0.0072	9.830
99	135.8899	0.0069	9.837
100	144.0433	0.0066	9.844
101	152.6859	0.0064	9.850
102	161.8471	0.0061	9.856
103	171.5579	0.0059	9.862
104	181.8514	0.0056	9.868
105	192.7625	0.0054	9.873
106	204.3282	0.0052	9.878
107	216.5879	0.0050	9.883
108	229.5832	0.0048	9.888
109	243.3582	0.0046	9.892
110	257.9597	0.0044	9.897
111	273.4373	0.0042	9.901
112	289.8435	0.0040	9.905
113	307.2341	0.0039	9.909
114	325.6682	0.0037	9.913
115	345.2082	0.0036	9.916
116	365.9207	0.0034	9.920
117	387.876	0.0033	9.923
118	411.1485	0.0031	9.926
119	435.8174	0.0030	9.929
120	461.9665	0.0029	9.932
121	489.6845	0.0028	9.935
122	519.0656	0.0027	9.937
123	550.2095	0.0026	9.940
124	583.2221	0.0024	9.942
125	618.2154	0.0023	9.945
126	655.3083	0.0023	9.947
127	694.6268	0.0022	9.949
128	736.3044	0.0021	9.951
129	780.4827	0.0020	9.953
130	827.3116	0.0019	9.955
131	876.9503	0.0018	9.957
132	929.5674	0.0018	9.959
133	985.3414	0.0017	9.960
134	1044.462	0.0016	9.962
135	1107.13	0.0015	9.963
136	1173.557	0.0015	9.965
137	1243.971	0.0014	9.966
138	1318.609	0.0014	9.968
139	1397.726	0.0013	9.969
140	1481.589	0.0013	9.970
141	1570.484	0.0012	9.972
142	1664.714	0.0012	9.973
143	1764.596	0.0011	9.974
144	1870.472	0.0011	9.975
145	1982.7	0.0010	9.976
146	2101.663	0.0010	9.977
147	2227.762	0.0009	9.978
148	2361.428	0.0009	9.979
149	2503.114	0.0009	9.980
150	2653.3	0.0008	9.980
151	2812.499	0.0008	9.981
152	2981.248	0.0008	9.982
153	3160.123	0.0007	9.983
154	3349.731	0.0007	9.983
155	3550.715	0.0007	9.984
156	3763.757	0.0006	9.985
157	3989.583	0.0006	9.985
158	4228.958	0.0006	9.986
159	4482.695	0.0006	9.987
160	4751.657	0.0005	9.987
161	5036.757	0.0005	9.988
162	5338.962	0.0005	9.988
163	5659.3	0.0005	9.989
164	5998.858	0.0005	9.989
165	6358.789	0.0004	9.990
166	6740.316	0.0004	9.990
167	7144.735	0.0004	9.990
168	7573.419	0.0004	9.991
169	8027.825	0.0004	9.991
170	8509.494	0.0004	9.991
171	9020.064	0.0003	9.992
172	9561.268	0.0003	9.992
173	10134.94	0.0003	9.992
174	10743.04	0.0003	9.993
175	11387.62	0.0003	9.993
176	12070.88	0.0003	9.993
177	12795.13	0.0003	9.994
178	13562.84	0.0003	9.994
179	14376.61	0.0002	9.994
180	15239.21	0.0002	9.994
181	16153.56	0.0002	9.995
182	17122.77	0.0002	9.995
183	18150.14	0.0002	9.995
184	19239.15	0.0002	9.995
185	20393.5	0.0002	9.995
186	21617.11	0.0002	9.996
187	22914.13	0.0002	9.996
188	24288.98	0.0002	9.996
189	25746.32	0.0002	9.996
190	27291.1	0.0002	9.996
191	28928.57	0.0002	9.996
192	30664.28	0.0001	9.997
193	32504.14	0.0001	9.997
194	34454.39	0.0001	9.997
195	36521.65	0.0001	9.997
196	38712.95	0.0001	9.997
197	41035.72	0.0001	9.997
198	43497.87	0.0001	9.997
199	46107.74	0.0001	9.997
200	48874.2	0.0001	9.998

Histogram

A bar graph in which the frequency of occurrence for each class of data is represented by the relative height of the bars.

Income Return

The component of total return that results from a periodic cash flow, such as dividends or coupon payments.

Index Value

The cumulative value of returns on a dollar amount invested. It is used when measuring investment performance and computing returns over non-calendar periods.

Inflation

The rate of change in consumer prices. The Consumer Price Index for All Urban Consumers (CPI-U), not seasonally adjusted, is used to measure inflation. Prior to January 1978, the CPI (as compared with CPI-U) was used. Both inflation measures are constructed by the U.S. Department of Labor, Bureau of Labor Statistics, Washington.

Inflation-Adjusted Returns

Returns in real terms. The inflation-adjusted return of an asset is calculated by geometrically subtracting inflation from the asset's nominal return.

Intermediate-Term Government Bonds

A one-bond portfolio with a maturity near five years. From 1987 to the present the portfolio is constructed with data from *The Wall Street Journal.* The bond used in 2002 is the 6.125-percent issue that matures in August 2007. Returns from 1934–1986 are obtained from the CRSP Government Bond File. Over 1926–1933, few suitable bonds were available. Estimates were obtained from Thomas S. Coleman, Lawrence Fisher, and Roger G. Ibbotson, *Historical U.S. Treasury Yield Curves.*

January Effect

The empirical regularity with which rates of return for small stocks have historically been higher in January than in the other months of the year.

Levered Beta

Measures the systematic risk for the equity shareholders of a company and is therefore commonly referred to as the equity beta. It is measured directly from the company's returns with no adjustment made for debt financing undertaken by the company.

Logarithmic Scale

A scale in which equal percentage changes are represented by equal distances.

Lognormal Distribution

The distribution of a random variable whose natural logarithm is normally distributed. A lognormal distribution is skewed so that a higher proportion of possible returns exceed the expected value versus falling short of the expected value.

Long-Term Corporate Bonds

Salomon Brothers long-term, high-grade corporate bond total return index.

Long-Term Government Bonds

A one-bond portfolio with a maturity near 20 years. From 1977 to the present the portfolio is constructed with data from *The Wall Street Journal.* The bond used in 2002 is the 6.25-percent issue that matures on August 15, 2023. The data from 1926–1976 are obtained from the Government Bond File at the Center for Research in Security Prices (CRSP) at the University of Chicago Graduate School of Business.

Low-Cap Stocks

The portfolio of stocks comprised of the 6th-8th deciles of the New York Stock Exchange.

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- China's Consumer Market is More Limited Than it Appears
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The U.S. Economic Forecast*

December 2003 - Revised

	2003		2004				2003	2004	200
	III Q*	IV Q	I Q	II Q	III Q	IV Q	ANNUAL	ANNUAL	ANNUA
Real GDP	8.2	5.9	5.8	6.2	5.2	4.8	3.2	5.9	4.0
CPI Inflation	2.3	1.7	2.3	2.6	2.7	3.0	2.3	2.2	3.2
Real Consumer Spending	6.4	4.0	5.5	6.4	5.1	5.2	3.2	5.3	4.5
Unemployment Rate (%)	6.1	6.0	5.9	5.7	5.4	5.3	6.0	5.6	5.2
90 Day T-Bills (%)	0.93	0.83	0.98	1.23	1.73	1.90	0.99	1.46	3.66
10 Yr Treas Bonds (%)	4.23	4.37	4.60	5.00	5.25	5.50	4.04	5.09	5.63

*Seasonally adjusted, annual rates except where noted.
Source: The Conference Board

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Table A20. Macroeconomic Indicators
(Billion 1996 Chain-Weighted Dollars, Unless Otherwise Noted)

Growth 2015-2025	Indicators	Reference Case 2000	2001	2005	2010	2015	2020	2025	Annual Growth 2001-2025 (percent)	Growth 2008-2025
					2008 1.364					
2.92	GDP Chain-Type Price Index (1996=1.000)	1.000	1.094	1.195	1.313	1.486	1.708	1.981	2.5%	2.68%
				11,461						
2.85	Real Gross Domestic Product	9191	9215	10361	12258	14288	16459	18917	3.0%	2.99%
	Real Consumption	6224	6377	7151	8412	9626	11351	13012	3.0%	
	Real Investment	1763	1575	1868	2499	3151	3755	4492	4.5%	
	Real Government Spending	1583	1640	1790	1895	2026	2212	2429	1.6%	
	Real Exports	1137	1076	1287	1784	2426	3360	4695	6.3%	
	Real Imports	1536	1492	1788	2301	3044	4059	5398	5.5%	
	Real Disposable Personal Income	6630	6748	7421	8637	10087	11713	13435	2.9%	
	AA Utility Bond Rate (percent)	7.91	7.43	8.10	7.24	8.05	9.18	9.63	N/A	
	Real Yield on Government 10 Year Bonds (percent)	4.85	3.51	5.10	5.26	5.60	6.56	6.76	N/A	
	Real Utility Bond Rate (percent)	6.32	5.45	5.61	5.35	5.42	6.32	6.56	N/A	
	Energy Intensity (thousand Btu per 1996 dollar of GDP)									
	Delivered Energy	7.91	7.74	7.36	6.87	6.39	5.94	5.55	-1.4%	
	Total Energy	10.82	10.57	9.96	9.24	8.54	7.92	7.36	-1.5%	
				2.099						
3.33	Consumer Price Index (1982-84=1.00)	1.72	1.77	1.97	2.19	2.50	2.93	3.47	2.8%	3,00%
	Unemployment Rate (percent)	4.02	4.79	5.57	4.41	4.88	5.89	5.77	0.8%	
	Housing Starts (millions)	1.82	1.80	1.90	2.17	1.99	1.92	2.02	0.5%	
	Single-Family	1.23	1.27	1.22	1.34	1.19	1.12	1.12	-0.5%	
	Multifamily	0.34	0.33	0.34	0.47	0.46	0.48	0.57	2.3%	
	Mobile Home Shipments	0.25	0.19	0.34	0.37	0.34	0.32	0.33	2.3%	
	Commercial Floorspace, Total (billion square feet)	68.5	70.2	76.1	81.8	88.2	94.6	101.1	1.5%	
	Value of Shipments (billion 1996 dollars)									
	Total Industrial	5719	5425	5882	6959	8029	8963	10126	2.6%	
	Nonmanufacturing	1341	1346	1340	1505	1636	1743	1869	1.4%	
	Manufacturing	4378	4079	4542	5453	6393	7220	8257	3.0%	
	Energy-Intensive Manufacturing	1113	1086	1141	1256	1360	1446	1532	1.4%	
	Non-Energy-Intensive Manufacturing	3264	2993	3402	4197	5033	5774	6725	3.4%	
	Unit Sales of Light-Duty Vehicles (millions)	17.36	17.11	16.50	18.27	19.77	19.91	19.97	0.6%	
	Population (millions)									
	Population with Armed Forces Overseas	275.7	278.2	288.1	300.2	312.7	325.3	338.2	0.8%	
	Population (aged 16 and over)	213.1	215.4	224.8	236.6	246.7	256.5	266.6	0.9%	
	Employment, Non-Agriculture	131.3	131.7	137.0	147.1	154.0	159.2	165.9	1.0%	
	Employment, Manufacturing	18.3	17.5	17.4	17.9	17.5	17.3	18.4	0.2%	
	Labor Force	140.9	141.8	148.7	156.5	163.9	169.8	177.4	0.9%	

GDP = Gross domestic product.
Btu = British thermal unit.
N/A = Not applicable.
Sources: 2000 and 2001: Global Insight macroeconomic model CTL0802. Projections: Energy Information Administration, AEO2003 National Energy Modeling System run AEO2003.D110502C.

Real GDP Growth 2.99%

Inflation:

GDP Defl 2.68
CPI 3.00
Avg. 2.84 2.84

6.06% 2015-2025 Nominal GDP Growth (2008-2025) 5.91%

PRICE-BOOK RATIO

	Recent Price (1)	2003 BPS (2)	Recent Price-Book Ratio (3)	Projected 2007 Price (4)	Projected 2007 Book Value (5)	Projected Price-Book Ratio (6)
Alliant Energy	20.02	20.15	0.99	27.50	23.30	1.18
Ameren	44.10	26.35	1.67	50.00	29.40	1.70
CH Energy Group	44.02	29.30	1.50	45.00	31.25	1.44
Consolidated Edison	39.52	28.90	1.37	50.00	32.60	1.53
DTE Energy	39.50	28.40	1.39	55.00	36.50	1.51
Exelon	58.53	23.00	2.54	82.50	36.80	2.24
MGE Energy	30.75	15.70	1.96	27.50	18.00	1.53
NStar	44.63	25.80	1.73	50.00	30.25	1.65
Pinnacle West Capital	33.37	30.40	1.10	42.50	35.10	1.21
SCANA	33.77	21.10	1.60	42.50	26.00	1.63
Southem Company	28.50	12.90	2.21	35.00	15.15	2.31
Vectren	25.47	14.55	1.75	32.50	17.75	1.83
Wisconsin Energy	29.40	20.00	1.47	35.00	27.25	1.28
Average			1.64			1.62
Median			1.60			1.53

Source: VL 7/4/03, 8/15/03 and 9/5/03

Price Goes to Book in Year 5

D	0.50	D/P	5.00
Po	10.00		
Bo	6.25		g = 5.0%
B_5	7.98		

IRR

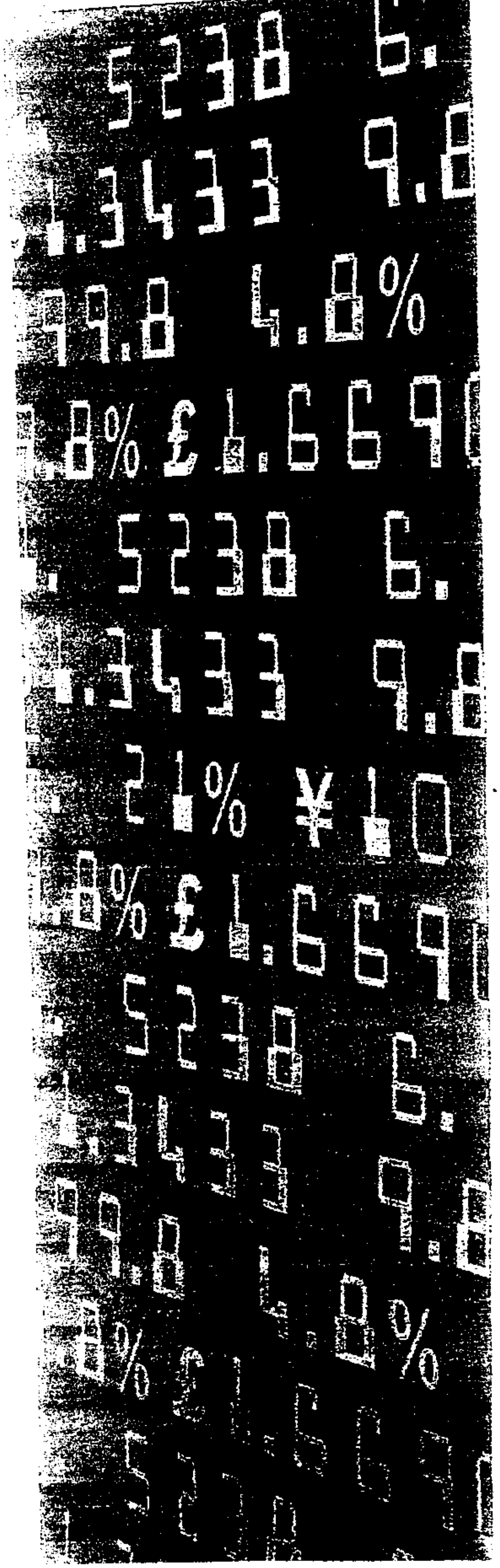
1.8953 %

	Cash Flows			
Year				
0	-10.00			
1	0.525			0.515235
2	0.551			0.530933
3	0.579			0.547111
4	0.608			0.563781
5	8.615	0.638	7.98	7.842941
		D	P	
				10.00

WEAVER

	10-Year	20-Year	LTT
9/19/03	4.23	5.18	5.22
9/26/03	4.16	5.09	5.13
10/3/03	4.05	5.00	5.04
10/10/03	4.26	5.21	5.24
10/17/03	4.42	5.35	5.37
10/24/03	4.33	5.23	5.27
10/31/03	4.31	5.20	5.24
11/7/03	4.41	5.27	5.29
11/14/03	4.36	5.22	5.25
11/21/03	4.18	5.07	5.11
11/28/03	4.25	5.13	5.15
12/5/03	4.36	5.20	5.22
12/12/03	4.29	5.15	5.19
12/19/03	4.20	5.05	5.10
12/26/03	4.21	5.03	5.08
1/2/04	4.30	5.13	5.17
1/9/04	4.27	5.11	5.15
1/16/04	4.04	4.92	4.98
1/23/04	4.05	4.92	4.97
1/30/04	4.17	5.02	5.06
2/6/04	4.16	4.99	5.04
2/13/04	4.08	4.93	4.99
Average	4.23	5.11	5.15
Median	4.24	5.12	5.15

Source: Federal Reserve website.



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ecial Questions:

The table below contains results of our twice-annual LONG-RANGE CONSENSUS survey. There are also Top 10 and Bottom 10 averages for each variable. Shown are estimates for the years 2005 through 2009 and averages for the five-year periods 2005-2009 and 2010-2014. Apply these projections cautiously. Few economic, demographic and political forces can be evaluated accurately over such time spans.

		Average For The Year					Five Year Averages	
Interest Rates		**2005**	**2006**	**2007**	**2008**	**2009**	**2005-2009**	**2010-201**
1. Federal Funds Rate	**CONSENSUS**	**3.1**	**4.0**	**4.4**	**4.6**	**4.7**	**4.1**	**4.3**
	Top 10 Avg.	3.8	4.6	5.3	5.8	6.0	5.1	5.2
	Bottom 10 Avg.	2.3	3.2	3.4	3.4	3.4	3.1	3.4
2. Prime Rate	**CONSENSUS**	**6.0**	**6.9**	**7.3**	**7.5**	**7.6**	**7.1**	**7.3**
	Top 10 Avg.	6.7	7.6	8.2	8.8	9.0	8.1	8.2
	Bottom 10 Avg.	5.3	6.2	6.3	6.4	6.3	6.1	6.4
3. LIBOR, 3-Mo.	**CONSENSUS**	**3.2**	**4.1**	**4.5**	**4.7**	**4.8**	**4.3**	**4.6**
	Top 10 Avg.	3.9	4.7	5.4	6.0	6.2	5.2	5.5
	Bottom 10 Avg.	2.5	3.4	3.6	3.6	3.6	3.3	3.6
4. Commercial Paper, 1-Mo.	**CONSENSUS**	**3.1**	**3.9**	**4.4**	**4.7**	**4.8**	**4.2**	**4.4**
	Top 10 Avg.	3.8	4.6	5.2	5.9	6.1	5.1	5.4
	Bottom 10 Avg.	2.4	3.2	3.5	3.5	3.5	3.2	3.5
5. Treasury Bill Yield, 3-Mo.	**CONSENSUS**	**3.0**	**3.8**	**4.2**	**4.5**	**4.6**	**4.0**	**4.3**
	Top 10 Avg.	3.8	4.5	5.1	5.8	6.0	5.0	5.3
	Bottom 10 Avg.	2.3	3.1	3.3	3.3	3.3	3.1	3.4
6. Treasury Bill Yield, 6-Mo.	**CONSENSUS**	**3.1**	**3.9**	**4.4**	**4.7**	**4.8**	**4.2**	**4.4**
	Top 10 Avg.	3.9	4.6	5.3	5.9	6.1	5.2	5.4
	Bottom 10 Avg.	2.4	3.2	3.5	3.5	3.5	3.2	3.5
7. Treasury Bill Yield, 1-Yr.	**CONSENSUS**	**3.4**	**4.2**	**4.6**	**4.9**	**5.0**	**4.4**	**4.7**
	Top 10 Avg.	4.1	4.8	5.4	6.1	6.3	5.3	5.6
	Bottom 10 Avg.	2.6	3.4	3.6	3.7	3.7	3.4	3.7
8. Treasury Note Yield, 2-Yr.	**CONSENSUS**	**3.8**	**4.6**	**5.0**	**5.2**	**5.3**	**4.8**	**5.0**
	Top 10 Avg.	4.5	5.3	4.5	6.6	6.7	5.5	6.1
	Bottom 10 Avg.	3.1	3.8	4.0	4.0	4.0	3.8	4.0
9. Treasury Note Yield, 5-Yr.	**CONSENSUS**	**4.8**	**5.3**	**5.7**	**5.9**	**5.9**	**5.5**	**5.7**
	Top 10 Avg.	5.4	6.0	6.6	7.3	7.4	6.6	6.7
	Bottom 10 Avg.	4.0	4.6	4.6	4.7	4.7	4.5	4.7
10. Treasury Note Yield, 10-Yr.	**CONSENSUS**	**5.6**	**6.0**	**6.2**	**6.3**	**6.3**	**6.1**	**6.1**
	Top 10 Avg.	6.2	6.8	7.4	7.6	7.6	7.1	7.3
	Bottom 10 Avg.	4.8	5.2	5.1	5.2	5.2	5.1	5.1
11. Treasury Long-Term Avg. Yield	**CONSENSUS**	**6.1**	**6.5**	**6.7**	**6.8**	**6.7**	**6.6**	**6.7**
	Top 10 Avg.	6.8	7.3	7.9	8.1	8.0	7.6	8.0
	Bottom 10 Avg.	5.4	5.7	5.7	5.6	5.6	5.6	5.7
12. Corporate Aaa Bond Yield.	**CONSENSUS**	**6.9**	**7.3**	**7.6**	**7.7**	**6.7**	**7.2**	**7.6**
	Top 10 Avg.	7.7	8.4	8.9	9.2	8.5	8.5	9.1
	Bottom 10 Avg.	6.1	6.4	6.4	6.4	4.3	5.9	6.4
13. Corporate Baa Bond Yield	**CONSENSUS**	**7.9**	**8.2**	**8.5**	**8.6**	**8.6**	**8.4**	**8.4**
	Top 10 Avg.	8.7	9.4	9.9	10.2	10.2	9.7	10.0
	Bottom 10 Avg.	7.1	7.3	7.3	7.3	7.3	7.3	7.2
14. State & Local Bonds Yield	**CONSENSUS**	**5.7**	**6.0**	**6.2**	**6.2**	**6.2**	**6.1**	**6.2**
	Top 10 Avg.	6.4	6.6	6.8	7.0	7.1	6.8	7.0
	Bottom 10 Avg.	5.1	5.4	5.6	5.6	5.5	5.5	5.5
15. Home Mortgage Rate	**CONSENSUS**	**7.0**	**7.4**	**7.7**	**7.8**	**7.8**	**7.5**	**7.6**
	Top 10 Avg.	7.9	8.5	9.2	9.5	9.5	8.9	9.2
	Bottom 10 Avg.	6.1	6.4	6.3	6.3	6.2	6.3	6.2
A. FRB Major Currency Index	**CONSENSUS**	**88.1**	**89.2**	**90.3**	**91.1**	**91.3**	**90.0**	**90.5**
	Top 10 Avg.	94.2	95.9	97.8	98.7	99.3	97.2	98.6
	Bottom 10 Avg.	82.7	82.7	82.5	82.7	82.8	82.7	81.6
		Year-Over-Year , % Change					**Five Year Averages**	
		2005	**2006**	**2007**	**2008**	**2009**	**2005-2009**	**2010-201**
B. Real GDP	**CONSENSUS**	**3.6**	**3.5**	**3.4**	**3.5**	**3.5**	**3.5**	**3.4**
	Top 10 Avg.	4.0	4.0	4.1	4.1	4.0	4.0	3.7
	Bottom 10 Avg.	3.1	3.1	2.8	2.9	2.9	3.0	3.0
C. GDP Chained Price Index	**CONSENSUS**	**1.9**	**2.2**	**2.2**	**2.3**	**2.3**	**2.2**	**2.3**
	Top 10 Avg.	2.4	2.6	2.7	2.8	2.9	2.7	2.9
	Bottom 10 Avg.	1.5	1.8	1.8	1.8	1.8	1.7	1.8
D. Consumer Price Index	**CONSENSUS**	**2.2**	**2.5**	**2.5**	**2.6**	**2.6**	**2.5**	**2.6**
	Top 10 Avg.	2.7	2.9	2.8	3.0	3.2	2.9	3.0
	Bottom 10 Avg.	1.8	2.2	2.3	2.2	2.2	2.1	2.3

IbbotsonAssociates

Risk Premia over Time Report: 2004

Estimates for 1926-2003

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Table 1 **Total Returns, Income Returns and Capital Appreciation**

Summary Statistics of Annual Returns

From 1926 to 2003

Series	Geometric Mean	Arithmetic Mean	Standard Deviation
Large Company Stocks			
Total Returns	10.4	12.4	20.4
Income	4.3	4.3	1.5
Capital Appreciation	5.9	7.8	19.7
Ibbotson Small Company Stocks			
Total Returns	12.7	17.5	33.3
Mid-Cap Stocks*			
Total Returns	11.3	14.2	25.1
Income	4.1	4.1	1.7
Capital Appreciation	7.0	9.8	24.4
Low-Cap Stocks*			
Total Returns	11.7	15.7	29.9
Income	3.8	3.8	1.9
Capital Appreciation	7.7	11.7	29.2
Micro-Cap Stocks*			
Total Returns	12.7	19.0	39.7
Income	2.6	2.7	1.8
Capital Appreciation	10.1	16.2	39.1
Long-Term Corporate Bonds			
Total Returns	5.9	6.2	8.6
Long-Term Government Bonds			
Total Returns	5.4	5.8	9.4
Income	5.2	5.2	2.8
Capital Appreciation	0.0	0.3	8.2
Intermediate-Term Government Bonds			
Total Returns	5.4	5.5	5.7
Income	4.7	4.8	3.0
Capital Appreciation	0.5	0.6	4.5
Treasury Bills			
Total Returns	3.7	3.8	3.1
Inflation	3.0	3.1	4.3

Total return is equal to the sum of income return, capital appreciation return, and reinvestment return.
**Source: Center for Research in Security Prices, University of Chicago.*

Table 2 Key Variables in Estimating the Cost of Capital

(As of Year-end 2003)

	Value
Yields (Riskless Rates)	
Long-Term (20-year) U.S. Treasury Coupon Bond Yield	5.1%
Intermediate-term (5-year) U.S. Treasury Coupon Note Yield	3.0%
Short-term (30-day) U.S. Treasury Bill Yield	0.9%
Equity Risk Premium[3]	
Long-horizon expected equity risk premium: large company stock total returns minus long-term government bond income returns	7.2%
Intermediate-horizon expected equity risk premium: large company stock total returns minus intermediate-term government bond income returns	7.6%
Short-horizon expected equity risk premium: large company stock total returns minus U.S. Treasury bill total returns	8.6%

Size Premium[4]

Decile	Market Capitalization of Smallest Company (in millions)		Market Capitalization of Largest Company (in millions)	Size Premium (Return in Excess of CAPM)
Mid-Cap, 3-5	$1,167.040	-	$4,794.027	0.91%
Low-Cap, 6-8	$330.797	-	$1,166.799	1.70%
Micro-Cap, 9-10	$0.332	-	$330.608	4.01%
Breakdown of Deciles 1-10				
1-Largest	$11,444.104	-	$286,638.305	-0.34%
2	$4,809.422	-	$11,366.767	0.50%
3	$2,592.978	-	$4,794.027	0.67%
4	$1,723.907	-	$2,585.984	1.11%
5	$1,167.040	-	$1,720.959	1.36%
6	$797.302	-	$1,166.799	1.59%
7	$508.210	-	$795.983	1.57%
8	$330.797	-	$507.820	2.25%
9	$166.445	-	$330.608	2.90%
10-Smallest	$0.332	-	$166.414	6.34%
Breakdown of the 10th Decile				
10a	$96.961	-	$166.414	4.50%
10b-Smallest	$0.332	-	$96.928	9.82%

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[3] Expected risk premia for equities are based on the differences of historical arithmetic mean returns from 1926-2003 using the S&P 500 as the market benchmark.

[4] Expected return in excess of that predicted by the capital asset pricing model, also known as the beta-adjusted size premium. Underlying data provided by CRSP, the Center for Research in Security Prices. See Chapter 7 of Ibbotson's *SBBI Valuation Edition Yearbook* for methodology.

LOUISVILLE GAS AND ELECTRIC COMPANY
Capital Asset Pricing Model Analysis

5-Yr T "Intermediate

Historic Market Premium

	Geometric Mean	Arithmetic Mean		
Long-Term Annual Return on Stocks	10.20%	12.20%		
Long-Term Annual Income Return on Long-Term Government Bond:	~~5.20%~~ 4.8	~~5.20%~~	4.8	5 Yr-T
Historical Market Risk Premium	~~5.00%~~ 5.4	~~7.00%~~	7.4	
Electric Group Beta	0.68	0.68		
Beta * Market Premium	~~3.40%~~ 3.67	~~4.77%~~	5.03	
Current ~~20~~ 5 Year Tresury Bond Yield	~~5.11%~~ 3.19	~~5.11%~~	3.19	
CAPM Cost of Equity	8.51% 6.86	9.87%	8.22	

5 Yr T

2003	Sept	3.18
	Oct	3.19
	Nov	3.29
	Dec	3.27
2004	Jan	3.12
	Feb	3.07

Avg. 3.19

Histogram

A bar graph in which the frequency of occurrence for each class of data is represented by the relative height of the bars.

Income Return

The component of total return that results from a periodic cash flow, such as dividends or coupon payments.

Index Value

The cumulative value of returns on a dollar amount invested. It is used when measuring investment performance and computing returns over non-calendar periods.

Inflation

The rate of change in consumer prices. The Consumer Price Index for All Urban Consumers (CPI-U), not seasonally adjusted, is used to measure inflation. Prior to January 1978, the CPI (as compared with CPI-U) was used. Both inflation measures are constructed by the U.S. Department of Labor, Bureau of Labor Statistics, Washington.

Inflation-Adjusted Returns

Returns in real terms. The inflation-adjusted return of an asset is calculated by geometrically subtracting inflation from the asset's nominal return.

Intermediate-Term Government Bonds

A one-bond portfolio with a maturity near five years. From 1987 to the present the portfolio is constructed with data from *The Wall Street Journal*. The bond used in 2002 is the 6.125-percent issue that matures in August 2007. Returns from 1934–1986 are obtained from the CRSP Government Bond File. Over 1926–1933, few suitable bonds were available. Estimates were obtained from Thomas S. Coleman, Lawrence Fisher, and Roger G. Ibbotson, *Historical U.S. Treasury Yield Curves*.

January Effect

The empirical regularity with which rates of return for small stocks have historically been higher in January than in the other months of the year.

Levered Beta

Measures the systematic risk for the equity shareholders of a company and is therefore commonly referred to as the equity beta. It is measured directly from the company's returns with no adjustment made for debt financing undertaken by the company.

Logarithmic Scale

A scale in which equal percentage changes are represented by equal distances.

Lognormal Distribution

The distribution of a random variable whose natural logarithm is normally distributed. A lognormal distribution is skewed so that a higher proportion of possible returns exceed the expected value versus falling short of the expected value.

Long-Term Corporate Bonds

Salomon Brothers long-term, high-grade corporate bond total return index.

Long-Term Government Bonds

A one-bond portfolio with a maturity near 20 years. From 1977 to the present the portfolio is constructed with data from *The Wall Street Journal*. The bond used in 2002 is the 6.25-percent issue that matures on August 15, 2023. The data from 1926–1976 are obtained from the Government Bond File at the Center for Research in Security Prices (CRSP) at the University of Chicago Graduate School of Business.

Low-Cap Stocks

The portfolio of stocks comprised of the 6th-8th deciles of the New York Stock Exchange.

Table 2-1

Total Returns, Income Returns, and Capital Appreciation of the Basic Asset Classes

Summary Statistics of Annual Returns

from 1926 to 2002

Series	Geometric Mean	Arithmetic Mean	Standard Deviation	Serial Correlation
Large Company Stocks				
Total Returns	10.2%	12.2%	20.5%	0.05
Income	4.3	4.3	1.5	0.88
Capital Appreciation	5.7	7.6	19.8	0.05
Ibbotson Small Company Stocks				
Total Returns	12.1	16.9	33.2	0.07
Mid-Cap Stocks*				
Total Returns	11.0	13.8	25.1	−0.01
Income	4.2	4.2	1.6	0.87
Capital Appreciation	6.6	9.4	24.3	−0.01
Low-Cap Stocks*				
Total Returns	11.2	15.2	29.9	0.05
Income	3.8	3.8	1.9	0.88
Capital Appreciation	7.3	11.2	29.1	0.04
Micro-Cap Stocks*				
Total Returns	12.1	18.2	39.3	0.10
Income	2.7	2.7	1.8	0.90
Capital Appreciation	9.4	15.4	38.7	0.10
Long-Term Corporate Bonds				
Total Returns	5.9	6.2	8.7	0.08
Long-Term Government Bonds				
Total Returns	5.5	5.8	9.4	−0.07
Income	5.2	5.2	2.8	0.96
Capital Appreciation	0.1	0.4	8.2	−0.22
Intermediate-Term Government Bonds				
Total Returns	5.4	5.6	5.8	0.15
Income	4.8	4.8	3.0	0.96
Capital Appreciation	0.5	0.6	4.5	−0.20
Treasury Bills				
Total Returns	3.8	3.8	3.2	0.91
Inflation	3.0	3.1	4.4	0.65

Total return is equal to the sum of three component returns; income return, capital appreciation return, and reinvestment return.

*Source: Center for Research in Security Prices, University of Chicago. See Chapter 7 for details on decile construction.

Responses of the Attorney General to
PSC Order dated April 6, 2004
Pertaining to Louisville Gas & electric Company
Case No. 2003-00433

Witness Responding: Carl G. K. Weaver

20. Refer to the Testimony of Carl G. K. Weaver ("Weaver Testimony"), page 28. Dr. Weaver provides citations from *Security Analysis and Portfolio Management* in his discussion of the arithmetic and geometric means. Provide a copy of the pages from *Security Analysis and Portfolio Management* that discuss this subject.

Answer:

Attached are pages 210 through 223 from Chapter 8 entitled "Financial Mathematics and Decision Making." The section that begins the discussion of the arithmetic and geometric mean is entitled "Measures of Central Tendency."

'R distribution. Here
.stribution:

$$- SD))]^{1/2} \quad (8\text{-}14)$$

;ood/bad year HPRs, we see
above the full distribution's
3 one SD below the full dis-
nultivalued and two-valued
;eometric means the same?
erlying HPR distribution is

Actually, they are usually
eme observations in the tails
nal distribution. Their fre-
:urtic curve in Figure 8-3.
.cy curve.)
only approximately normal,
rmula to show the relation-
nean, arithmetic mean, and

$$)^{1/2} \quad (8\text{-}15)$$

ect an approximation of an

$$(\quad (8\text{-}16)$$

make such extensive use of
ssign it a special symbol: S.

$$^{1/2} \quad (8\text{-}17)$$

lationships between present
starting point, future guar-
ere related to $1 in hand at
shown to depend on two
compounding assumed) and
ounting future payments to
e an alternate, equivalent
Finally, since such future
have both a present value

and a growth rate, the Soldofsky-Murphy tables were presented as a method of considering growth and discounting jointly.

The second part of the chapter discussed real-world uncertainty as related to present money and future money payments. Present money is certain; future money payments are usually uncertain. Therefore, the analyst cannot assume a definite future payment. Rather, he must set up a probability distribution of future payments and estimate the likelihood of each. The rest of the chapter described and explained four characteristics of such probability distributions and also explained central tendency, dispersion, skewness, and kurtosis—statistical concepts and measures used to quantify the characteristics of probability distributions.

The chapter attempted to touch on only the essential concepts and methodologies of the mathematics of finance and matrix probability analysis. The reader interested in pursuing these topics in depth may want to become familiar with appropriate texts available in these areas.

QUESTIONS

1. Contrast the "actual value" and the "time value" of money. Contrast the effects of continuous compounding and discrete compounding.
2. What is the relationship of growth rate g to discount rate r, expressed in terms of terminal values vs. present values computed over n periods?
3. (a) Refer to Table 8-1. If you invest $1,000 for 8 years at a continuously compounded growth rate of 12 per cent, what will your terminal value be?
   (b) Refer to Table 8-2. Find and interpret the number .854. What is the growth rate required to produce a terminal wealth value of $3.50 per original dollar, assuming continuous compounding over a period of 5 years? How long will it take a $1,000 portfolio to increase in value to $1,250, if there is a continuously compounded growth rate of 5 per cent?
   (c) Refer to Table 8-3. Find and explain the number .144.
4. How is discounting used in portfolio performance evaluation?
5. What is the function of the Soldofsky-Murphy tables? What two estimates are critical to successful application of the tables? What important factor underlies these estimates but is not explicitly stated?
6. Stock ABC has for the past few years been paying a $3 dividend. As an analyst, you believe that dividends will grow at a 3 per cent rate for the next 20 years and after that not at all. An investor interested in a long-term commitment and requiring a rate of return (discount rate) of 7 per cent asks you what price he would be justified in paying for the stock. What do you tell him? (Use Table 8-4.)
7. What is the principal problem in forming judgments about returns from any given stock or portfolio? What is the "payoff matrix" approach to security analysis? Give a common sense example illus-

AG-20-page 15

Inflation

Valuation Edition
2003 Yearbook

Ibbotson Associates

For example, if bond yields rise unexpectedly, investors can receive a higher coupon payment from a newly issued bond than from the purchase of an outstanding bond with the former lower-coupon payment. The outstanding lower-coupon bond will thus fail to attract buyers, and its price will decrease, causing its yield to increase correspondingly, as its coupon payment remains the same. The newly priced outstanding bond will subsequently attract purchasers who will benefit from the shift in price and yield; however, those investors who already held the bond will suffer a capital loss due to the fall in price.

Anticipated changes in yields are assessed by the market and figured into the price of a bond. Future changes in yields that are not anticipated will cause the price of the bond to adjust accordingly. Price changes in bonds due to unanticipated changes in yields introduce price risk into the total return. Therefore, the total return on the bond series does not represent the riskless rate of return. There is no evidence that investors expect the historical trend of bond capital losses to be repeated in the future (otherwise, bond prices would be adjusted accordingly). Therefore, historical total returns are biased downward as indicators of future expectations. The income return better represents the unbiased estimate of the purely riskless rate of return, since an investor can hold a bond to maturity and be entitled to the income return with no capital loss.

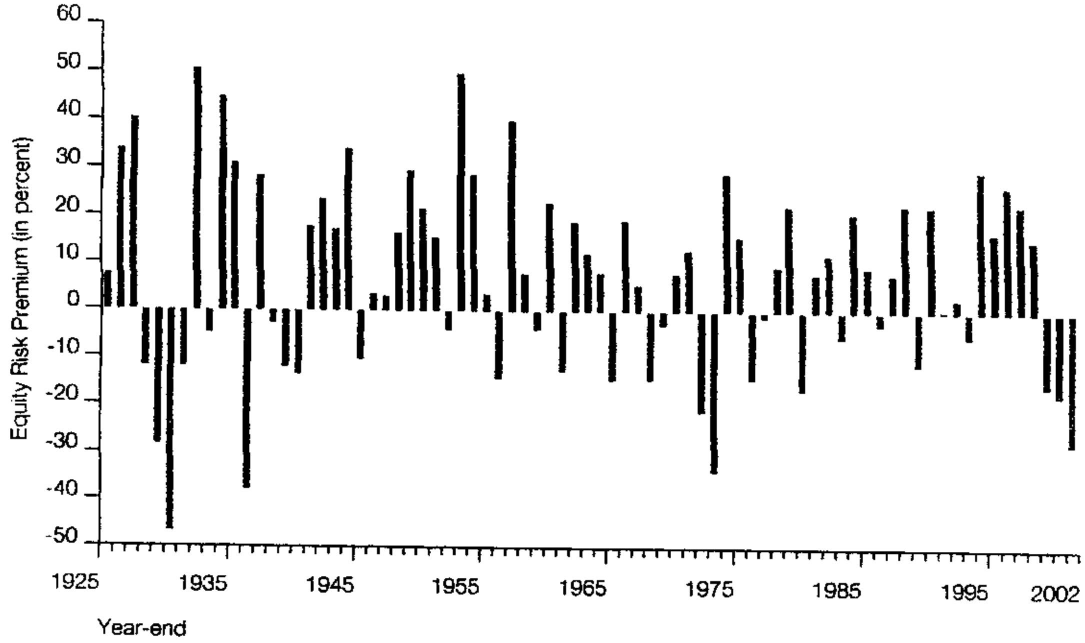
Arithmetic versus Geometric Means

The equity risk premium data presented in this book are arithmetic average risk premia as opposed to geometric average risk premia. The arithmetic average equity risk premium can be demonstrated to be most appropriate when discounting future cash flows. For use as the expected equity risk premium in either the CAPM or the building block approach, the arithmetic mean or the simple difference of the arithmetic means of stock market returns and riskless rates is the relevant number. This is because both the CAPM and the building block approach are additive models, in which the cost of capital is the sum of its parts. The geometric average is more appropriate for reporting past performance, since it represents the compound average return.

The argument for using the arithmetic average is quite straightforward. In looking at projected cash flows, the equity risk premium that should be employed is the equity risk premium that is expected to actually be incurred over the future time periods. Graph 5-3 shows the realized equity risk premium for each year based on the returns of the S&P 500 and the income return on long-term government bonds. (The actual, observed difference between the return on the stock market and the riskless rate is known as the realized equity risk premium.) There is considerable volatility in the year-by-year statistics. At times the realized equity risk premium is even negative.

Graph 5-3

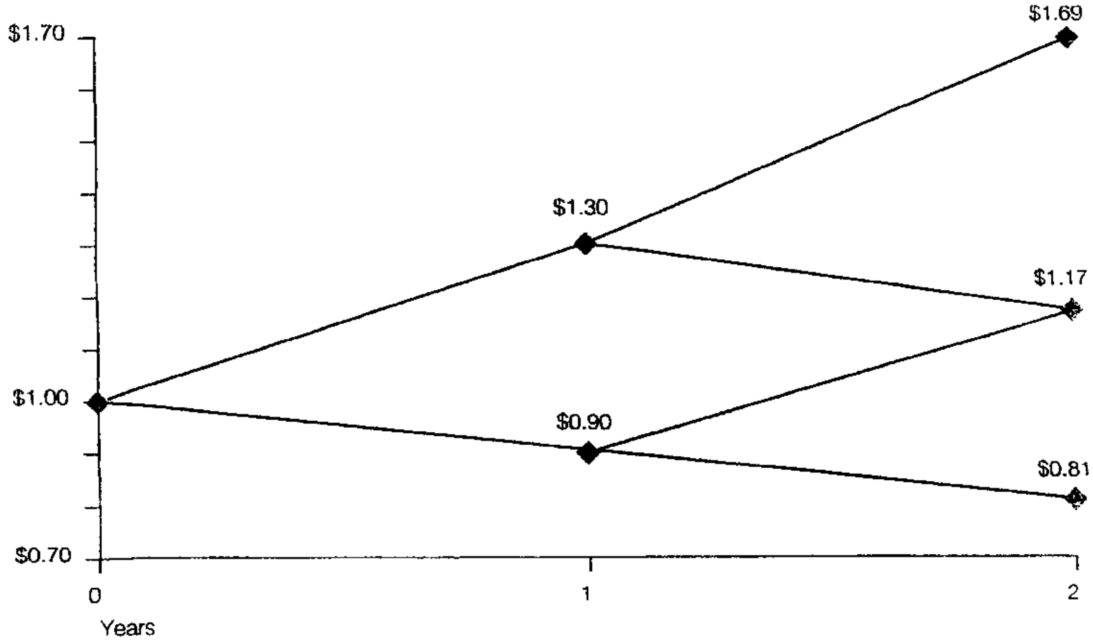
Realized Equity Risk Premium Per Year
1926–2002



To illustrate how the arithmetic mean is more appropriate than the geometric mean in discounting cash flows, suppose the expected return on a stock is 10 percent per year with a standard deviation of 20 percent. Also assume that only two outcomes are possible each year— +30 percent and –10 percent (i.e., the mean plus or minus one standard deviation). The probability of occurrence for each outcome is equal. The growth of wealth over a two-year period is illustrated in Graph 5-4.

Graph 5-4

Growth of Wealth Example



The most common outcome of $1.17 is given by the geometric mean of 8.2 percent. Compounding the possible outcomes as follows derives the geometric mean:

$$[(1+0.30)\times(1-0.10)]^{\frac{1}{2}}-1=0.082$$

However, the expected value is predicted by compounding the arithmetic, not the geometric, mean. To illustrate this, we need to look at the probability-weighted average of all possible outcomes:

$$\begin{aligned} &(0.25 \times \$1.69) = \$0.4225 \\ + &(0.50 \times \$1.17) = \$0.5850 \\ + &(0.25 \times \$0.81) = \underline{\$0.2025} \\ &\text{Total} \qquad\qquad \$1.2100 \end{aligned}$$

Therefore, $1.21 is the probability-weighted expected value. The rate that must be compounded to achieve the terminal value of $1.21 after 2 years is 10 percent, the arithmetic mean:

$$\$1\times(1+0.10)^2=\$1.21$$

The geometric mean, when compounded, results in the median of the distribution:

$$\$1\times(1+0.082)^2=\$1.17$$

The arithmetic mean equates the expected future value with the present value; it is therefore the appropriate discount rate.

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IBBOTSON
ASSOCIATES

Calculating the Expected Equity Risk Premium

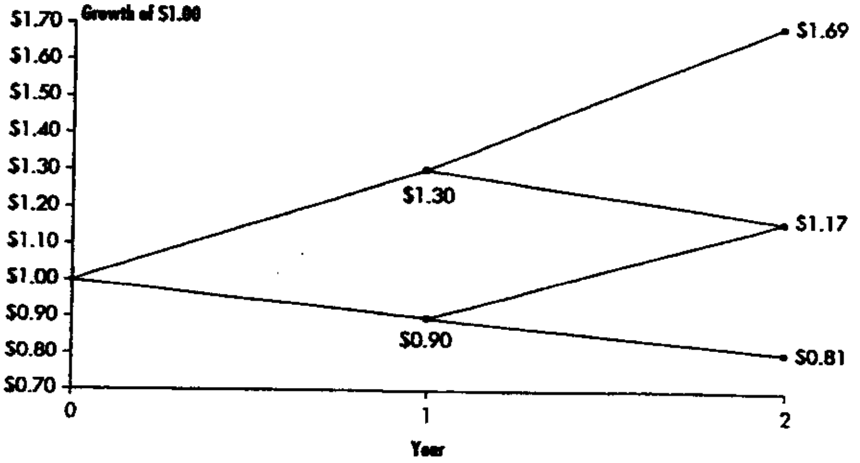
Arithmetic Versus Geometric Differences

For use as the expected equity risk premium in the CAPM, the ***arithmetic*** or ***simple difference*** of the ***arithmetic means*** of stock market returns and riskless rates is the relevant number. This is because the CAPM is an additive model where the cost of capital is the sum of its parts. Therefore, the CAPM expected equity risk premium must be derived by arithmetic, ***not geometric***, subtraction.

Arithmetic Versus Geometric Means

The expected equity risk premium should always be calculated using the arithmetic mean. The arithmetic mean is the rate of return which, when compounded over multiple periods, gives the mean of the probability distribution of ending wealth values. (A simple example given below shows that this is true.) This makes the arithmetic mean return appropriate for computing the cost of capital. The discount rate that equates expected (mean) future values with the present value of an investment is that investment's cost of capital. The logic of using the discount rate as the cost of capital is reinforced by noting that investors will discount their expected (mean) ending wealth values from an investment back to the present using the arithmetic mean, for the reason given above. They will, therefore, require such an expected (mean) return prospectively (that is, in the present looking toward the future) to commit their capital to the investment.

For example, assume a stock has an expected return of +10 percent in each year and a standard deviation of 20 percent. Assume further that only two outcomes are possible each year— +30 percent and -10 percent (that is, the mean plus or minus one standard deviation), and that these outcomes are equally likely. (The arithmetic mean of these returns is 10 percent, and the geometric mean is 8.2 percent.) Then the growth of wealth over a two-year period occurs as shown below:



Note that the median (middle outcome) and mode (most common outcome) are given by the geometric mean, 8.2 percent, which compounds up to 17 percent over a 2-year period (hence a terminal wealth of $1.17). However, the *expected value*, or probability-weighted average of all possible outcomes, is equal to:

	(.25	x	1.69)	=	0.4225
+	(.50	x	1.17)	=	0.5850
+	(.25	x	0.81)	=	0.2025
TOTAL					1.2100

Now, the rate that must be compounded up to achieve a terminal wealth of $1.21 after 2 years is 10 percent; that is, the expected value of the terminal wealth is given by compounding up the *arithmetic*, not the geometric mean. Since the arithmetic mean equates the expected future value with the present value, it is the discount rate.

Stated another way, the arithmetic mean is correct because an investment with uncertain returns will have a higher expected ending wealth value than an investment that earns, with certainty, its compound or geometric rate of return every year. In the above example, compounding at the rate of 8.2 percent for two years yields a terminal wealth of $1.17, based on $1.00 invested. But holding the uncertain investment, with a possibility of high returns (two +30 percent years in a row) as well as low returns (two -10 percent years in a row), yields a higher expected terminal wealth, $1.21. In other words, more money is gained by higher-than-expected returns than is lost by lower-than-expected returns. Therefore, in the investment markets, where returns are described by a probability distribution, the arithmetic mean is the measure that accounts for uncertainty, and is the appropriate one for estimating discount rates and the cost of capital.

Arbitrage Pricing Theory

APT is a model of the expected return on a security. It was originated by Stephen A. Ross, and elaborated by Richard Roll. APT treats the expected return on a security (*i.e.*, its cost of capital) as the sum of the payoffs for an indeterminate number of risk factors, where the amount of each risk factor inherent in a given security is estimated. Like the CAPM, APT is a model that is consistent with equilibrium and does not attempt to outguess the market. APT may be viewed as an extended CAPM with multiple "betas" and multiple risk premia.

REGULATORY FINANCE:

UTILITIES' COST OF CAPITAL

Roger A. Morin, PhD

in collaboration with
Lisa Todd Hillman

1994
PUBLIC UTILITIES REPORTS, INC.
Arlington, Virginia

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The *Hope* and *Bluefield* cases established the fundamental premise that investors should receive a return commensurate with returns currently available on comparable risk investments, not that investors be guaranteed a return coinciding with their initial return expectations. Consequently, the determination of a fair and reasonable return on equity should rest preferably on investor expectations, and historical risk premiums should be based on expected returns rather than on realized returns, data permitting.

While forward-looking risk premiums based on expected returns are preferable, historical return studies over long periods still provide a useful guide for the future. This is because over long periods investor expectations and realizations converge. Otherwise, investors would never commit investment capital. Investors expectations are eventually revised to match historical realizations, as market prices adjust to bring anticipated and actual investment results into conformity. In the long-run, the difference between expected and realized risk premiums will decline because short-run periods during which investors earn a lower risk premium than they expect are offset by short-run periods during which investors earn a higher risk premium than they expect.

Computational Issues

The third problem in relying on historical return results is the method of averaging historical returns.

Geometric v. Arithmetic Averages. One major issue relating to the use of realized returns is whether to use the ordinary average (arithmetic mean) or the geometric mean return. Only arithmetic means are correct for forecasting purposes and for estimating the cost of capital. When using historical risk premiums as a surrogate for the expected market risk premium, the relevant measure of the historical risk premium is the arithmetic average of annual risk premiums over a long period of time. This is formally shown in *Principles of Corporate Finance,* a widely used and respected textbook on corporate finance by Brealey and Myers (1991). Appendix 11-A illustrates that only arithmetic averages can be used as estimates of cost of capital, and that the geometric mean is not an appropriate measure of cost of capital. A widely-used Ibbotson Associates publication title contains a rigorous discussion of the impropriety of using geometric averages in estimating the cost of capital (Ibbotson Associates 1993).

The use of the arithmetic mean appears counter-intuitive at first glance, because we commonly use the geometric mean return to measure the average annual achieved return over some time period. In estimating the cost of capital, the goal is to obtain the rate of return that investors expect, that is, a target rate of return. On average, investors expect to achieve their target return. This target expected return is in effect an arithmetic average. The achieved or retrospective return is the geometric average. In statistical parlance, the arithmetic average is the unbiased measure of the expected value of repeated observations of a random variable, not the geometric mean.

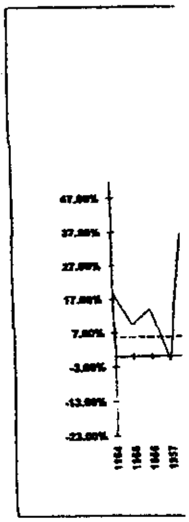
The geometric mean answers the question of what constant return an investor would have to achieve in each year to have his or her investment growth match the return achieved by the stock market. The arithmetic mean answers the question of what growth rate is the best estimate of the future amount of money that will be produced by continually reinvesting in the stock market. It is the rate of return that, compounded over multiple periods, gives the mean of the probability distribution of ending wealth.

While the geometric mean is the best estimate of performance over a long period of time, this does not contradict the statement that the arithmetic mean compounded over a number of years that an investment is held provides the best estimate of the ending wealth value of the investment. The reason is that an investment with uncertain returns will have a higher ending wealth value than an investment that simply earns (with certainty) its compound or geometric rate of return every year. In other words, more money, or terminal wealth, is gained by the occurrence of higher than expected returns than is lost by lower than expected returns.

In capital markets, where returns are a probability distribution, the answer that takes account of uncertainty, the arithmetic mean, is the correct one for estimating discount rates and the cost of capital.

EXAMPLE 11-1

A historical risk premium for Peoples Gas, a subsidiary of Consolidated Natural Gas, was estimated with an annual time series analysis from 1954 to 1992 applied to the gas distribution industry as a whole, using Moody's Gas Distribution Utility Index as an industry proxy. The analysis is depicted in Figure 11-2.



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Appendix 11-A

Comparison of the Use of Arithmetic and Geometric Means in Estimating the Cost of Capital

This appendix shows why arithmetic rather than geometric means should be used for forecasting, discounting, and estimating the cost of capital. Similar treatments and demonstrations are available from Brealey and Myers (1991), Ibbotson Associates (1993), and Litzenberger (1984). This appendix draws from the three aforementioned sources, particularly the latter.

By definition, the cost of equity capital is the annual discount rate that equates the discounted value of expected future cash flows (from dividends and the sale of the stock at the end of the investor's investment horizon) to the current market price of a share in the firm. The discount rate that equates the discounted value of future expected dividends and the end of period expected stock price to the current stock price is a prospective arithmetic, rather than a prospective geometric mean rate of return. Since future dividends and stock prices cannot be predicted with certainty, the "expected" annual rate of return that investors require is an average "target" percentage rate around which the actual, year-by-year returns will vary. This target rate is, in effect, an arithmetic average.

A numerical illustration adapted from Litzenberger (1984) will clarify this important point. Consider a non-dividend paying stock trading for $100 which has, in every year, an equal chance of appreciating by 20% or declining by 10%. Thus, after one year, there is an equal chance that the stock's price will be $120 and an equal chance the price will be $90. Figure 11A-1 presents all possible eventualities after two periods have elapsed (the rates of return are presented at the end of the lines in the diagram).

The possible stock prices are shown in the following table.

TABLE 11A-1
STOCK PRICES AFTER TWO PERIODS

Price	Chance
$144	1 chance in 4
$108	2 chances in 4
$ 81	1 chance in 4

The expected future stock price after two periods is then:

$$1/4\ (\$144) + 2/4\ (\$108) + 1/4(\$81) = \$110.25$$

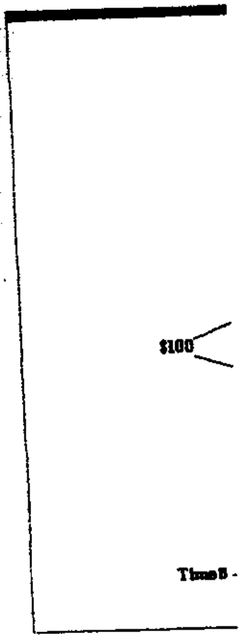

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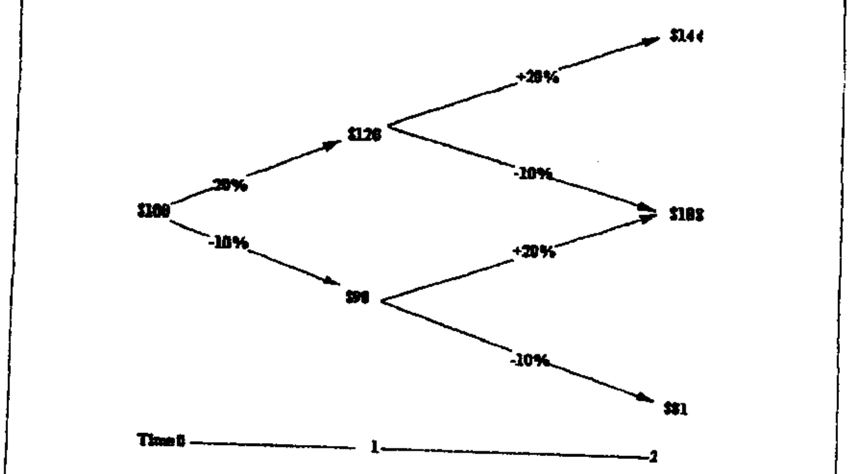
FIGURE 11A-1
POSSIBLE STOCK PRICES



The cost of equity capital is calculated as the discount rate that equates the present value of the future expected cash flows to the current stock price. In the present simple example, the only cash flow is the gain from selling the stock after two periods have elapsed. Thus, using the expected stock price of $110.25 calculated above, the expected rate of return is that r, which solves the following equation:

$$\text{Current Stock Price} = \frac{\text{Expected Stock Price}}{(1 + r)^2}$$

The factor $(1 + r)^2$ discounts the expected stock price to the present. Substituting the numerical values, we have:

$$\$100 = \frac{\$100.25}{(1 + r)^2}$$

$$r = 5\%$$

Thus, the cost of equity capital is 5%. This 5% cost of equity capital is equal to the prospective arithmetic mean rate of return, which is the probability-weighted average single period rate of return on equity. Since in every period there is an equal chance that the stock's return will be 20% or -10%, the probability-weighted average is:

$$1/2\,(20\%) + 1/2\,(-10\%) = 5\%$$

However, the 5% cost of equity capital is not equal to the prospective geometric mean rate of return, which is a probability-weighted average of the possible compounded rates of return over the two periods. Now consider the prospective geometric mean rate of return. Table 11A-2 shows the possible compounded rates of return over two periods, and the probability of each.

TABLE 11A-2
STOCK PRICES AND RETURNS AFTER TWO PERIODS

Price	Chance	Compounded Return
$144	1 chance in 4	20.00%
$108	2 chances in 4	3.92%
$ 81	1 chance in 4	-10.00%

Thus, the prospective geometric mean rate of return is:

$$1/4\,(20\%) = 2/4\,(3.92\%) + 1/4\,(-10\%) = 4.46\%$$

This return is not equal to the 5% cost of equity capital.

Litzenberger (1984) extended the example to include the case of a dividend-paying company and reached the same conclusion: the implied discount rate calculated in the DCF model is an expected arithmetic rather than an expected geometric mean rate of return.

The foregoing analysis shows that it is erroneous to use a prospective multi-year geometric mean rate of return as a "target" rate of return for each year of the period. If, for example, investors currently require an expected future rate of return on an investment of 13% each year, then 13% is the appropriate annual rate of return on equity for ratemaking purposes. Consequently, in using a risk premium approach for the purposes of rate of return regulation, the single-year annual required rate of return should be estimated using arithmetic mean risk premiums.

Chapter 1
Capital A

This chapter desc
to cost of capital
public utilities.
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realized. Realized returns can be substantially different from prospective returns anticipated by investors especially over short time periods. But over very long periods, such as the 1926-1992 period, investor expectations coincide with realizations; otherwise, investors would never invest any money. Note also that the entire period for which data are available should be used and all years weighted equally. There is no reason to weigh recent returns more heavily than distant returns because of the random behavior of the market risk premium.

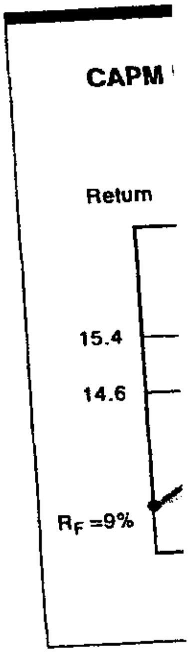
In Chapter 11, it was shown that the arithmetic average of year-to-year risk premiums over an extended time period is the appropriate one for measuring the cost of capital, and not the geometric mean return. This is because the arithmetic mean return, compounded over the number of years that an investment is held, provides the best estimate of the ending wealth value of that investment.

Cost of capital is synonymous with investor expected return. The expected return is not guaranteed, of course. Deviations around the expected return are likely to occur. In good years, the actual return will exceed the expected return, and conversely in bad years. But on average, over long time periods, investors expectations are achieved, or else no one would invest funds. Looking forward, the expected return is an arithmetic mean. Looking backward, the historical achieved return is a geometric average. When looking at the future, the arithmetic mean is relevant. When examining the past, the geometric mean is relevant. In statistical parlance, the arithmetic average is the unbiased measure of the expected value of repeated observations of a random variable, not the geometric mean.

As in the case of the beta estimate and risk-free rate estimate, a sensitivity analysis of possible CAPM cost of capital estimates should be conducted for a specified utility using a reasonable range of estimates for the market return. See Figure 12-7 for an illustration.

The range of cost of capital estimates obtained using a separate range for each of the three input variables to the CAPM—beta, risk-free rate, and market return—can be combined to produce an overall sensitivity analysis for the cost of equity value. This is illustrated in Figure 12-8, where the range of estimates obtained is 12.55% to 16.65%, with a midpoint value of 14.6%. See Rhyne (1982) for a similar illustration.

The broad range of estimates obtained is typical of CAPM application. The results obtained will vary somewhat depending upon the choice of proxies.



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NON-DIVIDEND PAYING STOCKS IN THE VALUE LINE UNIVERSE

Page No.	Number of Stocks Not Paying Dividends
2	23
3	31
4	33
5	28
6	40
7	41
8	34
9	33
10	32
11	28
12	43
13	30
14	34
15	31
16	45
17	28
18	30
19	40
20	35
21	32
22	36
23	19
Total Non-Div Payers	726
Total Companies in VL Universe	1700
Non-Div Payers as % of Universe	42.7%

Source: Value Line *Summary & Index*, March 5, 2004.

THE VALUE LINE®
Investment Survey®

Part 1
Summary & Index

File at the front of the *Ratings & Reports* binder. Last week's *Summary & Index* should be removed.

March 5, 2004

TABLE OF SUMMARY & INDEX CONTENTS

Summary & Index Page Number

SCREENS

The Median of Estimated
PRICE-EARNINGS RATIOS
of all stocks with earnings

19.2

26 Weeks Ago	Market Low 9-21-01	Market High 4-16-02
17.5	15.4	20.9

The Median of Estimated
DIVIDEND YIELDS
(next 12 months) of all dividend paying stocks under review

1.6%

26 Weeks Ago	Market Low 9-21-01	Market High 4-16-02
1.9%	2.2%	1.6%

The Estimated Median Price
APPRECIATION POTENTIAL
of all 1700 stocks in the hypothesized economic environment 3 to 5 years hence

45%

26 Weeks Ago	Market Low 9-21-01	Market High 4-16-02
55%	105%	55%

ANALYSES OF INDUSTRIES IN ALPHABETICAL ORDER WITH PAGE NUMBER

Numeral in parenthesis after the industry is rank for probable performance (next 12 months).

	PAGE		PAGE		PAGE		PAGE
Advertising (44)	1923	Educational Services (6)	1584	Insurance (Prop/Cas.) (28)	585	Railroad (32)	285
Aerospace/Defense (30)	543	Electrical Equipment (61)	1001	Internet (1)	2228	R.E.I.T. (98)	1176
Air Transport (36)	253	Electric Util. (Central) (95)	695	Investment Co. (33)	963	Recreation (65)	1841
Apparel (75)	1651	*Electric Utility (East) (96)	154	Investment Co.(Foreign) (17)	364	Restaurant (31)	840, 293
*Auto & Truck (45)	181	Electric Utility (West) (92)	1774	Machinery (72)	1331	Retail Automotive (34)	1665
Auto Parts (27)	798	Electronics (24)	1024	Manuf. Housing/RV (12)	1554	Retail Building Supply (14)	881
Bank (67)	2101	Entertainment (23)	1862	Maritime (13)	278	Retail (Special Lines) (38)	1708
Bank (Canadian) (51)	1570	Entertainment Tech (40)	1598	Medical Services (8)	629	Retail Store (37)	1673
Bank (Midwest) (81)	613	Environmental (57)	353	*Medical Supplies (22)	178	Securities Brokerage (58)	1425
Beverage (Alcoholic) (64)	1537	Financial Svcs. (Div.) (26)	2133	Metal Fabricating (94)	565	Semiconductor (11)	1053
Beverage (Soft Drink) (15)	1545	Food Processing (71)	1481	Metals & Mining (Div.) (10)	1227	Semiconductor Equip (41)	1094
Biotechnology (63)	671	Food Wholesalers (47)	1532	Natural Gas (Distrib.) (97)	458	Shoe (66)	1695
Building Materials (76)	851	Foreign Electronics (28)	1561	Natural Gas (Div.) (53)	437	Steel (General) (69)	575
Cable TV (52)	831	Foreign Telecom. (4)	771	Newspaper (79)	1909	Steel (Integrated) (83)	1415
Canadian Energy (86)	428	Furn/Home Furnishings (70)	895	Office Equip/Supplies (49)	1139	Telecom. Equipment (5)	745
Cement & Aggregates (46)	886	Grocery (77)	1517	Oilfield Svcs/Equip. (82)	1943	Telecom. Services (43)	719
Chemical (Basic) (88)	1237	Healthcare Information (18)	658	Packaging & Container (89)	927	Thrift (90)	1161
Chemical (Diversified) (74)	1965	*Home Appliance (48)	117	Paper/Forest Products (87)	909	*Tire & Rubber (29)	111
Chemical (Specialty) (78)	477	Homebuilding (2)	867	Petroleum (Integrated) (55)	405	Tobacco (91)	1577
Coal (93)	526	Hotel/Gaming (62)	1877	Petroleum (Producing) (50)	1932	Toiletries/Cosmetics (9)	820
Computers/Peripherals (25)	1109	Household Products (84)	944	Pharmacy Services (3)	786	Trucking (59)	266
Computer Software/Svcs (19)	2171	Human Resources (73)	1287	Power (60)	978	Water Utility (80)	1421
Diversified Co. (55)	1377	Industrial Services (68)	323	Precious Metals (35)	1218	Wireless Networking (21)	511
Drug (42)	1244	Information Services (16)	379	*Precision Instrument (54)	124		
E-Commerce (7)	1435	Insurance (Life) (39)	1204	Publishing (85)	1895		

*Reviewed in this week's issue.

In three parts: This is Part 1, the Summary & Index. Part 2 is Selection & Opinion. Part 3 is Ratings & Reports. Volume LIX, No. 27.
Published weekly by VALUE LINE PUBLISHING, INC. 220 East 42nd Street, New York, N.Y. 10017-5891

Company		S&P 500
Average Price		100.00
Indicated Dividend		1.75
5-Yr Pr. Growth		13.0
L-T Pr. Growth in GDP		5.91
IRR		8.41
		S&P 500 Cash Flow
	Price	-100.00
Year	1	1.98
	2	2.23
	3	2.53
	4	2.85
	5	3.22
	6	3.41
	7	3.62
	8	3.83
	9	4.06
	10	4.30
	11	4.55
	12	4.82
	13	5.10
	14	5.41
Calculation	15	5.73
Continues	16	6.06
on through	17	6.42
Year 200	18	6.80
↓	19	7.20
	20	7.63

Date	Medium Projected Price Appreciation for VL Universe
09/19/03	50
09/26/03	50
10/03/03	50
10/10/03	50
10/17/03	50
10/24/03	45
10/31/03	50
11/07/03	45
11/14/03	45
11/21/03	45
11/28/03	45
12/05/03	45
12/12/03	40
12/19/03	45
12/26/03	40
01/02/04	40
01/09/04	35
01/16/04	35
01/23/04	35
01/30/04	35
02/06/04	35
02/13/04	40
Average	43
Median	45

Source: Value Line Summary & Index.

Value Line's 3- to 5-year Price Appreciation Potential—An Update

The following is an update to the evaluation of our 3- to 5-year price appreciation potential that was first published on November 8, 2002. That article and accompanying chart detailed the methodology behind our evaluation and discussed some of the more interesting results. For the benefit of our subscribers, we briefly review the methodology used for this, and the previous, evaluation.

Price Appreciation Potential

The estimate of the median price appreciation potential is found by first calculating the percentage change between the current price of each stock in our universe and the middle of its 3- to 5-year Target Price Range. These figures are then arrayed, and the median price appreciation potential is determined. We select the median of the array (the middle) as the most likely price, in order to play down the effect of outliers, that is, excessively large or small percentage price changes.

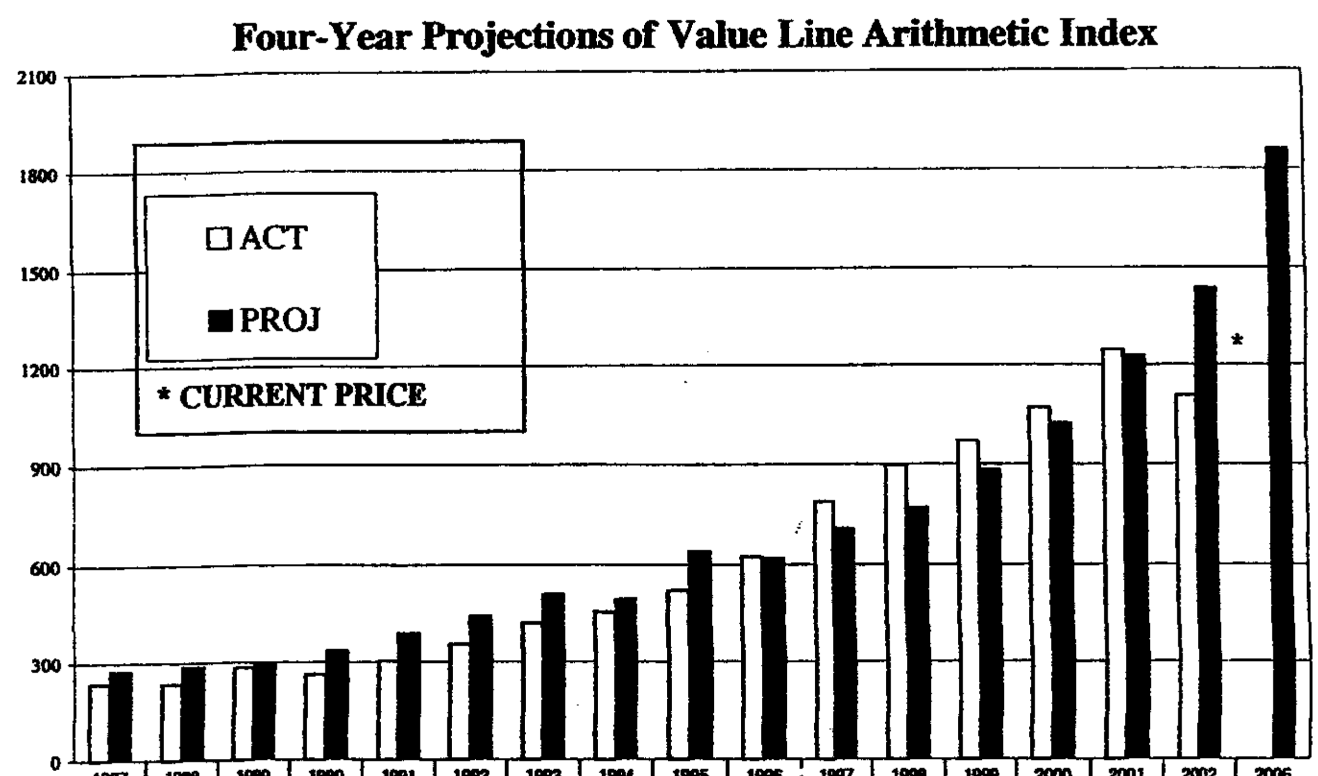
The chart included below depicts the results of those projections from 1983 to 2002, using the Value Line Arithmetic Index as our measure of the market. For simplicity sake, we take the actual price as the average of the middle year of the 3- to 5-year forecast, so that a projection made at the end of 1983 would be compared to the average price of the index in 1987. Strictly speaking this would be a 3 1/2 year forecast, from the end of 1983 to midyear 1987.

Update for 2002

In contrast to the 1997-2001 period, our estimate for the 4-year appreciation potential for the Value Line Arithmetic Index turned out to be too high by some 30% in 2002. The projection was based on earnings estimates made at the end of 1998—during the heady days of the market bubble.

The current projection for 2006 stands at 1,860. This figure is based on estimates made in the far more sober market environment at the end of 2002. Meanwhile, the Value Line Arithmetic Index has already risen by about 22% since that date.

Samuel Eisenstadt
Research Chairman



	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2006
☐ ACT	236	234	281	262	303	354	421	455	518	621	788	897	971	1072	1247	1107	
■ PROJ	274	287	296	335	390	442	508	495	637	618	707	769	883	1024	1228	1438	1860

Table 7-14

Size Effect within Industries

Summary Statistics and Excess Returns

(Through Year-end 2002)

			Large Company Group		
SIC Code	**Description**	**Years**	**Geometric Mean**	**Arithmetic Mean**	**Standard Deviation**
10	Metal Mining	77	7.21%	10.77%	29.04%
13	Oil and Gas Extraction	40	9.48%	12.34%	25.76%
15	Building Construction-General Contractors & Op. Builders	31	10.23%	16.54%	38.09%
16	Hvy. Construction Other than Bldg. Construction-Contractors	32	5.05%	8.60%	30.33%
20	Food and Kindred Spirits	77	11.14%	12.83%	19.30%
22	Textile Mill Products	77	6.87%	11.92%	33.55%
23	Apparel & other Finished Products Made from Fabrics & Similar	43	7.77%	12.71%	33.92%
24	Lumber and Wood Products, Except Furniture	40	8.45%	10.99%	24.67%
25	Furniture and Fixtures	33	10.03%	12.50%	22.90%
26	Paper & Allied Products	74	10.53%	13.67%	27.25%
27	Printing, Publishing and Allied Products	44	11.32%	13.48%	21.33%
28	Chemicals and Allied Products	77	11.90%	14.11%	22.82%
29	Petroleum Refining & Related Industries	77	10.93%	13.10%	21.71%
30	Rubber & Miscellaneous Plastics Products	56	10.34%	13.11%	25.66%
31	Leather & Leather Products	40	11.56%	16.10%	33.90%
32	Stone, Clay, Glass & Concrete Products	74	8.18%	12.17%	32.20%
33	Primary Metal Industries	77	7.13%	11.15%	30.74%
34	Fabricated Metal Products, Except Machinery & Trans. Equip.	75	8.68%	11.28%	23.49%
35	Industrial & Commercial Machinery & Computer Equipment	77	10.43%	13.94%	28.05%
36	Electrical Equipment & Components, Except Computer	77	9.54%	13.24%	28.34%
37	Transportation Equipment	77	10.63%	15.01%	32.63%
38	Measuring, Analyzing & Controlling Instruments	66	11.82%	13.97%	22.29%
39	Miscellaneous Manufacturing Industries	43	9.01%	13.17%	30.02%
40	Railroad Transportation	77	8.72%	11.75%	24.93%
42	Motor Freight Transportation & Warehousing	39	9.35%	12.97%	28.99%
45	Transport by Air	57	6.84%	11.46%	33.22%
48	Communications	40	8.92%	11.38%	22.85%
49	Electric, Gas & Sanitary Services	77	8.35%	10.53%	21.94%
50	Wholesale Trade-Durable Goods	57	9.54%	11.76%	22.65%
51	Wholesale Trade-Nondurable Goods	35	9.81%	13.00%	25.92%
53	General Merchandise Stores	77	10.03%	13.38%	27.09%
54	Food Stores	46	11.35%	14.00%	24.07%
56	Apparel & Accessory Stores	56	13.57%	17.83%	32.87%
57	Home Furniture, Furnishings, and Equipment Stores	30	11.72%	23.91%	62.89%
58	Eating and Drinking Places	34	9.73%	14.49%	34.17%
59	Miscellaneous Retail	40	12.08%	15.52%	27.67%
60	Depository Institutions	34	11.04%	13.27%	21.82%
61	Nondepository Credit Institutions	53	12.82%	15.73%	26.91%
62	Security and Commod. Brokers, Dealers, Exchanges	30	17.11%	24.47%	45.05%
63	Insurance Carriers	34	9.81%	11.81%	21.07%
64	Insurance Agents, Brokers, and Service	30	14.67%	16.28%	19.15%
65	Real Estate	40	6.31%	10.83%	30.79%
67	Holding & Other Investment Offices	73	9.72%	12.99%	25.65%
70	Hotels, Rooming Houses, Camps, & Other Lodging	33	8.45%	14.32%	35.82%
72	Personal Services	33	7.55%	12.42%	31.29%
73	Business Services	40	9.88%	15.00%	33.64%
78	Motion Pictures	53	11.67%	16.35%	33.60%
79	Amusement and Recreation Services	30	11.82%	15.66%	27.97%
80	Health Services	31	11.83%	18.05%	37.43%

Table 7-14 (continued)

Size Effect within Industries
Summary Statistics and Excess Returns

(Through Year-end 2002)

		Small Company Group			
SIC Code	**Description**	**Geometric Mean**	**Arithmetic Mean**	**Standard Deviation**	**Excess Return**
10	Metal Mining	7.26%	14.63%	43.59%	3.86%
13	Oil and Gas Extraction	9.38%	17.64%	47.01%	5.30%
15	Building Construction-General Contractors & Op. Builders	3.57%	13.12%	44.17%	-3.42%
16	Hvy. Construction Other than Bldg. Construction-Contractors	15.95%	20.58%	35.16%	11.98%
20	Food and Kindred Spirits	11.50%	15.02%	29.58%	2.19%
22	Textile Mill Products	9.40%	15.06%	34.99%	3.14%
23	Apparel & other Finished Products Made from Fabrics & Similar	5.13%	11.27%	39.13%	-1.44%
24	Lumber and Wood Products, Except Furniture	10.65%	21.32%	54.76%	10.33%
25	Furniture and Fixtures	6.92%	11.10%	30.09%	-1.40%
26	Paper & Allied Products	11.27%	17.43%	41.36%	3.76%
27	Printing, Publishing and Allied Products	16.06%	18.80%	24.32%	5.32%
28	Chemicals and Allied Products	12.77%	18.14%	39.09%	4.03%
29	Petroleum Refining & Related Industries	11.61%	16.01%	31.65%	2.91%
30	Rubber & Miscellaneous Plastics Products	13.11%	17.48%	32.72%	4.37%
31	Leather & Leather Products	9.98%	14.96%	33.92%	-1.14%
32	Stone, Clay, Glass & Concrete Products	9.16%	14.04%	33.37%	1.87%
33	Primary Metal Industries	11.20%	16.55%	36.52%	5.40%
34	Fabricated Metal Products, Except Machinery & Trans. Equip.	10.30%	15.81%	36.86%	4.53%
35	Industrial & Commercial Machinery & Computer Equipment	11.04%	16.13%	33.84%	2.19%
36	Electrical Equipment & Components, Except Computer	11.33%	19.05%	44.63%	5.81%
37	Transportation Equipment	11.72%	18.04%	38.46%	3.03%
38	Measuring, Analyzing & Controlling Instruments	12.05%	16.60%	32.76%	2.63%
39	Miscellaneous Manufacturing Industries	8.56%	13.33%	33.03%	0.16%
40	Railroad Transportation	7.89%	14.21%	36.39%	2.46%
42	Motor Freight Transportation & Warehousing	5.27%	11.25%	39.03%	-1.72%
45	Transport by Air	7.30%	15.65%	48.22%	4.19%
48	Communications	16.68%	24.44%	44.34%	13.06%
49	Electric, Gas & Sanitary Services	9.74%	13.47%	30.17%	2.94%
50	Wholesale Trade-Durable Goods	9.92%	15.18%	36.50%	3.42%
51	Wholesale Trade-Nondurable Goods	8.04%	11.72%	28.40%	-1.28%
53	General Merchandise Stores	8.23%	15.80%	43.61%	2.42%
54	Food Stores	7.98%	11.61%	28.58%	-2.39%
56	Apparel & Accessory Stores	10.95%	17.32%	39.73%	-0.51%
57	Home Furniture, Furnishings, and Equipment Stores	14.86%	26.25%	53.47%	2.34%
58	Eating and Drinking Places	-0.17%	6.02%	37.93%	-8.47%
59	Miscellaneous Retail	11.71%	17.35%	36.89%	1.83%
60	Depository Institutions	14.77%	17.55%	25.65%	4.28%
61	Nondepository Credit Institutions	11.22%	15.32%	30.35%	-0.41%
62	Security and Commod. Brokers, Dealers, Exchanges	13.20%	20.07%	40.90%	-4.40%
63	Insurance Carriers	12.23%	15.12%	24.16%	3.31%
64	Insurance Agents, Brokers, and Service	11.24%	18.19%	39.67%	1.91%
65	Real Estate	4.97%	9.89%	34.93%	-0.94%
67	Holding & Other Investment Offices	11.21%	15.69%	32.17%	2.70%
70	Hotels, Rooming Houses, Camps, & Other Lodging	4.53%	10.96%	38.33%	-3.36%
72	Personal Services	14.98%	18.56%	27.53%	6.14%
73	Business Services	12.35%	22.04%	60.11%	7.04%
78	Motion Pictures	3.18%	10.03%	41.37%	-6.32%
79	Amusement and Recreation Services	12.01%	17.01%	37.77%	1.35%
80	Health Services	13.56%	20.04%	41.03%	1.99%

Response of the Attorney General to
Requests for Information from
Louisville Gas & Electric Company
Case No. 2003-00433

Witness Responding: Carl G. K. Weaver

25. In reference to Schedules 38, 39 and 65:
    a. Provide a copy of the source of all data referenced.
    b. Provide all calculations, data, regressions, adjustments, assumptions, etc., used by Dr. Weaver in performing the CAPM calculations.

Answer:

a. Attached. The Note #3 in Schedule 39 should read as follows:

Forecasted 10-year Treasury Note rate @ 4.9% which is the average for the annual projected rates for the years 2005 through 2008 from the Office of the Management and Budget projections released August 27, 2003. (http://www.whitehouse.gov)

b. The CAPM calculations were performed as follows:

$$k_e = R_f + B\,(k_m - R_f)$$

and embrace all of the assumptions of the CAPM model.

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CALCULATION OF SPREAD BETWEEN MOODY'S UTILITY STOCKS AND BONDS

	Moody's Utility Common Stock Index			Long-Term Government Bond
Year	Year-End Price	Year-End Dividend	Market Return 1/	Income Return
	(1)	(2)	(3)	(4)
1931	$43.23			
1932	39.42	$2.22	-3.68 %	3.69
1933	28.73	1.75	-22.68	3.12
1934	21.06	1.42	-21.75	3.18
1935	36.06	1.33	77.54	2.81
1936	41.80	1.78	20.30	2.77
1937	24.24	1.68	-37.69	2.66
1938	27.55	1.45	19.64	2.64
1939	28.85	1.51	10.20	2.40
1940	22.22	1.57	-17.54	2.23
1941	13.45	1.27	-33.75	1.94
1942	14.29	1.28	15.76	2.46
1943	21.01	1.46	57.24	2.44
1944	21.09	1.35	6.81	2.46
1945	31.14	1.37	54.15	2.34
1946	32.71	1.48	9.79	2.04
1947	25.60	1.58	-16.91	2.13
1948	26.20	1.63	8.71	2.40
1949	30.57	1.68	23.09	2.25
1950	30.81	1.85	6.84	2.12
1951	33.85	1.90	16.03	2.38
1952	37.85	1.92	17.49	2.66
1953	39.61	2.09	10.17	2.84
1954	47.56	2.14	25.47	2.79
1955	49.35	2.27	8.54	2.75
1956	48.96	2.37	4.01	2.99
1957	50.30	2.46	7.76	3.44
1958	66.37	2.57	37.06	3.27
1959	65.77	2.64	3.07	4.01
1960	76.82	2.74	20.97	4.28
1961	99.32	2.86	33.01	3.83
1962	96.49	3.07	0.24	4.00
1963	102.31	3.33	9.48	3.89
1964	115.54	3.68	16.53	4.15
1965	114.66	4.02	2.89	4.19
1966	105.99	4.18	-4.08	4.49
1967	98.19	4.44	-3.17	4.59
1968	104.04	4.58	10.62	5.50
1969	84.62	4.83	-14.22	5.95
1970	88.59	4.73	10.28	6.74
1971	85.56	4.81	2.01	6.32
1972	83.61	4.92	3.47	5.87
1973	60.87	5.04	-21.17	6.51
1974	41.17	4.83	-24.43	7.27
1975	55.66	4.99	47.32	7.99
1976	66.29	5.25	28.53	7.89
1977	68.19	5.68	11.43	7.14
1978	59.75	5.98	-3.61	7.90
1979	56.41	6.34	5.02	8.86
1980	54.42	6.67	8.30	9.97
1981	57.20	7.16	18.27	11.55
1982	70.26	7.64	36.19	13.50
1983	72.03	8.00	13.91	10.38
1984	80.16	8.37	22.91	11.74
1985	94.98	8.71	29.35	11.25
1986	113.66	8.97	29.11	8.98
1987	94.24	9.12	-9.06	7.92
1988	100.94	8.71	16.35	8.97
1989	122.52	8.85	30.15	8.81
1990	117.77	8.76	3.27	8.19
1991	144.02	9.02	29.95	8.22
1992	141.06	8.82	4.07	7.26
1993	146.70	9.04	10.41	7.17
1994	115.50	9.01	-15.13	6.59
1995	142.90	9.06	31.57	7.60
1996	136.00	9.06	1.51	6.18
1997	155.08	9.06	20.69	6.64
1998	181.84	8.01	22.42	5.83
1999	137.30	8.06	-20.06	5.57
2000	227.09	8.71	71.74	6.50
2001	200.50	8.95	-7.77	5.53
2002	169.50	8.83	-11.06	5.59
2003	201.20	8.52	23.73	4.80
Average: 1955-2003			11.27 %	6.70

Average spread: Stocks - Bonds: 1955-2003 4.57 %

1/ ({[P(t)+D(t)]/P(t-1)}-1)x100

Source: Cols. (1) & (2)--Moody's Public Utility Manual and News Reports.
Col. (4)--Ibbotson Associates Valuation Edition, Table B7.

CALCULATION OF SPREAD BETWEEN MOODY'S UTILITY STOCKS AND BONDS

Year	Moody's Utility Common Stock Index Year-End Price	Year-End Dividend	Market Return 1/	Long-Term Government Bond Income Return
	(1)	(2)	(3)	(4)
1931	$43.23			
1932	39.42	$2.22	-3.68 %	3.69
1933	28.73	1.75	-22.68	3.12
1934	21.06	1.42	-21.75	3.18
1935	36.06	1.33	77.54	2.81
1936	41.60	1.78	20.30	2.77
1937	24.24	1.68	-37.69	2.66
1938	27.55	1.45	19.64	2.64
1939	28.85	1.51	10.20	2.40
1940	22.22	1.57	-17.54	2.23
1941	13.45	1.27	-33.75	1.94
1942	14.29	1.28	15.76	2.46
1943	21.01	1.46	57.24	2.44
1944	21.09	1.35	6.81	2.46
1945	31.14	1.37	54.15	2.34
1946	32.71	1.48	9.79	2.04
1947	25.60	1.58	-16.91	2.13
1948	26.20	1.63	8.71	2.40
1949	30.57	1.68	23.09	2.25
1950	30.81	1.85	6.84	2.12
1951	33.85	1.90	16.03	2.38
1952	37.85	1.92	17.49	2.66
1953	39.61	2.09	10.17	2.84
1954	47.56	2.14	25.47	2.79
1955	49.35	2.27	8.54	2.75
1956	48.96	2.37	4.01	2.99
1957	50.30	2.46	7.76	3.44
1958	66.37	2.57	37.06	3.27
1959	65.77	2.64	3.07	4.01
1960	76.82	2.74	20.97	4.26
1961	99.32	2.86	33.01	3.83
1962	96.49	3.07	0.24	4.00
1963	102.31	3.33	9.48	3.89
1964	115.54	3.68	16.53	4.15
1965	114.86	4.02	2.89	4.19
1966	105.99	4.18	-4.08	4.49
1967	98.19	4.44	-3.17	4.59
1968	104.04	4.58	10.62	5.50
1969	84.62	4.63	-14.22	5.95
1970	88.59	4.73	10.28	6.74
1971	85.56	4.81	2.01	6.32
1972	83.61	4.92	3.47	5.87
1973	60.87	5.04	-21.17	6.51
1974	41.17	4.83	-24.43	7.27
1975	55.66	4.99	47.32	7.99
1976	66.29	5.25	28.53	7.89
1977	68.19	5.68	11.43	7.14
1978	59.75	5.98	-3.61	7.90
1979	56.41	6.34	5.02	8.86
1980	54.42	6.67	8.30	9.97
1981	57.20	7.16	18.27	11.55
1982	70.26	7.64	36.19	13.50
1983	72.03	8.00	13.91	10.38
1984	80.16	8.37	22.91	11.74
1985	94.98	8.71	29.35	11.25
1986	113.66	8.97	29.11	8.98
1987	94.24	9.12	-9.06	7.92
1988	100.94	8.71	16.35	8.97
1989	122.52	8.85	30.15	8.81
1990	117.77	8.76	3.27	8.19
1991	144.02	9.02	29.95	8.22
1992	141.06	8.82	4.07	7.26
1993	146.70	9.04	10.41	7.17
1994	115.50	9.01	-15.13	6.59
1995	142.90	9.06	31.57	7.60
1996	136.00	9.06	1.51	6.18
1997	155.08	9.06	20.69	6.64
1998	181.84	8.01	22.42	5.83
1999	137.30	8.06	-20.06	5.57
2000	227.09	8.71	71.74	6.50
2001	200.50	8.95	-7.77	5.53
2002	169.50	8.63	-11.06	5.59
2003	201.20	8.52	23.73	4.80
Average			10.80 %	5.38

Average spread: Stocks - Bonds 5.42 %

1/ (([P(t)+D(t)]/P(t-1))-1)x100

Source: Cols. (1) & (2)--Moody's Public Utility Manual and News Reports.
Col. (4)--Ibbotson Associates Valuation Edition, Table B7.

CALCULATION OF SPREAD BETWEEN MOODY'S UTILITY STOCKS AND BONDS

Year	Moody's Utility Common Stock Index			Long-Term Government Bond Income Return			
	Year-End Price	Year-End Dividend	Market Return 1/		T	St	St-1
1931	$43.23						
1932	39.42	$2.22	-3.68 %	3.69	1	-7.37	
1933	28.73	1.75	-22.68	3.12	2	-25.80	-7.37
1934	21.06	1.42	-21.75	3.18	3	-24.93	-25.80
1935	36.06	1.33	77.54	2.81	4	74.73	-24.93
1936	41.60	1.79	20.30	2.77	5	17.53	74.73
1937	24.24	1.66	-37.69	2.66	6	-40.35	17.53
1938	27.55	1.45	19.64	2.64	7	17.00	-40.35
1939	28.85	1.51	10.20	2.40	8	7.80	17.00
1940	22.22	1.57	-17.54	2.23	9	-19.77	7.80
1941	13.45	1.27	-33.75	1.94	10	-35.69	-19.77
1942	14.29	1.28	15.76	2.46	11	13.30	-35.69
1943	21.01	1.46	57.24	2.44	12	54.80	13.30
1944	21.09	1.35	6.81	2.46	13	4.35	54.80
1945	31.14	1.37	54.15	2.34	14	51.81	4.35
1946	32.71	1.48	9.79	2.04	15	7.75	51.81
1947	25.60	1.56	-16.91	2.13	16	-19.04	7.75
1948	26.20	1.63	8.71	2.40	17	6.31	-19.04
1949	30.57	1.66	23.09	2.25	18	20.84	6.31
1950	30.81	1.85	6.84	2.12	19	4.72	20.84
1951	33.85	1.90	16.03	2.38	20	13.65	4.72
1952	37.65	1.92	17.49	2.66	21	14.83	13.65
1953	39.61	2.09	10.17	2.84	22	7.33	14.83
1954	47.56	2.14	25.47	2.79	23	22.68	7.33
1955	49.35	2.27	8.54	2.75	24	5.79	22.68
1956	48.96	2.37	4.01	2.99	25	1.02	5.79
1957	50.30	2.46	7.76	3.44	26	4.32	1.02
1958	66.37	2.57	37.06	3.27	27	33.79	4.32
1959	65.77	2.84	3.07	4.01	28	-0.94	33.79
1960	76.82	2.74	20.97	4.26	29	16.71	-0.94
1961	99.32	2.86	33.01	3.83	30	29.18	16.71
1962	96.49	3.07	0.24	4.00	31	-3.76	29.18
1963	102.31	3.33	9.48	3.89	32	5.59	-3.76
1964	115.54	3.68	16.53	4.15	33	12.38	5.59
1965	114.86	4.02	2.89	4.19	34	-1.30	12.38
1966	105.99	4.16	-4.08	4.49	35	-8.57	-1.30
1967	98.19	4.44	-3.17	4.59	36	-7.76	-8.57
1968	104.04	4.58	10.62	5.50	37	5.12	-7.76
1969	84.62	4.63	-14.22	5.95	38	-20.17	5.12
1970	88.59	4.73	10.28	6.74	39	3.54	-20.17
1971	85.58	4.61	2.01	6.32	40	-4.31	3.54
1972	83.61	4.92	3.47	5.87	41	-2.40	-4.31
1973	60.87	5.04	-21.17	6.51	42	-27.68	-2.40
1974	41.17	4.83	-24.43	7.27	43	-31.70	-27.68
1975	55.66	4.89	47.32	7.99	44	39.33	-31.70
1976	66.29	5.25	28.53	7.89	45	20.64	39.33
1977	68.19	5.66	11.43	7.14	46	4.29	20.64
1978	59.75	5.98	-3.61	7.90	47	-11.51	4.29
1979	56.41	6.34	5.02	8.86	48	-3.84	-11.51
1980	54.42	6.67	8.30	9.97	49	-1.67	-3.84
1981	57.20	7.16	18.27	11.55	50	6.72	-1.67
1982	70.26	7.64	36.19	13.50	51	22.69	6.72
1983	72.03	8.00	13.91	10.38	52	3.53	22.69
1984	80.16	8.37	22.91	11.74	53	11.17	3.53
1985	94.98	8.71	29.35	11.25	54	18.10	11.17
1986	113.66	8.97	29.11	8.98	55	20.13	18.10
1987	94.24	9.12	-9.06	7.92	56	-16.98	20.13
1988	100.94	8.71	16.35	8.97	57	7.38	-16.98
1989	122.52	8.85	30.15	8.81	58	21.34	7.38
1990	117.77	8.76	3.27	8.19	59	-4.92	21.34
1991	144.02	9.02	29.95	8.22	60	21.73	-4.92
1992	141.06	8.82	4.07	7.26	61	-3.19	21.73
1993	146.70	9.04	10.41	7.17	62	3.24	-3.19
1994	115.50	9.01	-15.13	6.59	63	-21.72	3.24
1995	142.80	9.08	31.57	7.60	64	23.97	-21.72
1996	136.00	9.06	1.51	6.18	65	-4.67	23.97
1997	155.08	9.06	20.69	6.64	66	14.05	-4.67
1998	181.84	8.01	22.42	5.83	67	16.59	14.05
1999	137.30	8.06	-20.06	5.57	68	-25.63	16.59
2000	227.09	8.71	71.74	6.50	69	65.24	-25.63
2001	200.50	8.95	-7.77	5.53	70	-13.30	65.24
2002	169.50	8.83	-11.06	5.59	71	-16.65	-13.30
2003	201.20	8.52	23.73	4.80	72	18.93	-16.65

	Column 1	*Column 2*
Column 1	1	
Column 2	-0.094175	1

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.005515
R Square	3.04E-05
Adjusted R	-0.014255
Standard E	21.9055
Observatio	72

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regressior	1	1.021809	1.021809	0.002129	0.963326
Residual	70	33589.57	479.851		
Total	71	33590.59			

	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	5.630467	5.217432	1.079164	0.284219	-4.775364	16.0363	-4.775364	16.0363
T	-0.005732	0.124219	-0.046146	0.963325	-0.253478	0.242014	-0.253478	0.242014

1/ (([P(t)+D(t)]/P(t-1)]-1)x100

Source: Cols. (1) & (2)—Moody's Public Utility Manual and News Reports.
Col. (4)—Ibbotson Associates Valuation Edition, Table B7.

U. S. Department of Defense

Case No. 2003-00433

Response to Initial Data Request of Louisville Gas and Electric Company

Question No. 3

Responding Witness: Kenneth L. Kincel

Q.2. In reference to Exhibit KLK-9, indicate why Mr. Kincel started his analysis in 1954, when there are data available earlier than that year.

A.2. Mr. Kincel used the same period for the electric utility industry as was available for the natural gas distribution industry, in order to perform a comparable analysis of industry risk premiums. If the data on Exhibit KLK-9 is extended to include all the data available, as shown in Attachment 1 to this response, the electric utility industry risk premium is increased from 4.27% to 5.23%. This is probably due to the Government's heavy drive to sell bonds, and the extended period of rationing where little else could be bought, during World War II. This is a period of time not truly comparable to the present, but one could argue that all available electric utility data should be used for the industry risk premium analysis when the comparable CAPM analysis employs risk premium data going back to 1926.

Using the 5.23% in the ROE calculation shown on Exhibit KLK-5, that is, adding the yield on 20-year Treasury bonds of 4.95%, results in an estimated ROE of 10.18%. This is near the high side, but within the reasonable range of ROE recommended by Mr. Kincel for the electric component of LG&E, namely 9.2% to 10.2%. This calculation is provided in this response only to indicate that use of all the available electric industry data would result in an ROE that would fall within Mr. Kincel's recommended reasonable range for ROE in his Direct Testimony, and would not change his recommended ROE for the electric utility component of LG&E of 10.0%.

Extended Exhibit KLK-9

Annual Long Term Risk Premium Analysis For Electric Utility Common Stocks Using Government Bond Income Returns

	Long Term Government	Electric Utility Common Stock Data					
Year	Bond Income Return*	Year End Stock Price	Capital Gain/Loss	Year End Dividend	Yield	Total Return	Equity Risk Premium
1931		43.23					
1932	0.0369	39.42	-0.0881	2.22	0.0514	-0.0366	-0.0737
1933	0.0312	28.73	-0.2712	1.75	0.0444	-0.2268	-0.2580
1934	0.0318	21.06	-0.2670	1.42	0.0494	-0.2175	-0.2493
1935	0.0281	36.06	0.7123	1.33	0.0632	0.7754	0.7473
1936	0.0277	41.60	0.1536	1.78	0.0494	0.2030	0.1753
1937	0.0266	24.24	-0.4173	1.68	0.0404	-0.3769	-0.4035
1938	0.0264	27.55	0.1366	1.45	0.0598	0.1964	0.1700
1939	0.0240	28.85	0.0472	1.51	0.0548	0.1020	0.0780
1940	0.0223	22.22	-0.2298	1.57	0.0544	-0.1754	-0.1977
1941	0.0194	13.45	-0.3947	1.27	0.0572	-0.3375	-0.3569
1942	0.0246	14.29	0.0625	1.28	0.0952	0.1576	0.1330
1943	0.0244	21.01	0.4703	1.46	0.1022	0.5724	0.5480
1944	0.0246	21.09	0.0038	1.35	0.0643	0.0681	0.0435
1945	0.0234	31.14	0.4765	1.37	0.0650	0.5415	0.5181
1946	0.0204	32.71	0.0504	1.48	0.0475	0.0979	0.0775
1947	0.0213	25.60	-0.2174	1.58	0.0483	-0.1691	-0.1904
1948	0.0240	26.20	0.0234	1.63	0.0637	0.0871	0.0631
1949	0.0225	30.57	0.1668	1.68	0.0641	0.2309	0.2084
1950	0.0212	30.81	0.0079	1.85	0.0605	0.0684	0.0472
1951	0.0238	33.85	0.0987	1.90	0.0617	0.1603	0.1365
1952	0.0266	37.85	0.1182	1.92	0.0567	0.1749	0.1483
1953	0.0284	39.61	0.0465	2.09	0.0552	0.1017	0.0733
1954	0.0279	47.56	0.2007	2.14	0.0540	0.2547	0.2268
1955	0.0275	49.35	0.0376	2.27	0.0477	0.0854	0.0579
1956	0.0299	48.96	-0.0079	2.37	0.0480	0.0401	0.0102
1957	0.0344	50.30	0.0274	2.46	0.0502	0.0776	0.0432
1958	0.0327	66.37	0.3195	2.57	0.0511	0.3706	0.3379
1959	0.0401	65.77	-0.0090	2.64	0.0398	0.0307	-0.0094
1960	0.0426	76.82	0.1680	2.74	0.0417	0.2097	0.1671
1961	0.0383	99.32	0.2929	2.86	0.0372	0.3301	0.2918
1962	0.0400	96.49	-0.0285	3.07	0.0309	0.0024	-0.0376
1963	0.0389	102.31	0.0603	3.33	0.0345	0.0948	0.0559
1964	0.0415	115.54	0.1293	3.68	0.0360	0.1653	0.1238
1965	0.0419	114.86	-0.0059	4.02	0.0348	0.0289	-0.0130
1966	0.0449	105.99	-0.0772	4.18	0.0364	-0.0408	-0.0857
1967	0.0459	98.19	-0.0736	4.44	0.0419	-0.0317	-0.0776
1968	0.0550	104.04	0.0596	4.58	0.0466	0.1062	0.0512
1969	0.0595	84.62	-0.1867	4.63	0.0445	-0.1422	-0.2017
1970	0.0674	88.59	0.0469	4.73	0.0559	0.1028	0.0354
1971	0.0632	85.56	-0.0342	4.81	0.0543	0.0201	-0.0431
1972	0.0587	83.61	-0.0228	4.92	0.0575	0.0347	-0.0240
1973	0.0651	60.87	-0.2720	5.04	0.0603	-0.2117	-0.2768

1974	0.0727	41.17	-0.3236	4.83	0.0793	-0.2443	-0.3170
1975	0.0799	55.66	0.3520	4.99	0.1212	0.4732	0.3933
1976	0.0789	66.29	0.1910	5.25	0.0943	0.2853	0.2064
1977	0.0714	68.19	0.0287	5.68	0.0857	0.1143	0.0429
1978	0.0790	59.75	-0.1238	5.98	0.0877	-0.0361	-0.1151
1979	0.0886	56.41	-0.0559	6.34	0.1061	0.0502	-0.0384
1980	0.0997	54.42	-0.0353	6.67	0.1182	0.0830	-0.0167
1981	0.1155	57.20	0.0511	7.16	0.1316	0.1827	0.0672
1982	0.1350	70.26	0.2283	7.64	0.1336	0.3619	0.2269
1983	0.1038	72.03	0.0252	8.00	0.1139	0.1391	0.0353
1984	0.1174	80.16	0.1129	8.37	0.1162	0.2291	0.1117
1985	0.1125	94.98	0.1849	8.71	0.1087	0.2935	0.1810
1986	0.0898	113.66	0.1967	8.97	0.0944	0.2911	0.2013
1987	0.0792	94.24	-0.1709	9.12	0.0802	-0.0906	-0.1698
1988	0.0897	100.94	0.0711	8.71	0.0924	0.1635	0.0738
1989	0.0881	122.52	0.2138	8.85	0.0877	0.3015	0.2134
1990	0.0819	117.77	-0.0388	8.76	0.0715	0.0327	-0.0492
1991	0.0822	144.02	0.2229	9.02	0.0766	0.2995	0.2173
1992	0.0726	141.06	-0.0206	8.82	0.0612	0.0407	-0.0319
1993	0.0717	146.70	0.0400	9.04	0.0641	0.1041	0.0324
1994	0.0659	115.50	-0.2127	9.01	0.0614	-0.1513	-0.2172
1995	0.0760	142.90	0.2372	9.06	0.0784	0.3157	0.2397
1996	0.0618	136.00	-0.0483	9.06	0.0634	0.0151	-0.0467
1997	0.0664	155.73	0.1451	9.06	0.0666	0.2117	0.1453
1998	0.0583	181.84	0.1677	8.01	0.0514	0.2191	0.1608
1999	0.0557	137.30	-0.2449	8.06	0.0443	-0.2006	-0.2563
2000	0.0650	227.09	0.6540	8.71	0.0634	0.7174	0.6524
2001	0.0553	200.50	-0.1171	8.95	0.0394	-0.0777	-0.1330
2002	0.0559	169.50	-0.1546	8.83	0.0440	-0.1106	-0.1665
Mean '65-'02	0.0674					0.1101	0.0427
Mean '32-'02	0.0539					0.1062	0.0523

* Ibbotson Associates utilizes Treasury bonds with 20 years to maturity.

Sources: For Bond Data: Ibbotson Associates, Stocks, Bonds, Bills, and Inflation, Valuation Edition 2003 Yeabook, Table B7.
For Electric Utility Common Stock Company Data: Mergent Public Utility Manual, 2003, pages a15, a16.

	Moody's Utility Common Stock Index			Moody's Utility Composite Bond Yield			
Year	Year-End Price	Year-End Dividend	Market Return 1/		Time	S t	S t-1
1931	$43.23						
1932	39.42	$2.22	-3.68 %	6.30	1	-9.98	
1933	28.73	1.75	-22.68	6.25	2	-28.93	-9.98
1934	21.06	1.42	-21.75	5.40	3	-27.15	-28.93
1935	36.06	1.33	77.54	4.43	4	73.11	-27.15
1936	41.60	1.78	20.30	3.88	5	16.42	73.11
1937	24.24	1.68	-37.69	3.93	6	-41.62	16.42
1938	27.55	1.45	19.64	3.87	7	15.77	-41.62
1939	28.85	1.51	10.20	3.48	8	6.72	15.77
1940	22.22	1.57	-17.54	3.25	9	-20.79	6.72
1941	13.45	1.27	-33.75	3.11	10	-36.86	-20.79
1942	14.29	1.28	15.76	3.11	11	12.65	-36.86
1943	21.01	1.46	57.24	2.99	12	54.25	12.65
1944	21.09	1.35	6.81	2.97	13	3.84	54.25
1945	31.14	1.37	54.15	2.87	14	51.28	3.84
1946	32.71	1.48	9.79	2.71	15	7.08	51.28
1947	25.60	1.58	-16.91	2.78	16	-19.69	7.08
1948	26.20	1.63	8.71	3.03	17	5.68	-19.69
1949	30.57	1.68	23.09	2.90	18	20.19	5.68
1950	30.81	1.85	6.84	2.82	19	4.02	20.19
1951	33.85	1.90	16.03	3.09	20	12.94	4.02
1952	37.85	1.92	17.49	3.20	21	14.29	12.94
1953	39.61	2.09	10.17	3.45	22	6.72	14.29
1954	47.56	2.14	25.47	3.15	23	22.32	6.72
1955	49.35	2.27	8.54	3.22	24	5.32	22.32
1956	48.96	2.37	4.01	3.54	25	0.47	5.32
1957	50.30	2.46	7.76	4.18	26	3.58	0.47
1958	66.37	2.57	37.06	4.10	27	32.96	3.58
1959	65.77	2.64	3.07	4.70	28	-1.63	32.96
1960	76.82	2.74	20.97	4.69	29	16.28	-1.63
1961	99.32	2.86	33.01	4.57	30	28.44	16.28
1962	96.49	3.07	0.24	4.51	31	-4.27	28.44
1963	102.31	3.33	9.48	4.41	32	5.07	-4.27
1964	115.54	3.68	16.53	4.53	33	12.00	5.07
1965	114.86	4.02	2.89	4.60	34	-1.71	12.00
1966	105.99	4.18	-4.08	5.36	35	-9.44	-1.71
1967	98.19	4.44	-3.17	5.81	36	-8.98	-9.44
1968	104.04	4.58	10.62	6.49	37	4.13	-8.98
1969	84.62	4.63	-14.22	7.49	38	-21.71	4.13
1970	88.59	4.73	10.28	8.68	39	1.60	-21.71
1971	85.56	4.81	2.01	8.13	40	-6.12	1.60
1972	83.61	4.92	3.47	7.74	41	-4.27	-6.12
1973	60.87	5.04	-21.17	7.83	42	-29.00	-4.27
1974	41.17	4.83	-24.43	9.27	43	-33.70	-29.00
1975	55.66	4.99	47.32	9.88	44	37.44	-33.70
1976	66.29	5.25	28.53	9.17	45	19.36	37.44
1977	68.19	5.68	11.43	8.58	46	2.85	19.36
1978	59.75	5.98	-3.61	9.22	47	-12.83	2.85
1979	56.41	6.34	5.02	10.39	48	-5.37	-12.83
1980	54.42	6.67	8.30	13.15	49	-4.85	-5.37
1981	57.20	7.16	18.27	15.62	50	2.65	-4.85
1982	70.26	7.64	36.19	15.33	51	20.86	2.65
1983	72.03	8.00	13.91	13.31	52	0.60	20.86
1984	80.16	8.37	22.91	14.03	53	8.88	0.60
1985	94.98	8.71	29.35	12.29	54	17.06	8.88
1986	113.66	8.87	28.11	9.46	55	18.65	17.06
1987	94.24	9.12	-9.06	9.98	56	-19.04	18.65
1988	100.94	8.71	16.35	10.45	57	5.90	-19.04
1989	122.52	8.85	30.15	9.66	58	20.49	5.90
1990	117.77	8.76	3.27	9.76	59	-6.49	20.49
1991	144.02	9.02	29.95	9.21	60	20.74	-6.49
1992	141.06	8.82	4.07	8.57	61	-4.50	20.74
1993	146.70	9.04	10.41	7.56	62	2.85	-4.50
1994	115.50	9.01	-15.13	8.30	63	-23.43	2.85
1995	142.90	9.06	31.57	7.91	64	23.66	-23.43
1996	136.00	9.06	1.51	7.74	65	-6.23	23.66
1997	155.08	9.06	20.69	7.63	66	13.06	-6.23
1998	181.84	8.01	22.42	7.00	67	15.42	13.06
1999	137.30	8.06	-20.06	7.55	68	-27.61	15.42
2000	227.09	8.71	71.74	8.14	69	63.60	-27.61
2001	200.80	8.95	-7.64	7.72	70	-15.36	63.60

	Column 1	*Column 2*
Column 1	1	
Column 2	-0.08524	1

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.004056
R Square	1.65E-05
Adjusted R	-0.01469
Standard E	22.21965
Observatio	70

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	1	0.552899	0.552899	0.00112	0.973402
Residual	68	33573.08	493.7218		
Total	69	33573.64			

	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	4.450886	5.368965	0.828996	0.410007	-6.28277	15.1845	-6.28277	15.1845
Time	-0.0044	0.13144	-0.03346	0.973402	-0.26868	0.257867	-0.26868	0.257867

1/ ((P(t)+D(t))/P(t-1))-1)x100

Source: Cols. (1), (2)&(4)--Moody's Public Utility Manual and News Reports.

Response of the Attorney General to
Requests for Information from
Louisville Gas & Electric Company
Case No. 2003-00433

Witness Responding: Carl G. K. Weaver

18. In reference the statement at page 22, line 19, that the high R_2 was due in part to autocorrelation:
    a. Provide all studies that Dr. Weaver performed on Mr. Rosenberg's second risk premium analysis that demonstrated the presence of autocorrelation.
    b. Provide, on a computer disk, all data and calculations used in the analysis requested in (a), above.
    c. Provide a copy of a statistical text that justifies the test for autocorrelation used in parts (a) and (b), above, if such a test was conducted.

Answer:

a. Attached please find chapter 8 from Economic Methods, 2d edition, by J. Johnson which describes autocorrelation. Refer to the last sentence of the first paragraph of the attached text material in the section entitled "8.1 Nature of Autocorrelation." It states, "...and in time-series data it means *serial* independence for the disturbance terms." The disturbance term is the independent variable. This sentence refers to a previous sentence that states, "For a model with normally distributed disturbances this implies that all such disturbances are pairwise independent."

On page 42, lines 4-7 of his LG&E testimony (page 38, lines17-20 of the KU testimony), Mr. Rosenberg states that, "the yield on long-term Treasury bonds lagged two quarters behind the allowed return on equity, was the independent variable."

In response to the Attorney General's 1st Data Request, question 30 which refers to the response in question 28, the yields on Long-term T Bonds are provided in "Response to AG1-28(b)" pages 1 of11 through 6 of 11. On page 1 of 11, the yields start as 8.94, 9.00, 9.03, and so forth through 5.23 on page 6 of 11. On page 1 of 11, the reason the second yield is 9.00 is that the preceding yield was 8.94 and the reason that the third yield was 9.03 is that the preceding yield was 9.00 and so forth. The relationship of the yields one to the other can be followed through all of the independent variables shown on pages 1 of 11 through page 6 of 11.

These variables are clearly not independent of one another and violate the need for the independent variables to be pairwise independent to avoid autocorrelation. I described this dependency relationship in my testimony on page

23 lines 1 to 4 and the consequence of the relationship, that is also described in Johnson's chapter 8, in lines 4-6 of page 23.

I did not perform any specific studies of Mr. Rosenberg's second risk premium analysis. It was not necessary. Autocorrelation is a known problem when interest rate data is used as an independent variable in a time series analysis. As I state in my testimony on page 23, lines 4 through 6, "When autocorrelation is present, the variances in the model are incorrect and the resulting model's statistics, such as the R^2's, are meaningless."

The autocorrelation problem and his misstatements about the high R^2's indicate that Mr. Rosenberg lacks expertise in the use of regression analysis. The failure of the model to provide logical results -- that is -- high interest rates can cause negative risk premiums on equity is a more serious problem in the analysis.

b. not applicable.

c. not applicable.

; tr had been estimated as 0.28 ± 0.05
ntially the same definitions but
ove the results set out above?
(Cambridge Economics Tripos, 1969)

equently deflated, e.g., by a measure of
what condition is this a sensible pro-
coefficient to be affected in a "typical"
(Oxford Diploma, 1965)

dependent and independent variables
$E(\mathbf{u}) = \mathbf{0}$ and $E(\mathbf{uu}') = \mathbf{V}$. Show that the

e matrix, under what conditions on x

(L.S.E. 1967)

f rank r and if $\mathbf{F}$ is any $r \times n$ submatrix
h submatrix may be written $\mathbf{F}^* = \mathbf{AF}$,
hever submatrix of full rank we choose

8

Autocorrelation

8-1 NATURE OF AUTOCORRELATION

One of the crucial assumptions of the linear model of Chap. 5 is that of zero covariance for the disturbance terms implied in the assumption

$$E(\mathbf{uu}') = \sigma^2\mathbf{I}$$

in which the off-diagonal terms give

$$E(u_t u_{t+s}) = 0 \quad \text{for all } t \text{ and for all } s \neq 0$$

For a model with normally distributed disturbances this implies that all such disturbances are pairwise independent. For cross-section data this means we are assuming that the disturbance value that is "drawn" for any one unit is uninfluenced by the values drawn for other units, and in time-series data it means *serial* independence for the disturbance terms.

There are, however, circumstances in which the assumption of a serially independent disturbance term may not be very plausible. For example, one may make an incorrect specification of the *form* of the relationship between the variables. Suppose we specify a linear relation between Y and X when the true relation is, say, a quadratic. Even though the disturbance term in the true relation may be non-autocorrelated, the quasi-disturbance term associated with the linear relation will contain a term in X^2. If there is any serial correlation in the X values, then we will have serial correlation in the composite disturbance term. This example is a special case of the problem of omitted variables. In general, we include only certain important variables in the specified relation, and the disturbance term must then represent the influence of omitted variables. Serial correlation in individual omitted variables need not necessarily imply a serially correlated disturbance term, for individual components may cancel one another out. However, if the serial correlation in the omitted variables is pervasive and if the omitted variables tend to move in phase, then there is a real possibility of an autocorrelated disturbance term. A disturbance term may also contain a component due to measurement error in the "explained" variable. This too may be a source of serial correlation in the composite disturbance.

To illustrate the problem we shall consider a simple two-variable relation. Let us postulate

$$Y_t = \alpha + \beta X_t + u_t \tag{8-1}$$

where we assume that the disturbance u_t follows a first-order autoregressive scheme

$$u_t = \rho u_{t-1} + \varepsilon_t \tag{8-2}$$

where $|\rho| < 1$ and ε_t satisfies the assumptions

$$\left.\begin{aligned} E(\varepsilon_t) &= 0 \\ E(\varepsilon_t \varepsilon_{t+s}) &= \sigma_\varepsilon^2 \qquad s = 0 \\ &= 0 \qquad\ \ s \neq 0 \end{aligned}\right\} \text{ for all } t \tag{8-3}$$

We then have

$$\begin{aligned} u_t &= \rho u_{t-1} + \varepsilon_t \\ &= \rho(\rho u_{t-2} + \varepsilon_{t-1}) + \varepsilon_t \\ &= \cdots \\ &= \varepsilon_t + \rho\varepsilon_{t-1} + \rho^2\varepsilon_{t-2} + \cdots \end{aligned}$$

that is

$$u_t = \sum_{r=0}^{\infty} \rho^r \varepsilon_{t-r} \tag{8-4}$$

Therefore

$$E(u_t) = 0$$

---

since

$E(\varepsilon_t) = 0$ for all t

Furthermore,

$E(u_t^2) = E(\varepsilon_t^2) + \rho^2 E(\varepsilon$

since the ε are serially inde

$E(u_t^2) = (1 + \rho^2 + \rho^4$

Thus

$\sigma_u^2 = \dfrac{\sigma_\varepsilon^2}{1-\rho^2}$ (

$E(u_t u_{t-1}) = E[(\varepsilon_t + \rho\varepsilon$

$\times (\varepsilon_{t-1} +$

$= E\{[\varepsilon_t + \rho$

$= \rho E[(\varepsilon_{t-1}$

$= \rho\sigma_u^2$

Similarly,

$$E(u_t u_{t-2}) = \rho^2 \sigma_u^2$$

and in general,

$$E(u_t u_{t-s}) = \rho^s \sigma_u^2$$

so that relation (8-1) does n
disturbance term. Scheme
sive scheme; more compli
assumption of serial indepe

Relation (8-6) may be

$$\frac{E(u_t u_{t-s})}{\sigma_u^2} = \rho^s$$

The left-hand side of this
efficient of the u series. The
series is simply unity, and

ney actually were observations
which, strictly speaking,
ations on the actual series
ude

ions.

e von Neumann ratio,

(8-12)

fference to the variance.[2] In an
urse, zero. For large n, δ^2/s^2 may
ated with

n may then be made by
on Neumann ratio with a
distribution with the appropriate
mphasize that even the formulae
f the *e* values are independently
ast squares residuals, even when
ly distributed.
e econometrician to have small-
atson investigated the sampling

A. S. Fraser, *Nonparametric Methods in*
nparametric Statistics for the Behavioral

Mean Square Successive Difference to the
941; and B. I. Hart, "Tabulation of the
rence to the Variance and Significance
he Variance," *Ann. Math. Statist.*, vol. 13,

distribution of the statistic which has become known as the Durbin–Watson "*d*" statistic,[1] namely,

$$\boxed{d = \frac{\sum_{t=2}^{n} (e_t - e_{t-1})^2}{\sum_{t=1}^{n} e_t^2}} \quad ★ \tag{8-13}$$

which is, of course, related to the von Neumann ratio by

$$d = \left(\frac{\delta^2}{s^2}\right)\left(\frac{n-1}{n}\right)$$

The *e* values are both positive and negative with mean zero. It is intuitively clear that for a positively autocorrelated series the first differences will tend to be small in absolute value compared with the absolute values of *e*, while for a negatively autocorrelated series they will often be larger than the *e* values so that *d* will tend to be small for positively autocorrelated series, large for negatively autocorrelated series and somewhere in between for random series. For random *u*

$$E(d) = \frac{\text{tr A} - \text{tr}\{\mathbf{X'AX(X'X)}^{-1}\}}{n-k} \tag{8-14}$$

where A is the symmetric $n \times n$ matrix

$$\mathbf{A} = \begin{bmatrix} 1 & -1 & 0 & 0 & \cdots & 0 & 0 & 0 \\ -1 & 2 & -1 & 0 & \cdots & 0 & 0 & 0 \\ \vdots & & & & & & & \vdots \\ 0 & 0 & 0 & 0 & \cdots & -1 & 2 & -1 \\ 0 & 0 & 0 & 0 & \cdots & 0 & -1 & 1 \end{bmatrix} \tag{8-15}$$

so that tr (A) = $2(n-1)$. $E(d)$ thus depends on the X values in the sample, but illustrative calculations by Durbin and Watson show that it ranges around 2. If the X's are orthogonal

$$\text{tr}\{\mathbf{X'AX(X'X)}^{-1}\} = \frac{\Sigma(\Delta X_1)^2}{\Sigma X_1^2} + \cdots + \frac{\Sigma(\Delta X_k)^2}{\Sigma X_k^2}$$

where $\Sigma(\Delta X_i)^2$ indicates the sum of the squares of the first differences of X_i. If the first differences were small in absolute value in relation to X values

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[1] J. Durbin and G. S. Watson, "Testing for Serial Correlation in Least-squares Regression," *Biometrika*, vol. 37, pp. 409–428, 1950, and vol. 38, pp. 159–178, 1951.

$$\begin{array}{lcccccc} & & B_0' & & B_1' & & \\ RP' & = & 2.550 & - & 0.450 & \text{L-T} & T' \end{array}$$

$$B_0 = \frac{B_0'}{1 - rho} \qquad B_1 = B_1'$$

$$B_0 = \frac{2.550}{1 - .6125}$$

$$= 6.580$$

Transformed Model

$$RP = 6.580 - 0.450 \quad \text{L-T} \quad T$$

with LT-T = 4.95%:

$$RP = 6.580 - 0.450(4.95) = \underline{\underline{4.35}}\%$$

$$\text{Adj } R^2 = 0.78$$

rho= 0.612461

	LT.T	RiskPrem	Predicted	Residual	ResidLag	RLag*Res	RLag^2	RPt-rRPt-1 RP'	LTt-rLTt-1 LT'	E't	E't-1	(E't-E't-1)^2	(E't)^2
Q1 80	9.5587	3.2021	2.3459	0.8562									
Q2 80	10.8900	1.8379	1.7705	0.0674	0.8562	0.0577	0.7331	-0.1232	5.0357	-0.4081			0.1666
Q3 80	11.1088	1.3898	1.6768	-0.2873	0.0674	-0.0194	0.0045	0.2639	4.4371	-0.2902	-0.4081	0.0139	0.0842
Q4 80	10.6923	1.6929	1.8660	-0.1630	-0.2873	0.0468	0.0825	0.8419	3.8898	0.0416	-0.2902	0.1101	0.0017
Q1 81	11.4883	1.4883	1.5120	-0.0257	-0.1630	0.0042	0.0266	0.4494	4.9397	0.1213	0.0416	0.0064	0.0147
Q2 81	12.3302	0.6975	1.1482	-0.4507	-0.0257	0.0116	0.0007	-0.2128	5.2940	-0.3815	0.1213	0.2526	0.1455
Q3 81	12.9000	0.2525	0.9019	-0.6494	-0.4507	0.2927	0.2031	-0.1747	5.3483	-0.3190	-0.3815	0.0039	0.1018
Q4 81	13.6988	-0.3392	0.5567	-0.8959	-0.6494	0.5818	0.4218	-0.4938	5.7961	-0.4358	-0.3190	0.0136	0.1899
Q1 82	13.9880	-0.4754	0.4326	-0.9081	-0.8959	0.8135	0.8026	-0.2677	5.5960	-0.3006	-0.4358	0.0183	0.0904
Q2 82	13.9113	-0.6575	0.4649	-1.1224	-0.9081	1.0192	0.8246	-0.3663	5.3455	-0.5119	-0.3006	0.0447	0.2621
Q3 82	13.7515	-0.3583	0.5340	-0.8923	-1.1224	1.0015	1.2598	0.0444	5.2314	-0.1525	-0.5119	0.1291	0.0233
Q4 82	13.1530	0.3992	0.7926	-0.3934	-0.8923	0.3511	0.7962	0.6186	4.7307	0.1966	-0.1525	0.1219	0.0386
Q1 83	11.7723	1.0598	1.3892	-0.3297	-0.3934	0.1297	0.1548	0.8151	3.7168	-0.0631	0.1966	0.0674	0.0040
Q2 83	10.7322	1.5425	1.8387	-0.2962	-0.3297	0.0977	0.1087	0.8935	3.5221	-0.0722	-0.0631	0.0001	0.0052
Q3 83	10.6802	2.1342	1.8612	0.2729	-0.2962	-0.0809	0.0878	1.1894	4.1071	0.4869	-0.0722	0.3125	0.2371
Q4 83	11.1302	2.1288	1.6668	0.4620	0.2729	0.1261	0.0745	0.8217	4.5890	0.3358	0.4869	0.0228	0.1128
Q1 84	11.6747	1.7254	1.4315	0.2940	0.4620	0.1358	0.2134	0.4216	4.8579	0.0568	0.3358	0.0779	0.0032
Q2 84	11.8813	1.5825	1.3421	0.2404	0.2940	0.0707	0.0864	0.5257	4.7311	0.1038	0.0568	0.0022	0.0108
Q3 84	12.6005	1.1567	1.0314	0.1253	0.2404	0.0301	0.0578	0.1874	5.3236	0.0321	0.1038	0.0052	0.0010
Q4 84	12.9272	1.0800	0.8902	0.1898	0.1253	0.0238	0.0157	0.3716	5.2099	0.1650	0.0321	0.0177	0.0272
Q1 85	12.1843	1.6704	1.2112	0.4592	0.1898	0.0872	0.0360	1.0090	4.2669	0.3783	0.1650	0.0455	0.1431
Q2 85	11.6340	2.0498	1.4490	0.6008	0.4592	0.2758	0.2109	1.0265	4.1716	0.3529	0.3783	0.0006	0.1246
Q3 85	11.2835	1.9513	1.6005	0.3508	0.6008	0.2108	0.3607	0.6960	4.1581	0.0163	0.3529	0.1133	0.0003
Q4 85	10.7710	2.7813	1.8220	0.9593	0.3508	0.3365	0.1230	1.5862	3.8603	0.7726	0.0163	0.5719	0.5969
Q1 86	10.2945	2.7229	2.0279	0.6950	0.9593	0.6667	0.9202	1.0195	3.6977	0.1326	0.7726	0.4094	0.0176
Q2 86	9.3975	3.5783	2.4155	1.1628	0.6950	0.8082	0.4831	1.9107	3.0825	0.7518	0.1326	0.3831	0.5651
Q3 86	8.1268	3.4821	2.9646	0.5175	1.1628	0.6017	1.3522	1.2905	2.3712	-0.1928	0.7518	0.8922	0.0372
Q4 86	7.4490	4.2188	3.2575	0.9612	0.5175	0.4974	0.2678	2.0661	2.4716	0.6479	-0.1928	0.7069	0.4198
Q1 87	7.4665	3.7104	3.2500	0.4604	0.9612	0.4426	0.9239	1.1266	2.9043	-0.1170	0.6479	0.5851	0.0137
Q2 87	7.5086	4.1804	3.2318	0.9487	0.4604	0.4368	0.2120	1.9079	2.8357	0.6785	-0.1170	0.6328	0.4604
Q3 87	8.0121	3.9517	3.0142	0.9375	0.9487	0.8894	0.9000	1.3913	3.4134	0.3767	0.6785	0.0911	0.1419
Q4 87	8.8000	2.7363	2.6737	0.0625	0.9375	0.0586	0.8789	0.3160	3.6928	-0.4829	0.3767	0.7390	0.2332
Q1 88	9.1474	1.9967	2.5236	-0.5269	0.0625	-0.0329	0.0039	0.3208	3.7577	-0.5389	-0.4829	0.0031	0.2904
Q2 88	8.9293	2.0183	2.6179	-0.5995	-0.5269	0.3159	0.2777	0.7955	3.3269	-0.2581	-0.5389	0.0789	0.0666
Q3 88	8.6452	2.1863	2.6542	-0.4679	-0.5995	0.2805	0.3594	0.9501	3.3764	-0.0811	-0.2581	0.0313	0.0066
Q4 88	9.1156	2.2129	2.5373	-0.3244	-0.4679	0.1518	0.2189	0.8739	3.6962	-0.0125	-0.0811	0.0047	0.0002
Q1 89	9.0720	2.6342	2.5562	0.0780	-0.3244	-0.0253	0.1052	1.2788	3.4891	0.2963	-0.0125	0.0966	0.0890
Q2 89	9.0039	3.2146	2.5856	0.6290	0.0780	0.0491	0.0061	1.6013	3.4476	0.6021	0.2963	0.0923	0.3625
Q3 89	8.8710	2.4221	2.6430	-0.2209	0.6290	-0.1390	0.3956	0.4533	3.3565	-0.5869	0.6021	1.4136	0.3444
Q4 89	8.4132	3.2258	2.8409	0.3850	-0.2209	-0.0851	0.0488	1.7424	2.9601	0.5329	-0.5869	1.2540	0.2840
Q1 90	8.0256	3.3129	3.0064	0.3046	0.3850	0.1172	0.1482	1.3372	2.8726	0.0795	0.5329	0.2056	0.0063
Q2 90	8.1872	3.3746	2.9365	0.4361	0.3046	0.1328	0.0928	1.3456	3.2719	0.2673	0.0795	0.0353	0.0715
Q3 90	8.5451	2.8246	2.7839	0.0407	0.4361	0.0178	0.1902	0.7578	3.5307	-0.2040	0.2673	0.2222	0.0416
Q4 90	8.7226	2.8646	2.7072	0.1574	0.0407	0.0064	0.0017	1.1346	3.4881	0.1541	-0.2040	0.1283	0.0237
Q1 91	8.6710	2.8729	2.7295	0.1434	0.1574	0.0226	0.0248	1.1165	3.3287	0.0658	0.1541	0.0078	0.0043
Q2 91	8.3712	3.0821	2.8590	0.2231	0.1434	0.0320	0.0206	1.3225	3.0605	0.1492	0.0658	0.0070	0.0223

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.728369
R Square	0.530521
Adjusted R	0.525418
Standard E	0.440095
Observatic	94

ANOVA

	df	*SS*	*MS*	*F*	*gnificance F*
Regressio	1	20.13575	20.13575	103.9619	8.85E-17
Residual	92	17.81891	0.193684		
Total	93	37.95466			

	Coefficient	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	2.549841	0.148083	17.22134	1.57E-30	2.255776	2.843907	2.255776	2.843907
LT'	-0.44978	0.044112	-10.1962	8.85E-17	-0.53739	-0.36216	-0.53739	-0.36216

DW' = 2.221294

Q3 91	8.2566	3.1092	2.9065	0.2007	0.2231	0.0448	0.0498	1.2215	3.1298	0.0794	0.1492	0.0049	0.0063
Q4 91	8.2466	3.1613	2.9119	0.2693	0.2007	0.0541	0.0403	1.2770	3.1918	0.1628	0.0794	0.0070	0.0265
Q1 92	8.0163	3.3263	3.0124	0.3139	0.2693	0.0845	0.0725	1.3779	2.9642	0.1613	0.1628	0.0000	0.0260
Q2 92	7.8261	3.0046	3.0946	-0.0900	0.3139	-0.0283	0.0985	0.9674	2.9164	-0.2707	0.1613	0.1666	0.0733
Q3 92	7.8463	3.2917	3.0850	0.2067	-0.0900	-0.0186	0.0081	1.4515	3.0552	0.2758	-0.2707	0.2987	0.0761
Q4 92	7.6700	3.5750	3.1620	0.4130	0.2067	0.0854	0.0427	1.5590	2.8632	0.2969	0.2758	0.0004	0.0682
Q1 93	7.4650	3.4317	3.2420	0.1697	0.4130	0.0783	0.1705	1.2421	2.7874	-0.0540	0.2969	0.1232	0.0029
Q2 93	7.3050	3.4060	3.3198	0.0852	0.1697	0.0162	0.0360	1.3032	2.7207	-0.0229	-0.0540	0.0010	0.0005
Q3 93	6.9700	3.2700	3.4645	-0.1945	0.0852	-0.0166	0.0073	1.1646	2.4960	-0.2426	-0.0229	0.0483	0.0589
Q4 93	6.5900	3.5200	3.6287	-0.1087	-0.1945	0.0212	0.0378	1.5173	2.3211	0.0114	-0.2426	0.0646	0.0001
Q1 94	6.2200	3.9700	3.7886	0.1814	-0.1087	-0.0197	0.0118	1.8141	2.1839	0.2466	0.0114	0.0553	0.0608
Q2 94	6.3400	3.7600	3.7368	0.0232	0.1814	0.0042	0.0329	1.3285	2.5306	-0.0632	0.2466	0.1087	0.0069
Q3 94	6.9600	4.8500	3.4688	1.3812	0.0232	0.0321	0.0005	2.6471	3.0770	1.3813	-0.0632	2.1445	1.9079
Q4 94	7.4800	3.0100	3.2441	-0.2341	1.3812	-0.3234	1.9076	0.0398	3.2173	-1.0632	1.3813	5.9755	1.1305
Q1 95	7.7750	3.2600	3.1167	0.1433	-0.2341	-0.0336	0.0548	1.4165	3.1938	0.3031	-1.0632	1.8670	0.0919
Q2 95	7.7983	2.6250	3.1066	-0.4816	0.1433	-0.0690	0.0205	0.6264	3.0384	-0.5557	0.3031	0.7377	0.3089
Q3 95	7.2983	3.0650	3.3226	-0.2576	-0.4816	0.1241	0.2319	1.4573	2.5222	0.0419	-0.5557	0.3571	0.0018
Q4 95	6.8350	3.6867	3.5229	0.1638	-0.2576	-0.0422	0.0664	1.8095	2.3651	0.3234	0.0419	0.0793	0.1046
Q1 96	6.4700	3.7317	3.6806	0.0511	0.1638	0.0084	0.0268	1.4737	2.2838	-0.0489	0.3234	0.1366	0.0024
Q2 96	6.2650	4.0650	3.7692	0.2958	0.0511	0.0151	0.0026	1.7795	2.3024	0.2652	-0.0489	0.0967	0.0703
Q3 96	6.6200	3.0600	3.6158	-0.5558	0.2958	-0.1644	0.0875	0.5703	2.7829	-0.7278	0.2652	0.9661	0.5297
Q4 96	6.9500	3.6100	3.4732	0.1368	-0.5558	-0.0760	0.3089	1.7359	2.8955	0.4664	-0.7278	1.4790	0.2365
Q1 97	6.7900	3.5200	3.5423	-0.0223	0.1368	-0.0031	0.0187	1.3090	2.5334	-0.1014	0.4664	0.3478	0.0103
Q2 97	6.7150	3.9150	3.5747	0.3403	-0.0223	-0.0076	0.0005	1.7591	2.5564	0.3591	-0.1014	0.2120	0.1290
Q3 97	6.8767	4.1350	3.5049	0.6301	0.3403	0.2144	0.1158	1.7372	2.7640	0.4305	0.3591	0.0051	0.1854
Q4 97	6.7317	3.3800	3.5675	-0.1875	0.6301	-0.1182	0.3971	0.8475	2.5200	-0.5689	0.4305	0.9990	0.3237
Q1 98	6.3367	3.9167	3.7382	0.1784	-0.1875	-0.0335	0.0352	1.8465	2.2136	0.2924	-0.5689	0.7419	0.0855
Q2 98	6.0133	5.0300	3.8779	1.1521	0.1784	0.2056	0.0318	2.6312	2.1324	1.0404	0.2924	0.5596	1.0825
Q3 98	5.6667	4.7217	3.9413	0.7803	1.1521	0.8990	1.3272	1.6410	2.1837	0.0733	1.0404	0.9353	0.0054
Q4 98	5.6617	5.0217	4.0299	0.9916	0.7803	0.7739	0.6089	2.1298	2.0686	0.5104	0.0733	0.1910	0.2605
Q1 99	5.2900	3.6617	4.1906	-0.5289	0.9916	-0.5245	0.9836	0.5861	1.8225	-1.1441	0.5104	2.7371	1.3089
Q2 99	5.2383	3.9850	4.2129	-0.2279	-0.5289	0.1205	0.2797	1.7424	1.9964	0.0914	-1.1441	1.5263	0.0083
Q3 99	5.5850	3.4083	4.0630	-0.6547	-0.2279	0.1492	0.0519	0.9677	2.3787	-0.5132	0.0914	0.3655	0.2633
Q4 99	5.9200	3.4683	3.9183	-0.4499	-0.6547	0.2946	0.4286	1.3609	2.4994	-0.0448	-0.5132	0.2194	0.0020
1Q 00	6.1467	3.1750	3.6203	-0.6453	-0.4499	0.2904	0.2024	1.0506	2.5209	-0.3652	-0.0448	0.1027	0.1334
2Q 00	6.2783	3.0467	3.7634	-0.7168	-0.6453	0.4625	0.4164	1.1021	2.5137	-0.3171	-0.3652	0.0023	0.1006
3Q 00	6.1400	3.4517	3.8232	-0.3715	-0.7168	0.2663	0.5137	1.5857	2.2948	0.0680	-0.3171	0.1463	0.0046
4Q 00	5.8683	3.8650	3.9320	-0.0670	-0.3715	0.0249	0.1380	1.7510	2.1278	0.1582	0.0680	0.0081	0.0250
1Q 01	5.7450	3.3333	3.9939	-0.6606	-0.0670	0.0442	0.0045	0.9662	2.1386	-0.6218	0.1582	0.6083	0.3666
2Q 01	5.6667	3.0567	4.0710	-1.0143	-0.6606	0.6700	0.4363	1.0151	2.0481	-0.6135	-0.6218	0.0001	0.3764
3Q 01	5.5717	3.0333	4.0688	-1.0355	-1.0143	1.0503	1.0288	1.1612	2.1623	-0.4160	-0.6135	0.0390	0.1731
4Q 01	5.6117	3.9183	4.0515	-0.1332	-1.0355	0.1379	1.0722	2.0606	2.1992	0.4999	-0.4160	0.8389	0.2499
1Q 02	5.4150	3.1833	4.1365	-0.9532	-0.1332	0.1269	0.0177	0.7635	1.9761	-0.8766	0.4999	1.8948	0.7685
2Q 02	5.4683	3.7017	4.1135	-0.4118	-0.9532	0.3925	0.9085	1.7520	2.1519	0.1700	-0.8766	1.0955	0.0289
3Q 02	5.6933	3.3417	4.0162	-0.6746	-0.4118	0.2778	0.1696	1.0745	2.3442	-0.4209	0.1700	0.3492	0.1772
4Q 02	5.4900	3.6533	4.1041	-0.4508	-0.6746	0.3041	0.4550	1.6067	2.0031	-0.0422	-0.4209	0.1434	0.0018
1Q 03	5.1500	4.1883	4.2510	-0.0627	-0.4508	0.0283	0.2032	1.9506	1.7876	0.2050	-0.0422	0.0611	0.0420
2Q 03	5.0217	4.0283	4.3065	-0.2781	-0.0627	0.0174	0.0039	1.4631	1.8675	-0.2467	0.2050	0.2041	0.0609
3Q 03	4.8250	3.2683	4.3915	-1.1231	-0.2781	0.3124	0.0774	0.8011	1.7494	-0.9619	-0.2467	0.5114	0.9252
			SUM		1.1260	17.0018	27.7598					39.5810	17.8169

	X	Y					
	LT.T	RiskPrem	Y hat	Y - Y hat	(Y-Y hat)^2	Y - Y bar	(Y-Y bar)^2
Q1 80	9.5587	3.2021	2.2796	0.9225	0.8510	0.3281	0.1076
Q2 80	10.8900	1.8379	1.6805	0.1574	0.0248	-1.0361	1.0735
Q3 80	11.1068	1.3896	1.5829	-0.1933	0.0374	-1.4844	2.2035
Q4 80	10.6923	1.6929	1.7695	-0.0765	0.0059	-1.1811	1.3949
Q1 81	11.4883	1.4863	1.4113	0.0750	0.0056	-1.3877	1.9258
Q2 81	12.3302	0.6975	1.0324	-0.3349	0.1122	-2.1765	4.7371
Q3 81	12.9000	0.2525	0.7760	-0.5235	0.2741	-2.6215	6.8722
Q4 81	13.6988	-0.3392	0.4165	-0.7557	0.5711	-3.2132	10.3244
Q1 82	13.9860	-0.4754	0.2873	-0.7627	0.5817	-3.3494	11.2185
Q2 82	13.9113	-0.6575	0.3209	-0.9784	0.9573	-3.5315	12.4714
Q3 82	13.7515	-0.3583	0.3928	-0.7512	0.5642	-3.2323	10.4479
Q4 82	13.1530	0.3992	0.6622	-0.2630	0.0692	-2.4748	6.1248
Q1 83	11.7723	1.0596	1.2835	-0.2239	0.0501	-1.8144	3.2921
Q2 83	10.7322	1.5425	1.7515	-0.2090	0.0437	-1.3315	1.7729
Q3 83	10.6802	2.1342	1.7749	0.3592	0.1291	-0.7398	0.5473
Q4 83	11.1302	2.1288	1.5724	0.5563	0.3095	-0.7452	0.5554
Q1 84	11.6747	1.7254	1.3274	0.3980	0.1584	-1.1486	1.3192
Q2 84	11.8813	1.5825	1.2344	0.3481	0.1212	-1.2915	1.6679
Q3 84	12.6005	1.1567	0.9108	0.2459	0.0605	-1.7173	2.9492
Q4 84	12.9272	1.0800	0.7638	0.3162	0.1000	-1.7940	3.2184
Q1 85	12.1843	1.6704	1.0981	0.5724	0.3276	-1.2036	1.4486
Q2 85	11.6340	2.0496	1.3457	0.7039	0.4955	-0.8244	0.6796
Q3 85	11.2835	1.9513	1.5034	0.4478	0.2005	-0.9227	0.8515
Q4 85	10.7710	2.7813	1.7341	1.0472	1.0966	-0.0927	0.0086
Q1 86	10.2945	2.7229	1.9485	0.7744	0.5998	-0.1511	0.0228
Q2 86	9.3975	3.5783	2.3521	1.2262	1.5036	0.7043	0.4961
Q3 86	8.1268	3.4821	2.9239	0.5582	0.3115	0.6081	0.3698
Q4 86	7.4490	4.2188	3.2290	0.9898	0.9797	1.3448	1.8084
Q1 87	7.4665	3.7104	3.2211	0.4893	0.2395	0.8364	0.6996
Q2 87	7.5086	4.1804	3.2021	0.9783	0.9571	1.3064	1.7067
Q3 87	8.0121	3.9517	2.9755	0.9761	0.9528	1.0777	1.1614
Q4 87	8.8000	2.7363	2.6210	0.1152	0.0133	-0.1377	0.0190
Q1 88	9.1474	1.9967	2.4647	-0.4680	0.2190	-0.8773	0.7697
Q2 88	8.9293	2.0183	2.5628	-0.5445	0.2965	-0.8557	0.7322
Q3 88	8.8452	2.1863	2.6007	-0.4144	0.1717	-0.6877	0.4730
Q4 88	9.1156	2.2129	2.4790	-0.2661	0.0708	-0.6611	0.4370
Q1 89	9.0720	2.6342	2.4986	0.1356	0.0184	-0.2398	0.0575
Q2 89	9.0039	3.2146	2.5293	0.6853	0.4697	0.3406	0.1160
Q3 89	8.8710	2.4221	2.5890	-0.1670	0.0279	-0.4519	0.2042
Q4 89	8.4132	3.2258	2.7951	0.4308	0.1856	0.3518	0.1238
Q1 90	8.0256	3.3129	2.9695	0.3434	0.1179	0.4389	0.1927
Q2 90	8.1872	3.3746	2.8967	0.4778	0.2283	0.5006	0.2506
Q3 90	8.5451	2.8246	2.7357	0.0889	0.0079	-0.0494	0.0024
Q4 90	8.7226	2.8646	2.6558	0.2087	0.0436	-0.0094	0.0001
Q1 91	8.6710	2.8729	2.6791	0.1938	0.0376	-0.0011	0.0000
Q2 91	8.3712	3.0821	2.8140	0.2681	0.0719	0.2081	0.0433
Q3 91	8.2568	3.1092	2.8655	0.2437	0.0594	0.2352	0.0553
Q4 91	8.2488	3.1813	2.8690	0.3122	0.0975	0.3073	0.0944
Q1 92	8.0163	3.3263	2.9737	0.3526	0.1243	0.4523	0.2045
Q2 92	7.8261	3.0046	3.0593	-0.0547	0.0030	0.1306	0.0171
Q3 92	7.8483	3.2917	3.0493	0.2424	0.0588	0.4177	0.1745

Q4 92	7.6700	3.5750	3.1295	0.4455	0.1985	0.7010	0.4914
Q1 93	7.4850	3.4317	3.2128	0.2189	0.0479	0.5577	0.3110
Q2 93	7.3050	3.4050	3.2938	0.1112	0.0124	0.5310	0.2820
Q3 93	6.9700	3.2700	3.4445	-0.1745	0.0305	0.3960	0.1568
Q4 93	6.5900	3.5200	3.6155	-0.0955	0.0091	0.6460	0.4173
Q1 94	6.2200	3.9700	3.7820	0.1880	0.0353	1.0960	1.2012
Q2 94	6.3400	3.7600	3.7280	0.0320	0.0010	0.8860	0.7850
Q3 94	6.9600	4.8500	3.4490	1.4010	1.9628	1.9760	3.9046
Q4 94	7.4800	3.0100	3.2150	-0.2050	0.0420	0.1360	0.0185
Q1 95	7.7750	3.2600	3.0823	0.1778	0.0316	0.3860	0.1490
Q2 95	7.7983	2.6250	3.0718	-0.4468	0.1996	-0.2490	0.0620
Q3 95	7.2983	3.0650	3.2968	-0.2318	0.0537	0.1910	0.0365
Q4 95	6.8350	3.6867	3.5053	0.1814	0.0329	0.8127	0.6604
Q1 96	6.4700	3.7317	3.6695	0.0622	0.0039	0.8577	0.7356
Q2 96	6.2650	4.0650	3.7618	0.3033	0.0920	1.1910	1.4185
Q3 96	6.6200	3.0600	3.6020	-0.5420	0.2938	0.1860	0.0346
Q4 96	6.9500	3.6100	3.4535	0.1565	0.0245	0.7360	0.5417
Q1 97	6.7900	3.5200	3.5255	-0.0055	0.0000	0.6460	0.4173
Q2 97	6.7150	3.9150	3.5593	0.3558	0.1266	1.0410	1.0837
Q3 97	6.8767	4.1350	3.4865	0.6485	0.4206	1.2610	1.5901
Q4 97	6.7317	3.3800	3.5518	-0.1718	0.0295	0.5060	0.2560
Q1 98	6.3367	3.9167	3.7295	0.1872	0.0350	1.0427	1.0872
Q2 98	6.0133	5.0300	3.8750	1.1550	1.3340	2.1560	4.6484
Q3 98	5.8667	4.7217	3.9410	0.7807	0.6094	1.8477	3.4139
Q4 98	5.6617	5.0217	4.0333	0.9684	0.9770	2.1477	4.6125
Q1 99	5.2900	3.6617	4.2005	-0.5388	0.2903	0.7877	0.6204
Q2 99	5.2383	3.9850	4.2238	-0.2388	0.0570	1.1110	1.2343
Q3 99	5.5850	3.4083	4.0678	-0.6594	0.4348	0.5343	0.2855
Q4 99	5.9200	3.4683	3.9170	-0.4487	0.2013	0.5943	0.3532
1Q 00	6.1467	3.1750	3.8150	-0.6400	0.4096	0.3010	0.0906
2Q 00	6.2783	3.0467	3.7558	-0.7091	0.5028	0.1727	0.0298
3Q 00	6.1400	3.4517	3.8180	-0.3663	0.1342	0.5777	0.3337
4Q 00	5.8883	3.8650	3.9313	-0.0663	0.0044	0.9910	0.9821
1Q 01	5.7450	3.3333	3.9958	-0.6624	0.4388	0.4593	0.2110
2Q 01	5.5667	3.0567	4.0760	-1.0193	1.0390	0.1827	0.0334
3Q 01	5.5717	3.0333	4.0738	-1.0404	1.0825	0.1593	0.0254
4Q 01	5.6117	3.9183	4.0558	-0.1374	0.0189	1.0443	1.0907
1Q 02	5.4150	3.1833	4.1443	-0.9609	0.9234	0.3093	0.0957
2Q 02	5.4683	3.7017	4.1203	-0.4186	0.1752	0.8277	0.6850
3Q 02	5.6933	3.3417	4.0190	-0.6773	0.4588	0.4677	0.2187
4Q 02	5.4900	3.6533	4.1105	-0.4572	0.2090	0.7793	0.6074
1Q 03	5.1500	4.1883	4.2635	-0.0752	0.0057	1.3143	1.7275
2Q 03	5.0217	4.0283	4.3213	-0.2929	0.0858	1.1543	1.3325
3Q 03	4.8250	3.2683	4.4098	-1.1414	1.3028	0.3943	0.1555
Sum	791.9781	273.0292	268.8048	4.2243	29.3917	0.0000	135.8724
	X	Y	Y hat	Y - Y hat	(Y-Y hat)^2	Y - Y bar	(Y-Y bar)^2

Y bar
2.8740

R	0.8853
R2	0.7837
Adj R2	0.7814

Applied Linear Statistical Models

Regression, Analysis of Variance, and Experimental Designs

John Neter
University of Minnesota

and

William Wasserman
Syracuse University

1974

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Durbin-Watson Test for Autocorrelation

When regression analysis is based upon time series data, it is often desirable to test whether or not the error terms in the regression model are uncorrelated. One test widely used is the Durbin-Watson test. This test assumes the first-order autoregressive error model (10.30) with the values of the independent variable fixed, or a corresponding multiple regression model. The test consists of determining whether or not the autocorrelation parameter ρ is zero. Note from model (10.30) that if $\rho = 0$, $\varepsilon_t = u_t$. Hence the error terms ε_t are then independent since the u_t are independent.

In view of the fact that correlated error terms in business and economic applications tend to show positive serial correlation, the usual test alternatives considered are:

$$C_1: \rho = 0 \qquad C_2: \rho > 0 \tag{10.36}$$

The test statistic D is obtained by first fitting the ordinary least squares regression line and calculating the residuals:

$$e_t = Y_t - \hat{Y}_t \tag{10.37}$$

and then calculating the statistic:

$$D = \frac{\sum_{t=2}^{n} (e_t - e_{t-1})^2}{\sum_{t=1}^{n} e_t^2} \tag{10.38}$$

where n is the number of observations.

An exact test procedure is not available, but Durbin and Watson have obtained lower and upper bounds d_L and d_U such that a value of D outside these bounds leads to a definite decision. The decision rule for testing between the alternatives in (10.36) is:

(10.39)

If $D > d_U$, conclude C_1
If $D < d_L$, conclude C_2
If $d_L \leq D \leq d_U$, the test is inconclusive

Small values of D lead to the conclusion that $\rho > 0$ because the adjacent error terms ε_t and ε_{t-1} tend to be of the same magnitude when they are positively autocorrelated. Hence the differences in the residuals, $e_t - e_{t-1}$, would tend to be small when $\rho > 0$, leading to a small numerator in D and hence to a small test statistic D.

Table A-6 contains the bounds d_L and d_U for various sample sizes (n), for two levels of significance (.05 and .01), and for various numbers of X variables ($p - 1$) in the regression model.

Example. The Blaisdell Company wished to predict its sales by using as a predictor variable disposable personal income. In Table 10.5, columns 1 and 2 contain seasonally adjusted quarterly data on company sales and disposable personal income respectively for the period 1967–71. A scatter plot (not shown) suggested that a linear regression model is appropriate. The market research analyst was, however, concerned whether or not the error terms could be assumed to be uncorrelated. He therefore used the Durbin-Watson test with the alternatives:

$$C_1: \rho = 0$$
$$C_2: \rho > 0$$

He fitted an ordinary least squares regression line to the data in Table 10.5. The results are shown in Table 10.6a. He then calculated the residuals e_t, which are shown in column 3 of Table 10.5. Note how the residuals consistently are above or below the fitted values for extended periods. Autocorrelation

TABLE 10.5

Durbin-Watson Test Calculations for Blaisdell Company Example (sales and disposable personal income data are seasonally adjusted)

Year and Quarter	t	(1) *Company Sales (million dollars)* Y_t	(2) *Disposable Personal Income (billion dollars)* X_t	(3) *Residuals* e_t	(4) $e_t - e_{t-1}$	(5) $(e_t - e_{t-1})^2$	(6) e_t^2
1967: 1	1	34.97	133.6	−.99655	———	———	.99311190
2	2	35.35	135.4	−.98090	+.01565	.00024492	.96216481
3	3	35.92	137.6	−.85622	+.12468	.01554510	.73311269
4	4	36.64	140.0	−.62203	+.23419	.05484496	.38692132
1968: 1	5	37.65	143.8	−.38122	+.24081	.05798946	.14532869
2	6	38.57	147.1	−.12920	+.25202	.06351408	.01669264
3	7	39.13	148.8	.08669	+.21589	.04660849	.00751516
4	8	39.89	151.4	.32040	+.23371	.05462036	.10265616
1969: 1	9	40.42	153.3	.46580	+.14540	.02114116	.21696964
2	10	41.40	156.5	.79806	+.33226	.11039671	.63689976
3	11	42.34	160.8	.86766	+.06960	.00484416	.75283388
4	12	43.05	163.6	1.01089	+.14323	.02051483	1.02189859
1970: 1	13	44.04	166.9	1.33291	+.32202	.10369688	1.77664907
2	14	45.18	171.4	1.56202	+.22911	.05249139	2.43990648
3	15	45.70	174.0	1.55573	−.00629	.00003956	2.42029583
4	16	46.09	175.4	1.66235	+.10662	.01136782	2.76340752
1971: 1	17	46.29	180.5	.83001	−.83234	.69278988	.68891660
2	18	44.34	184.9	−2.01063	−2.84064	8.06923561	4.04263300
3	19	44.50	187.1	−2.29595	−.28532	.08140750	5.27138640
4	20	44.90	188.7	−2.21982	+.07613	.00579578	4.92760083
Total						9.46708865	30.30690097

TABLE 10.6

Regression Results for Blaisdell Company Example

(a) Original Variables Y_t and X_t

Regression Coefficient	Estimated Regression Coefficient	Estimated Standard Deviation
β_0	$b_0 = 8.92339$	$s(b_0) = 2.67208$
β_1	$b_1 = .20242$	$s(b_1) = .01660$

$$\hat{Y} = 8.92339 + .20242X$$

(b) Transformed Variables $Y_t' = Y_t - rY_{t-1}$ and $X_t' = X_t - rX_{t-1}$

Regression Coefficient	Estimated Regression Coefficient	Estimated Standard Deviation
β_0'	$b_0' = 4.02457$	$s(b_0') = 1.31639$
$\beta_1' = \beta_1$	$b_1' = .04862$	$s(b_1') = .06483$

$$b_0 = \frac{b_0'}{1-r} = \frac{4.02457}{1-.89100} = 36.92266$$

$$s(b_0) = \frac{s(b_0')}{1-r} = \frac{1.31639}{1-.89100} = 12.07697$$

(c) First Differences $Y_t' = Y_t - Y_{t-1}$ and $X_t' = X_t - X_{t-1}$

Regression Coefficient	Estimated Regression Coefficient	Estimated Standard Deviation
$\beta_1' = \beta_1$	$b_1 = .15068$	$s(b_1) = .05241$

in the error terms is suggested when such a pattern is obtained despite the fact that an appropriate regression function has been employed.

Columns 4, 5, and 6 of Table 10.5 contain the necessary calculations for the test statistic D. The analyst then obtained:

$$D = \frac{\sum_{t=2}^{20}(e_t - e_{t-1})^2}{\sum_{t=1}^{20} e_t^2} = \frac{9.4671}{30.3069} = .312$$

Using a level of significance of .01, he found in Table A-6 for $n = 20$ and $p - 1 = 1$:

$$d_L = .95$$
$$d_U = 1.15$$

Since $D = .312$ falls below $d_L = .95$, decision rule (10.39) indicates that the appropriate conclusion is C_2, namely that the error terms are positively autocorrelated.

Comments

1. If a test for negative autocorrelation is required, the test statistic to be used is $4 - D$, where D is defined as above. The test is then conducted in the same manner described for testing for positive autocorrelation. That is, if the quantity $4 - D$ falls below d_L, we conclude $\rho < 0$, that negative autocorrelation exists, and so on.

2. A two-sided test for C_1: $\rho = 0$ versus C_2: $\rho \neq 0$ can be made by employing both one-sided tests separately. The Type I risk with the two-sided test is 2α, where α is the Type I risk with each one-sided test.

3. When the Durbin-Watson test employing the bounds d_L and d_U gives indeterminate results, in principle more observations are required. Of course, with time series data it may be impossible to obtain more observations, or additional observations may lie in the future and be obtainable only with great delay. Durbin and Watson (Ref. 10.1) do give an approximate test which may be used when the bounds test is indeterminate, but the degrees of freedom should be larger than about 40 before this approximate test will give more than a rough indication of whether autocorrelation exists.

4. While the Durbin-Watson test is widely used, other tests for autocorrelation are available. One such alternative test, due to Theil and Nagar, is found in Reference 10.2.

Estimation of Regression Parameters

When the autocorrelation parameter ρ in model (10.30) is not zero, it is desirable to recognize the autocorrelated structure of the error terms for estimating the regression parameters. Two suggested methods of doing so will now be discussed, and our earlier Blaisdell Company example will be used to illustrate each.

Iterative Approach. The iterative approach is motivated by an interesting property of model (10.30). Consider the transformed dependent variable:

$$Y_t' = Y_t - \rho Y_{t-1}$$

Substituting in this expression for Y_t and Y_{t-1} according to model (10.30), we obtain:

$$Y_t' = (\beta_0 + \beta_1 X_t + \varepsilon_t) - \rho(\beta_0 + \beta_1 X_{t-1} + \varepsilon_{t-1})$$
$$= \beta_0(1 - \rho) + \beta_1(X_t - \rho X_{t-1}) + (\varepsilon_t - \rho\varepsilon_{t-1})$$

But by (10.30), $\varepsilon_t - \rho\varepsilon_{t-1} = u_t$. Hence:

$$Y_t' = \beta_0(1 - \rho) + \beta_1(X_t - \rho X_{t-1}) + u_t$$

where the u_t are independent error terms. Thus, when we use the transformed variables:

(10.40a) $$Y_t' = Y_t - \rho Y_{t-1}$$

(10.40b) $$X_t' = X_t - \rho X_{t-1}$$

the reparameterized regression model:

(10.41) $$Y_t' = \beta_0' + \beta_1' X_t' + u_t$$

has independent error terms. This means that ordinary least squares methods have their usual optimum properties with model (10.41).

The parameters in the original model (10.30) are related to the parameters in the transformed model (10.41) as follows:

(10.42a) $$\beta_0 = \frac{\beta_0'}{1-\rho}$$

(10.42b) $$\beta_1 = \beta_1'$$

The transformed model (10.41) unfortunately cannot be used directly because the autocorrelation parameter ρ needed to obtain the transformed variables in (10.40) is unknown. We can, however, estimate ρ. Note that the autoregressive error process assumed in model (10.30) can be viewed as a regression through the origin:

$$\varepsilon_t = \rho\varepsilon_{t-1} + u_t$$

where ε_t is the dependent variable, ε_{t-1} the independent variable, u_t the error term, and ρ the slope of the line through the origin. Since the ε_t and ε_{t-1} are unknown we use the residuals e_t and e_{t-1}, obtained by ordinary least squares methods, as the dependent and independent variables respectively, and estimate ρ by fitting a straight line through the origin. From our previous discussion of regression through the origin, we know by (5.32) that the estimate of the slope ρ, denoted by r, is:

(10.43) $$r = \frac{\sum_{t=2}^{n} e_{t-1}e_t}{\sum_{t=2}^{n} e_{t-1}^2}$$

We now obtain the transformed variables:

(10.44a) $$Y_t' = Y_t - rY_{t-1}$$

(10.44b) $$X_t' = X_t - rX_{t-1}$$

and use ordinary least squares with these transformed variables.

The Durbin-Watson test is then employed to test whether the error terms for the transformed model are uncorrelated. If the test indicates that they are uncorrelated, the procedure terminates. Otherwise, the parameter ρ is re-estimated from the new residuals for the regression model with the original variables, using the regression coefficients derived from the fit of the regression model with the transformed variables. A new set of transformed variables is then obtained with the new r. This process may be continued for several iterations until the Durbin-Watson test suggests that the error terms in the transformed model are uncorrelated.

This iterative approach does not always work properly. A major reason is that the estimate r in (10.43), when the error terms are positively autocorrelated, tends to underestimate the autocorrelation parameter ρ. This bias, when serious, can significantly reduce the effectiveness of the iterative approach.

Example. We demonstrate the iterative approach for our Blaisdell Company example, although this is one of the times when the iterative approach does not appear to work effectively. The necessary calculations for estimating the autocorrelation parameter ρ, based on the residuals obtained with ordinary least squares applied to the original variables, appear in columns 3 and 4 of Table 10.7. Hence we estimate:

$$r = \frac{22.61300}{25.37930} = .89100$$

We now obtain the transformed variables Y_t' and X_t' in (10.44a) and (10.44b):

$$Y_t' = Y_t - .89100Y_{t-1}$$
$$X_t' = X_t - .89100X_{t-1}$$

These are shown in Table 10.8. Ordinary least squares fitting of linear regression is now used with these transformed variables. The results are shown in Table 10.6b.

TABLE 10.7

Calculations for Estimating ρ for Blaisdell Company Example

t	(1) Dependent Variable e_t	(2) Independent Variable e_{t-1}	(3) e_te_{t-1}	(4) e_{t-1}^2
1	−.99655	———	———	———
2	−.98090	−.99655	.97751590	.99311190
3	−.85622	−.98090	.83986620	.96216481
4	−.62203	−.85622	.53259453	.73311269
5	−.38122	−.62203	.23713028	.38692132
6	−.12920	−.38122	.04925362	.14532869
7	.08669	−.12920	−.01120035	.01669264
8	.32040	.08669	.02777548	.00751516
9	.46580	.32040	.14924232	.10265616
10	.79806	.46580	.37173635	.21696964
11	.86766	.79806	.69244474	.63689976
12	1.01089	.86766	.87710882	.75283388
13	1.33291	1.01089	1.34742539	1.02189859
14	1.56202	1.33291	2.08203208	1.77664907
15	1.55573	1.56202	2.43008137	2.43990648
16	1.66235	1.55573	2.58616777	2.42029583
17	.83001	1.66235	1.37976712	2.76340752
18	−2.01063	.83001	−1.66884301	.68891660
19	−2.29595	−2.01063	4.61630595	4.04263300
20	−2.21982	−2.29595	5.09659573	5.27138640
Total			22.61300029	25.37930014

TABLE 10.8

Transformed Variables for First Iteration for Blaisdell Company Example

t	(1) Y_t	(2) X_t	(3) $Y_t' = Y_t - .89100\,Y_{t-1}$	(4) $X_t' = X_t - .89100\,X_{t-1}$
1	34.97	133.6	—	—
2	35.35	135.4	4.1917	16.362
3	35.92	137.6	4.4232	16.959
4	36.64	140.0	4.6353	17.398
5	37.65	143.8	5.0038	19.060
6	38.57	147.1	5.0238	18.974
7	39.13	148.8	4.7641	17.734
8	39.89	151.4	5.0252	18.819
9	40.42	153.3	4.8780	18.403
10	41.40	156.5	5.3858	19.910
11	42.34	160.8	5.4526	21.358
12	43.05	163.6	5.3251	20.327
13	44.04	166.9	5.6824	21.132
14	45.18	171.4	5.9404	22.692
15	45.70	174.0	5.4446	21.283
16	46.09	175.4	5.3713	20.366
17	46.29	180.5	5.2238	24.219
18	44.34	184.9	3.0956	24.074
19	44.50	187.1	4.9931	22.354
20	44.90	188.7	5.2505	21.994

Based on the fitted regression for the transformed variables in Table 10.6b, residuals were obtained and the Durbin-Watson statistic calculated. The result was (calculations not shown) $D = 1.37$. From Table A-6, we find for $\alpha = .01$, $p - 1 = 1$, and $n = 19$:

$$d_L = .93 \qquad d_U = 1.13$$

Since $D = 1.37 > d_U = 1.13$, we conclude that the autocorrelation coefficient for the error terms in the model with the transformed variables is zero. Hence, the estimated regression coefficients for the model with the original variables are (see Table 10.6b):

$$b_0 = 36.92266 \qquad s(b_0) = 12.07697$$
$$b_1 = .04862 \qquad s(b_1) = .06483$$

The estimated regression coefficient b_1 differs sharply from that obtained with ordinary least squares (see Table 10.6a), and is indeed not statistically significant. It also differs substantially from the regression coefficient obtained with the first differences approach, to be discussed next. It would therefore appear that the iterative approach did not work well in this example.

First Differences Approach. Some economists and statisticians have suggested that instead of iterative estimation of ρ, which is not always successful, the autocorrelation parameter be assumed to equal 1. If $\rho = 1$, the transformed model (10.41) becomes:

$$Y_t' = \beta_1' X_t' + u_t \qquad (10.45)$$

since $\beta_0' = \beta_0(1 - \rho)$. Thus the regression coefficient $\beta_1' = \beta_1$ can be directly estimated by regular least squares methods for regression through the origin with the transformed variables:

$$Y_t' = Y_t - Y_{t-1} \qquad (10.46a)$$

$$X_t' = X_t - X_{t-1} \qquad (10.46b)$$

Note that these transformed variables are ordinary first differences. It has been found that this first differences approach is effective in a variety of applications in reducing the autocorrelations of the error terms, and of course it is much simpler than the iterative approach.

Example. Table 10.9 contains the transformed variables Y_t' and X_t', based on the first differences transformation in (10.46) for our Blaisdell Company example. Application of the ordinary least squares method of estimating a linear regression through the origin led to the results shown in Table 10.6c. Note that the estimated regression coefficient $b_1 = .15068$ is similar to that obtained with ordinary least squares applied to the original variables ($b_1 = .20242$), but has an appreciably higher standard error. We

TABLE 10.9

First Differences for Blaisdell Company Data

t	(1) Y_t	(2) X_t	(3) $Y_t' = Y_t - Y_{t-1}$	(4) $X_t' = X_t - X_{t-1}$
1	34.97	133.6	—	—
2	35.35	135.4	.38	1.8
3	35.92	137.6	.57	2.2
4	36.64	140.0	.72	2.4
5	37.65	143.8	1.01	3.8
6	38.57	147.1	.92	3.3
7	39.13	148.8	.56	1.7
8	39.89	151.4	.76	2.6
9	40.42	153.3	.53	1.9
10	41.40	156.5	.98	3.2
11	42.34	160.8	.94	4.3
12	43.05	163.6	.71	2.8
13	44.04	166.9	.99	3.3
14	45.18	171.4	1.14	4.5
15	45.70	174.0	.52	2.6
16	46.09	175.4	.39	1.4
17	46.29	180.5	.20	5.1
18	44.34	184.9	−1.95	4.4
19	44.50	187.1	.16	2.2
20	44.90	188.7	.40	1.6

TABLE A-6

Durbin-Watson Test Bounds

Level of Significance $\alpha = .05$

n	$p-1=1$		$p-1=2$		$p-1=3$		$p-1=4$		$p-1=5$	
	d_L	d_U	d_L	d_U	d_L	d_U	d_L	d_U	d_L	d_U
15	1.08	1.36	0.95	1.54	0.82	1.75	0.69	1.97	0.56	2.21
16	1.10	1.37	0.98	1.54	0.86	1.73	0.74	1.93	0.62	2.15
17	1.13	1.38	1.02	1.54	0.90	1.71	0.78	1.90	0.67	2.10
18	1.16	1.39	1.05	1.53	0.93	1.69	0.82	1.87	0.71	2.06
19	1.18	1.40	1.08	1.53	0.97	1.68	0.86	1.85	0.75	2.02
20	1.20	1.41	1.10	1.54	1.00	1.68	0.90	1.83	0.79	1.99
21	1.22	1.42	1.13	1.54	1.03	1.67	0.93	1.81	0.83	1.96
22	1.24	1.43	1.15	1.54	1.05	1.66	0.96	1.80	0.86	1.94
23	1.26	1.44	1.17	1.54	1.08	1.66	0.99	1.79	0.90	1.92
24	1.27	1.45	1.19	1.55	1.10	1.66	1.01	1.78	0.93	1.90
25	1.29	1.45	1.21	1.55	1.12	1.66	1.04	1.77	0.95	1.89
26	1.30	1.46	1.22	1.55	1.14	1.65	1.06	1.76	0.98	1.88
27	1.32	1.47	1.24	1.56	1.16	1.65	1.08	1.76	1.01	1.86
28	1.33	1.48	1.26	1.56	1.18	1.65	1.10	1.75	1.03	1.85
29	1.34	1.48	1.27	1.56	1.20	1.65	1.12	1.74	1.05	1.84
30	1.35	1.49	1.28	1.57	1.21	1.65	1.14	1.74	1.07	1.83
31	1.36	1.50	1.30	1.57	1.23	1.65	1.16	1.74	1.09	1.83
32	1.37	1.50	1.31	1.57	1.24	1.65	1.18	1.73	1.11	1.82
33	1.38	1.51	1.32	1.58	1.26	1.65	1.19	1.73	1.13	1.81
34	1.39	1.51	1.33	1.58	1.27	1.65	1.21	1.73	1.15	1.81
35	1.40	1.52	1.34	1.58	1.28	1.65	1.22	1.73	1.16	1.80
36	1.41	1.52	1.35	1.59	1.29	1.65	1.24	1.73	1.18	1.80
37	1.42	1.53	1.36	1.59	1.31	1.66	1.25	1.72	1.19	1.80
38	1.43	1.54	1.37	1.59	1.32	1.66	1.26	1.72	1.21	1.79
39	1.43	1.54	1.38	1.60	1.33	1.66	1.27	1.72	1.22	1.79
40	1.44	1.54	1.39	1.60	1.34	1.66	1.29	1.72	1.23	1.79
45	1.48	1.57	1.43	1.62	1.38	1.67	1.34	1.72	1.29	1.78
50	1.50	1.59	1.46	1.63	1.42	1.67	1.38	1.72	1.34	1.77
55	1.53	1.60	1.49	1.64	1.45	1.68	1.41	1.72	1.38	1.77
60	1.55	1.62	1.51	1.65	1.48	1.69	1.44	1.73	1.41	1.77
65	1.57	1.63	1.54	1.66	1.50	1.70	1.47	1.73	1.44	1.77
70	1.58	1.64	1.55	1.67	1.52	1.70	1.49	1.74	1.46	1.77
75	1.60	1.65	1.57	1.68	1.54	1.71	1.51	1.74	1.49	1.77
80	1.61	1.66	1.59	1.69	1.56	1.72	1.53	1.74	1.51	1.77
85	1.62	1.67	1.60	1.70	1.57	1.72	1.55	1.75	1.52	1.77
90	1.63	1.68	1.61	1.70	1.59	1.73	1.57	1.75	1.54	1.78
95	1.64	1.69	1.62	1.71	1.60	1.73	1.58	1.75	1.56	1.78
100	1.65	1.69	1.63	1.72	1.61	1.74	1.59	1.76	1.57	1.78

TABLE A-6 *(continued)*

Durbin-Watson Test Bounds

Level of Significance $\alpha = .01$

n	$p-1=1$		$p-1=2$		$p-1=3$		$p-1=4$	
	d_L	d_U	d_L	d_U	d_L	d_U	d_L	d_U
15	0.81	1.07	0.70	1.25	0.59	1.46	0.49	1.70
16	0.84	1.09	0.74	1.25	0.63	1.44	0.53	1.66
17	0.87	1.10	0.77	1.25	0.67	1.43	0.57	1.63
18	0.90	1.12	0.80	1.26	0.71	1.42	0.61	1.60
19	0.93	1.13	0.83	1.26	0.74	1.41	0.65	1.58
20	0.95	1.15	0.86	1.27	0.77	1.41	0.68	1.57
21	0.97	1.16	0.89	1.27	0.80	1.41	0.72	1.55
22	1.00	1.17	0.91	1.28	0.83	1.40	0.75	1.54
23	1.02	1.19	0.94	1.29	0.86	1.40	0.77	1.53
24	1.04	1.20	0.96	1.30	0.88	1.41	0.80	1.53
25	1.05	1.21	0.98	1.30	0.90	1.41	0.83	1.52
26	1.07	1.22	1.00	1.31	0.93	1.41	0.85	1.52
27	1.09	1.23	1.02	1.32	0.95	1.41	0.88	1.51
28	1.10	1.24	1.04	1.32	0.97	1.41	0.90	1.51
29	1.12	1.25	1.05	1.33	0.99	1.42	0.92	1.51
30	1.13	1.26	1.07	1.34	1.01	1.42	0.94	1.51
31	1.15	1.27	1.08	1.34	1.02	1.42	0.96	1.51
32	1.16	1.28	1.10	1.35	1.04	1.43	0.98	1.51
33	1.17	1.29	1.11	1.36	1.05	1.43	1.00	1.51
34	1.18	1.30	1.13	1.36	1.07	1.43	1.01	1.51
35	1.19	1.31	1.14	1.37	1.08	1.44	1.03	1.51
36	1.21	1.32	1.15	1.38	1.10	1.44	1.04	1.51
37	1.22	1.32	1.16	1.38	1.11	1.45	1.06	1.51
38	1.23	1.33	1.18	1.39	1.12	1.45	1.07	1.52
39	1.24	1.34	1.19	1.39	1.14	1.45	1.09	1.52
40	1.25	1.34	1.20	1.40	1.15	1.46	1.10	1.52
45	1.29	1.38	1.24	1.42	1.20	1.48	1.16	1.53
50	1.32	1.40	1.28	1.45	1.24	1.49	1.20	1.54
55	1.36	1.43	1.32	1.47	1.28	1.51	1.25	1.55
60	1.38	1.45	1.35	1.48	1.32	1.52	1.28	1.56
65	1.41	1.47	1.38	1.50	1.35	1.53	1.31	1.57
70	1.43	1.49	1.40	1.52	1.37	1.55	1.34	1.58
75	1.45	1.50	1.42	1.53	1.39	1.56	1.37	1.59
80	1.47	1.52	1.44	1.54	1.42	1.57	1.39	1.60
85	1.48	1.53	1.46	1.55	1.43	1.58	1.41	1.60
90	1.50	1.54	1.47	1.56	1.45	1.59	1.43	1.61
95	1.51	1.55	1.49	1.57	1.47	1.60	1.45	1.62
100	1.52	1.56	1.50	1.58	1.48	1.60	1.46	1.63

Source: Reprinted, with permission, from J. Durbin and G. S. Watson, "Testing for
In Least Squares Regression, II," *Biometrika*, Vol. 38 (1951), pp. 159–78.

y'	x'	Et	Et-1	(Et-Et-1)^2	(Et)^2
4.1917	16.362	-0.6284			0.3949
4.4232	16.959	-0.4260	-0.6284	0.0410	0.1814
4.6353	17.398	-0.2352	-0.4260	0.0364	0.0553
5.0038	19.060	0.0525	-0.2352	0.0828	0.0028
5.0238	18.974	0.0766	0.0525	0.0006	0.0059
4.7641	17.734	-0.1228	0.0766	0.0398	0.0151
5.0252	18.819	0.0856	-0.1228	0.0434	0.0073
4.8780	18.403	-0.0414	0.0856	0.0161	0.0017
5.3858	19.910	0.3931	-0.0414	0.1888	0.1545
5.4526	21.358	0.3895	0.3931	0.0000	0.1517
5.3251	20.327	0.3121	0.3895	0.0060	0.0974
5.6824	21.132	0.6303	0.3121	0.1012	0.3973
5.9404	22.692	0.8124	0.6303	0.0332	0.6600
5.4446	21.283	0.3851	0.8124	0.1826	0.1483
5.3713	20.366	0.3564	0.3851	0.0008	0.1271
5.2238	24.219	0.0216	0.3564	0.1121	0.0005
3.0956	24.074	-2.0996	0.0216	4.4993	4.4083
4.9931	22.354	-0.1184	-2.0996	3.9250	0.0140
5.2505	21.994	0.1565	-0.1184	0.0756	0.0245
			SUM	9.3845	6.8480

DW= 1.370395

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.178998
R Square	0.03204
Adjusted R	-0.024899
Standard E	0.634686
Observatio	19

ANOVA

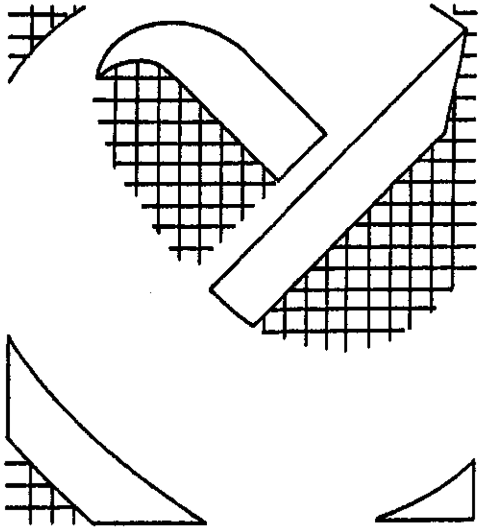
	df	*SS*	*MS*	*F*	*ignificance F*
Regression	1	0.226676	0.226676	0.562715	0.463425
Residual	17	6.848042	0.402826		
Total	18	7.074718			

	Coefficientstandard Err		*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	4.024383	1.31639	3.057135	0.00713	1.247039	6.801728	1.247039	6.801728
x'	0.048634	0.064832	0.750143	0.463425	-0.088151	0.185418	-0.088151	0.185418

econometric methods

m. dutta

Rutgers – The State University of New Jersey



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For computation the following formula is often convenient:

$$R = \frac{N\Sigma X_i Y_i - (\Sigma X_i)(\Sigma Y_i)}{\sqrt{N\Sigma X_i^2 - (\Sigma X_i)^2}\ \sqrt{N\Sigma Y_i^2 - (\Sigma Y_i)^2}} \qquad 3.3.3$$

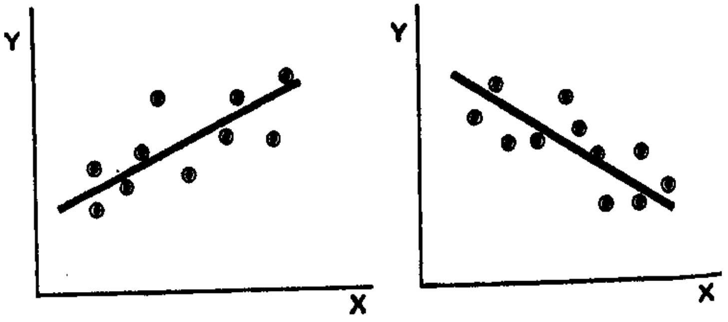
$$= \frac{\Sigma x_i y_i}{\sqrt{(\Sigma x_i^2)(\Sigma y_i^2)}} \qquad 3.3.4$$

where R = the coefficient of correlation
R^2 = the coefficient of determination

One corrects R^2 for the degrees of freedom used up in estimating the parameters as follows:

$$\boxed{\bar{R}^2 = 1 - (1 - R^2)\frac{N-1}{N-K}} \qquad 3.3.5$$

where N is the number of observations, and K is the number of parameters estimated. Obviously the correction will not be significant in the case of a truly large sample or in the case of a value of R^2 very close to one. The statistic R^2 is the measure of association between the two variables X_i and Y_i. In the case of perfect association between X_i and Y_i, both the coefficient of correlation R and the degree of determination R^2 will be unity. Therefore, $\bar{R}^2$ will also be unity. The coefficient of correlation R will be negative when smaller values of one variable are associated with larger values of the other, and positive when smaller values of one are associated with smaller values of the other and larger values with larger. If a linear relation between Y_i and X_i is assumed, a positive value for R will correspond to a positive slope for the conjectured line and a negative value to a negative slope, as in Figure 3-2.



$Y = \beta_0 + \beta_1 X;\ R > 0$ $Y = \beta_0 - \beta_1 X;\ R < 0$

FIGURE 3-2

The Relationship between the Correlation Coefficient and the Regression Coefficient

Consider model 2.1.1:

$$Y_i = \beta_0 + \beta_1 X_i + U_i$$

or in terms of deviation from the mean,

$$y_i = \beta_1 x_i + U_i$$

Recall equation 2.1.21 for the OLS estimator β_1:

$$\beta_1 = \frac{\Sigma x_i y_i}{\Sigma x_i^2}$$

From equation 3.3.2,

$$R = \frac{1}{N-1}\ \frac{\Sigma x_i y_i}{s_x s_y}$$

Multiplying both sides of equation 3.3.2 by s_y/s_x, we have:

$$R\frac{s_y}{s_x} = \frac{\Sigma x_i y_i}{(N-1)s_x s_y}\ \frac{s_y}{s_x}$$

$$= \frac{\Sigma x_i y_i}{(N-1)s_x^2}$$

Using equation 3.3.2.A,

$$R\frac{s_y}{s_x} = \frac{\Sigma x_i y_i}{(N-1)\left(\frac{\Sigma x_i^2}{N-1}\right)}$$

Therefore,

$$R\frac{s_y}{s_x} = \frac{\Sigma x_i y_i}{\Sigma x_i^2} \qquad 3.3.6$$

Notice that the right-hand quantity in equation 3.3.6 is the estimator β_1, exactly as in equation 2.1.21. We can then write:

$$\beta_1 = R\frac{s_y}{s_x} \qquad 3.3.7$$

The correspondence between the two statistical measures is thus evident. From equation 3.3.7 we can write:

$$\boxed{\beta_1 \frac{s_x}{s_y} = R} \qquad 3.3.8$$

or,

$$\hat{\beta}_1^2 \frac{s_x^2}{s_y^2} = R^2 \qquad 3.3.9$$

or,

$$\hat{\beta}_1^2 \frac{\Sigma x_i^2}{\Sigma y^2} = R^2 \qquad 3.3.10$$

or,

$$\frac{(\hat{\beta}_1 \Sigma x_i)^2}{\Sigma y_i^2} = R^2 \qquad 3.3.11$$

Since $\hat{y}_i = \hat{\beta}_1 x_i$, we can write:

$$\boxed{\frac{\Sigma \hat{y}_i^2}{\Sigma y_i^2} = R^2} \qquad 3.3.12$$

Note that $y_i = \hat{y}_i + U_i$, from which $\hat{U}_i = y_i - \hat{y}_i$ and $\hat{U}_i = y_i - \hat{\beta}_1 x_i$.

Total variation in Y is divided into two components, systematic $\hat{y}_i$ and random $\hat{U}_i$ (section 2.0). It follows that:

$$\Sigma y_i^2 = \Sigma \hat{y}_i^2 + \Sigma \hat{U}_i^2 + 2\Sigma \hat{y}_i \hat{U}_i \qquad 3.3.13$$

Since $\Sigma \hat{y}_i \hat{U}_i$ is zero,[9]

$$\Sigma y_i^2 - \Sigma \hat{U}_i^2 = \Sigma \hat{y}_i^2 \qquad 3.3.14$$

Equation 3.3.12 can then be rewritten as:

$$R^2 = \frac{\Sigma y_i^2 - \Sigma \hat{U}_i^2}{\Sigma y_i^2} \qquad 3.3.15$$

---

[9]

$$\Sigma \hat{y}_i \hat{U}_i = \hat{\beta}_1 \Sigma x_i (y_i - \hat{\beta}_1 x_i)$$
$$= \hat{\beta}_1 \Sigma x_i y_i - \hat{\beta}_1^2 \Sigma x_i^2$$

Substituting for $\hat{\beta}_1$,

$$\Sigma y_i U_i = \frac{(\Sigma x_i y_i)(\Sigma x_i y_i)}{\Sigma x_i^2} - \left(\frac{\Sigma x_i y_i}{\Sigma x_i^2}\right)^2 \Sigma x_i^2$$
$$= \frac{(\Sigma x_i y_i)^2}{\Sigma x_i^2} - \frac{(\Sigma x_i y_i)^2}{\Sigma x_i^2} = 0$$

or,

$$R^2 = 1 - \frac{\Sigma \hat{U}_i^2}{\Sigma y_i^2} \qquad 3.3.16$$

or,

$$R^2 = 1 - \frac{\Sigma (Y_i - \hat{Y})^2}{\Sigma (Y_i - \bar{Y})^2} \qquad 3.3.17$$

Therefore,

$$\boxed{R = \sqrt{1 - \frac{\Sigma (Y_i - \hat{Y})^2}{\Sigma (Y_i - \bar{Y})^2}}} \qquad 3.3.18$$

What we have under the square root sign is the ratio of the unexplained variation in Y_i and its total variation, subtracted from 1. In other words R^2 is the ratio of the "explained" variation in Y_i, "explained" by its regression on X_i, and the total variation in Y_i.

From equation 3.3.16 we have:

$$\boxed{R^2 = 1 - \frac{\Sigma \hat{U}_i^2}{\Sigma y_i^2}}$$

The above result will help explain the rationale for correcting R^2 as done in equation 3.3.5. Taking expected values,

$$E(R^2) = 1 - \frac{\Sigma E(\hat{U}_i^2)}{\Sigma E(y_i^2)} \qquad 3.3.19$$

Using equation 2.4.77, $\Sigma E(\hat{U}_i^2) = (N-2)\,\sigma_u^2$, so:

$$E(R^2) = 1 - \frac{(N-2)\hat{\sigma}_u^2}{(N-1)\hat{\sigma}_y^2} \qquad 3.3.20$$

We do not know the true U_i, nor can we compute σ_u^2 as such. In practice the computed residuals from regression analysis are used to estimate $\hat{\sigma}_u^2$. Let us assume that the true U_i are known, and let us rewrite the true R^2 as in equation 3.3.15:

$$R^2 = \frac{\Sigma y_i^2 - \Sigma U_i^2}{\Sigma y_i^2}$$

Taking expected values,[10]

---

[10] We know that:

$$\Sigma E(Y_i - \bar{Y})^2 = (N-1)\sigma_y^2$$

Similarly,

$$\Sigma E(U_i - \bar{U})^2 = (N-1)\sigma_u^2$$

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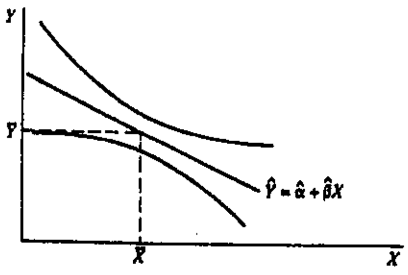


Figure 7-4

the estimation results we have derived. As an illustration, consider the variation of Y as shown in Figure 7-5. Here the values of Y observed in a given sample have been plotted against the corresponding values of X. Such a graph is generally known as a "scatter diagram." In Figure 7-5 we give 10 observations on Y corresponding to 10 different values of X. The question that now arises is why the values of Y differ from observation to observation. The answer, in accordance with the hypothesized regression model, is that the variation in Y is partly due to changes in X—which lead to changes in the expected value of Y—and partly due to the effect of the random disturbance. The next question, then, is how much of the observed variation in Y can be attributed to the variation in X and now much to the random effect of the disturbance. This question can be answered with the help of certain measures that we develop below.

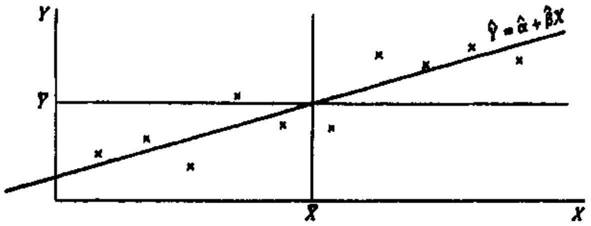


Figure 7-5

First of all, let us define the term "sample variation of Y." If there were no variation, all the values of Y, when plotted against X, would lie on a horizontal line. Since if all values of Y were the same, they would all be equal to their sample mean, the horizontal line would be the one corresponding to $\bar{Y}$ in Figure 7-5. Now, in reality, the observed values of Y will be scattered around this line so that the variation of Y could be measured by the distances of the observed values of Y from $\bar{Y}$. A convenient summary measure of these distances is the sum of their squared values, usually called the "total sum of squares," abbreviated to SST. That is, we define

$$\text{SST} = \sum_i (Y_i - \bar{Y})^2 = \sum_i y_i'^2.$$

Our aim is to decompose this sum of squares into two parts, one designed to account for the variations of Y which can be ascribed to the variations of X, and the other presumed to account for the variations in Y which can be ascribed to random causes.

Let us now return to Figure 7-5 and the sample observations shown therein. Suppose a sample regression line has been obtained by the method of least squares and drawn in the scatter diagram as shown. Since, as the name of the estimation method implies, the line is such that the sum of squares of deviations from it is a minimum, it is sometimes called the "line of the best fit." Consider now a specific observation, say Y_i, which corresponds to the value of X equal to X_i. We are interested in the vertical distance of (X_i, Y_i) from $\bar{Y}$. From Figure 7-6, we can see that this distance can be divided into two parts, one represented by the distance of the observed point from the sample regression line, and the other by the distance of the sample regression line from $\bar{Y}$. That is, we have

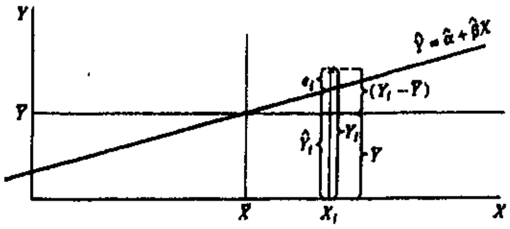


Figure 7-6

$$Y_i = \hat{Y}_i + e_i,$$

where $\hat{Y}_i$ is the point on the sample regression line corresponding to X_i. Deducting $\bar{Y}$ from both sides we obtain

$$\underbrace{(Y_i - \bar{Y})}_{\substack{\text{Total}\\ \text{distance}\\ \text{from } \bar{Y}}} = \underbrace{(\hat{Y}_i - \bar{Y})}_{\substack{\text{Distance}\\ \text{of the}\\ \text{regression}\\ \text{line from } \bar{Y}}} + \underbrace{e_i}_{\text{Residual}}.$$

This analysis applies to a single observation. Since we want a summary measure for *all* sample observations, we square both sides of this equality and sum over all sample observations. This gives

$$\sum_i (Y_i - \bar{Y})^2 = \sum_i [(\hat{Y}_i - \bar{Y}) + e_i]^2$$

$$= \sum_i (\hat{Y}_i - \bar{Y})^2 + \sum_i e_i^2 + 2\sum_i (\hat{Y}_i - \bar{Y})\, e_i.$$

Consider the last term on the right-hand side. Substituting for $\hat{Y}_i$ we get

$$2\sum_i (\hat{Y}_i - \bar{Y})e_i = 2\sum_i (\hat{\alpha} + \hat{\beta}X_i - \bar{Y})e_i$$

$$= \hat{\alpha}\sum_i e_i + \hat{\beta}\sum_i X_i e_i - \bar{Y}\sum_i e_i.$$

But by (7.10a) and (7.11a) we know that $\sum_i e_i = 0$ and $\sum_i X_i e_i = 0$, so we conclude that

$$2\sum_i (\hat{Y}_i - \bar{Y})e_i = 0.$$

Therefore,

(7.43)
$$\underbrace{\sum_i (Y_i - \bar{Y})^2}_{\substack{\text{Total sum}\\ \text{of squares}\\ \text{(SST)}}} = \underbrace{\sum_i (\hat{Y}_i - \bar{Y})^2}_{\substack{\text{Regression}\\ \text{sum of squares}\\ \text{(SSR)}}} + \underbrace{\sum_i e_i^2}_{\substack{\text{Error}\\ \text{sum of}\\ \text{squares}\\ \text{(SSE)}}}.$$

The term SSR can be further developed as follows:

(7.44)
$$\begin{aligned} \text{SSR} &= \sum (\hat{Y}_i - \bar{Y})^2 = \sum (\hat{\alpha} + \hat{\beta}X_i - \bar{Y})^2 \\ &= \sum [(\bar{Y} - \hat{\beta}\bar{X}) + \hat{\beta}X_i - \bar{Y}]^2 \\ &= \sum [-\hat{\beta}(X_i - \bar{X})]^2 \\ &= \hat{\beta}^2 \sum (X_i - \bar{X})^2 = \hat{\beta}^2 \sum x_i'^2. \end{aligned}$$

Thus we have found that the sample variation of Y (SST) can be decomposed into two parts, one describing the variation of the fitted values of Y and the other describing the variation of the regression residuals. That is, SSR represents the estimated effect of X on the variation of Y, and SSE the estimated effect of the random disturbance.

The decomposition of the sample variation of Y leads to a measure of the "goodness of fit," which is known as the *coefficient of determination* and denoted by R^2. This is simply the proportion of the variation of Y that can be attributed to the variation of X. Since

$$\text{SST} = \text{SSR} + \text{SSE},$$

dividing through by SST gives

$$1 = \frac{\text{SSR}}{\text{SST}} + \frac{\text{SSE}}{\text{SST}}.$$

The coefficient of determination is defined as

(7.45)
$$R^2 = \frac{\text{SSR}}{\text{SST}} = \frac{\hat{\beta}^2 \sum x_i'^2}{\sum y_i'^2},$$

or

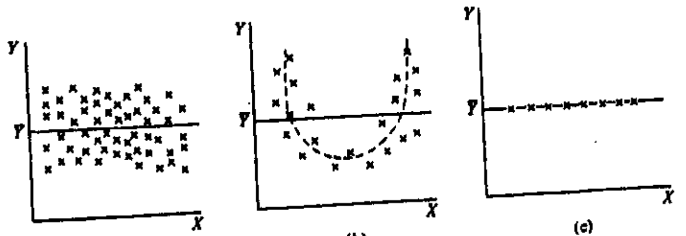
(7.45a)
$$R^2 = 1 - \frac{\text{SSE}}{\text{SST}} = 1 - \frac{\sum e_i^2}{\sum y_i'^2}.$$

R^2 is a measure commonly used to describe how well the sample regression line fits the observed data. Note that R^2 cannot be negative or greater than one, i.e.,

$$0 \leq R^2 \leq 1.$$

A zero value of R^2 indicates the poorest, and a unit value the best fit that can be attained.

A necessary but not sufficient condition for R^2 to be zero is that the sample regression line be horizontal—that is, that $\hat{\beta}$ be equal to zero. Note that the sample regression line can be horizontal for several different reasons. This is illustrated in Figure 7-7. In case (*a*) the observations are scattered randomly around $\bar{Y}$. In case (*b*) the observations are scattered around a curve such that the best-fitting straight line is a horizontal one. In this case there *is* a relationship between X and Y, but the relationship is highly nonlinear so that a straight line gives a very poor fit. Finally, in case (*c*) all observed values of Y are the same regardless of X. This is an exceptional case. With all values of Y being constant there is *no* variation to be explained, and thus the question of decomposition of variation is irrelevant. The value of R^2 in this case is indeterminate.



(a) (b) (c)

Figure 7-7

Two final points about decomposing the sample variation of Y should be noted.

following steps:

1. Obtain ordinary least squares estimates of

$$Y_t = \alpha + \beta X_t + \varepsilon_t,$$

   and calculate the residuals $\hat{\varepsilon}_1, \hat{\varepsilon}_2, \ldots, \hat{\varepsilon}_n$. Use these to get the "first round" estimate of ρ, say, $\hat{\rho}$, given as

$$\hat{\rho} = \frac{\sum \hat{\varepsilon}_t \hat{\varepsilon}_{t-1}}{\sum \hat{\varepsilon}_{t-1}^2} \qquad (t = 2, 3, \ldots, n).$$

2. Construct new variables $(Y_t - \hat{\rho} Y_{t-1})$ and $(X_t - \hat{\rho} X_{t-1})$, and obtain ordinary least squares estimates of

$$(Y_t - \hat{\rho} Y_{t-1}) = \alpha^* + \beta(X_t - \hat{\rho} X_{t-1}) + u_t,$$

   where $\alpha^* = \alpha(1 - \hat{\rho})$. These "second round" estimates, which may be called $\hat{\hat{\alpha}}$ and $\hat{\hat{\beta}}$, lead to "second round" residuals $\hat{\hat{\varepsilon}}_1, \hat{\hat{\varepsilon}}_2, \ldots, \hat{\hat{\varepsilon}}_n$ (calculated as $\hat{\hat{\varepsilon}}_t = Y_t - \hat{\hat{\alpha}} - \hat{\hat{\beta}} X_t$). The latter then are used to obtain a new estimate of ρ:

$$\hat{\hat{\rho}} = \frac{\sum \hat{\hat{\varepsilon}}_t \hat{\hat{\varepsilon}}_{t-1}}{\sum \hat{\hat{\varepsilon}}_{t-1}^2} \qquad (t = 2, 3, \ldots, n).$$

3. Construct new variables $(Y_t - \hat{\hat{\rho}} Y_{t-1})$ and $(X_t - \hat{\hat{\rho}} X_{t-1})$, and then proceed as in Step 2.

The steps are to be followed until the values of the estimators converge. It can be shown that the procedure is convergent and that, in fact, the "final round" estimates of α and β coincide with the values of the maximum likelihood estimators described above.[15] Thus the only difference between the maximum likelihood estimators developed above and the iterative estimators suggested by Orcutt and others is in the computational design.

The iterative procedure can be reduced to a *two-stage procedure* by stopping after obtaining the "second round" estimates of $\hat{\hat{\alpha}}$ and $\hat{\hat{\beta}}$, based on the "first round" value of ρ. The two-stage estimators will have the same asymptotic properties as the maximum likelihood estimators; some evidence concerning their small sample properties is presented on page 293. The estimates of the standard errors of $\hat{\hat{\alpha}}$ and $\hat{\hat{\beta}}$ can be obtained by using the formulas (8.49) and (8.51), with ρ replaced by $\hat{\rho}$.

EXAMPLE We can use the "quantity theory" relation and the data of the previous example to illustrate the two-stage estimation procedure. The "first round" estimate of ρ is

$$\hat{\rho} = 0.827.$$

---

[15] See J. D. Sargan, "Wages and Prices in the United Kingdom: A Study in Econometric Methodology," in P. E. Hart, G. Mills, and J. K. Whitaker (eds.), *Econometric Analysis for National Economic Planning* (London: Butterworths, 1964).

Note that this value is numerically very close to the maximum likelihood estimate of ρ of the previous example. The least squares estimates of the regression coefficients based on transformed data are

$$\underset{}{(C_t - 0.827C_{t-1})} = \underset{(13.760)}{-42.290} + \underset{(0.442)}{2.805}(M_t - 0.827M_{t-1}) + e_t, \qquad R^2 = 0.703.$$

This leads to the following estimates for the untransformed observations:

$$C_t = \underset{(79.537)}{-244.450} + \underset{(0.442)}{2.805}M_t + e_t, \qquad R^2 = 0.912.$$

These results are very similar to those obtained earlier by the maximum likelihood method.

Durbin's Method

A different estimation method has been suggested by Durbin.[16] Like the preceding method, *Durbin's procedure* consists of two steps. First, we rewrite (8.52) as

$$Y_t = \alpha(1 - \rho) + \rho Y_{t-1} + \beta X_t - \beta\rho X_{t-1} + u_t$$

or

$$Y_t = \alpha^* + \rho Y_{t-1} + \beta X_t + \gamma X_{t-1} + u_t.$$

This expression can be treated as a regression equation with three explanatory variables, X_t, X_{t-1} and Y_{t-1}, and estimated by the ordinary least squares method (as described in Chapter 10). The resulting estimator of ρ, say, $\tilde{\rho}$, is to be used to construct new variables $(Y_t - \tilde{\rho} Y_{t-1})$ and $(X_t - \tilde{\rho} X_{t-1})$. In the second step, we estimate

$$(Y_t - \tilde{\rho} Y_{t-1}) = \alpha^* + \beta(X_t - \tilde{\rho} X_{t-1}) + u_t^*,$$

where $\alpha^* = \alpha(1 - \rho)$. The estimators of α and β that we get will have the same *asymptotic* properties as the maximum likelihood estimators described earlier.

The Use of First Differences

In earlier applied studies, research workers frequently attempted to deal with the problem of autoregression in disturbances by using the *method of first differences*. This method calls for transforming the original data on Y and X into first differences $(Y_t - Y_{t-1})$ and $(X_t - X_{t-1})$, and for setting up the regression equation as

$$(Y_t - Y_{t-1}) = \alpha^{**} + \beta(X_t - X_{t-1}) + v_t. \tag{8.56}$$

α^{**} and β are then estimated by the method of least squares. Note that since

$$Y_t = \alpha + \beta X_t + \varepsilon_t$$

and

$$Y_{t-1} = \alpha + \beta X_{t-1} + \varepsilon_{t-1},$$

it follows that $\alpha^{**} = 0$ and $v_t = \varepsilon_t - \varepsilon_{t-1}$. The rationale of the method of first differences is the belief that the true value of ρ is close to unity. Since $\alpha^{**} = 0$,

---

[16] J. Durbin, "Estimation of Parameters in Time-Series Regression Models," *Journal of the Royal Statistical Society*, Series B, Vol. 22, January 1960, pp. 139–153.

The asymptotic variances of $\hat{\beta}$ and $\tilde{\tilde{\beta}}$ can be compared by forming the ratio

$$\frac{\text{Asympt. Var}(\hat{\beta})}{\text{Asympt. Var}(\tilde{\tilde{\beta}})} = \frac{(\sigma^2/nm_{xx})[1 + 2\rho r_1^* + 2\rho^2 r_2^* + \cdots]}{(\sigma^2/nm_{xx})[(1 - \rho^2)/(1 - 2\rho r_1^* + \rho^2)]}$$

$$= \frac{1 + 2\rho r_1^* + 2\rho^2 r_2^* + \cdots}{[(1 - \rho^2)/(1 - 2\rho r_1^* + \rho^2)]}.$$

If this ratio is greater than one, then $\hat{\beta}$ cannot be considered to be asymptotically efficient. (Strictly speaking, this statement is true only if ρ is known or can be consistently estimated; otherwise $\tilde{\tilde{\beta}}$ would not qualify as an estimator. The problem of developing a consistent estimator of ρ will be discussed in the latter part of the present section.) Suppose we evaluate the above ratio for $1 > \rho > 0$ and $r_2^* = r_1^{*2}$, $r_3^* = r_1^{*3}, \ldots$. That is, we consider a situation in which the disturbances are positively autocorrelated, and the coefficients of correlation between X_t and X_{t-1}, X_t and X_{t-2}, etc., follow a geometrical progression. Such situations are thought to be quite common with economic time series.[10] With this specification we obtain

$$\frac{\text{Asympt. Var}(\hat{\beta})}{\text{Asympt. Var}(\tilde{\tilde{\beta}})} = \frac{1 + 2\rho r_1^* + 2\rho^2 r_1^{*2} + \cdots}{[(1 - \rho^2)/(1 - 2\rho r_1^* + \rho^2)]}$$

$$= \frac{1 - \rho r_1^* - 2\rho^2 r_1^{*2} + \rho^2 + \rho^3 r_1^*}{1 - \rho r_1^* - \rho^2 + \rho^3 r_1^*}.$$

This expression will be greater than or equal to one if

$$1 - \rho r_1^* - 2\rho^2 r_1^{*2} + \rho^2 + \rho^3 r_1^* \geq 1 - \rho r_1^* - \rho^2 + \rho^3 r_1^*$$

or

$$-2\rho^2 r_1^{*2} + \rho^2 \geq -\rho^2;$$

that is, if

$$2\rho^2(1 - r_1^{*2}) \geq 0.$$

This condition will always be satisfied. For example, when $\rho = 0.6$ and $r_1^* = 0.8$, $r_2^* = 0.64$, $r_3^* = 0.512$, etc., the ratio of the two asymptotic variances is equal to 1.78, i.e., the asymptotic variance of $\hat{\beta}$ is 78 percent larger than that of $\tilde{\tilde{\beta}}$. A similar result can be obtained with respect to $\hat{\alpha}$. Thus we have to conclude that the least squares estimators of the regression coefficients are *not asymptotically efficient* when the disturbances are autoregressive.

Properties of the Estimated Variances of the Least Squares Estimators

To sum up, we have established that when the disturbances are autoregressive, the least squares estimators of the regression coefficients are unbiased and consistent, but they are not efficient or asymptotically efficient. Thus, if we use

---

[10] See E. Ames and S. Reiter, "Distributions of Correlation Coefficients in Economic Time Series," *Journal of the American Statistical Association*, Vol. 56, September 1961, pp. 637–656. The authors consider 100 annual series of 25 observations selected at random from the abstract of statistics of the United States. They find that, on the average, the first five autocorrelation coefficients were 0.84, 0.71, 0.60, 0.53 and 0.45.

the least squares formulas
sulting estimators will still
to use these estimators fo
confidence intervals, we re
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mators do, in fact, guara
disturbances. We note that
the variance of $\hat{\beta}$ is

where s^2 is an estimator of
residuals divided by $(n -$
cern ourselves with s^2. Fo

$$s^2 = \frac{1}{n-2}\sum_t$$

$$= \frac{1}{n-2}\sum_t$$

$$= \frac{1}{n-2}[(\beta$$

$$= \frac{1}{n-2}\Big[\sum_t$$

and

$$E(s^2) = \frac{1}{n-2}\Big[\sum_t$$

Now we know what Var(
$E(\varepsilon_t'^2)$. We have

$$E(\varepsilon_t'^2) = E(\varepsilon_t - \bar{\varepsilon})^2 =$$

$$= \sigma^2 + \frac{\sigma^2}{n} +$$

$$- \frac{2}{n} E[\varepsilon_t($$

$$= \sigma^2 + \frac{\sigma^2}{n} +$$

$$+ E(\varepsilon_2\varepsilon_4)$$

$$- \frac{2}{n}[E(\varepsilon_t$$

	ElectricRP	GasRP	1-Yr T	10-Yr T
1993	10.9	16.1	3.4	5.87
1994	-10.7	-1.8	5.3	7.09
1995	12.1	8.6	5.9	6.57
1996	10.9	11.3	5.5	6.44
1997	1.5	9.6	5.6	6.35
1998	14.1	1.5	5.1	5.26
1999	-8.6	-5.4	5.1	5.65
2000	2.0	9.5	6.1	6.03
2001	15.2	6.3	3.5	5.02
2002	-2.1	8.1	2.0	4.61
2003	10.6	16.2	2.4	4.01

	ElectricRP	*GasRP*	*1-Yr T*	*10-Yr T*
ElectricRP	1			
GasRP	0.587336	1		
1-Yr T	-0.14165	-0.36391	1	
10-Yr T	-0.30214	-0.26892	0.808009	1

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Rate
Rate of interest in money and capital markets
Federal Reserve System
Long-term or capital market
Government securities
Federal
Constant maturity
Ten-year
Not seasonally adjusted
Twelve months ending December
-------------------------------------------------------------
YIELDS ON TREASURY SECURITIES AT CONSTANT, FIXED MATURITY ARE
CONSTRUCTED BY THE TREASURY DEPARTMENT, BASED ON THE MOST
ACTIVELY TRADED MARKETABLE TREASURY SECURITIES.  YIELDS ON
THESE ISSUES ARE BASED ON COMPOSITE QUOTES REPORTED BY U.S.
GOVERNMENT SECURITIES DEALERS TO THE FEDERAL RESERVE BANK OF
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TREASURY CONSTRUCT A YIELD CURVE EACH BUSINESS DAY AND YIELD
VALUES ARE THEN READ FROM THE CURVE AT FIXED MATURITIES.

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      tcm10y
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1962    3.95
1963    4.00
1964    4.19
1965    4.28
1966    4.93
1967    5.07
1968    5.64
1969    6.67
1970    7.35
1971    6.16
1972    6.21
1973    6.85
1974    7.56
1975    7.99
1976    7.61
1977    7.42
1978    8.41
1979    9.43
1980   11.43
1981   13.92
1982   13.01
1983   11.10
1984   12.46
1985   10.62
1986    7.67
1987    8.39
1988    8.85
1989    8.49
1990    8.55
1991    7.86
1992    7.01
1993    5.87
1994    7.09
1995    6.57
1996    6.44
1997    6.35
1998    5.26
1999    5.65
2000    6.03
2001    5.02
2002    4.61
2003    4.01
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COMMONWEALTH OF KENTUCKY

BEFORE THE PUBLIC SERVICE COMMISSION

In the Matter of:

In the Matter of the Gas	)	
Rates of Louisville Gas	)	Case No. 2000-080
and Electric Company	)	

Testimony of Carl G. K. Weaver
Appearing on behalf of the Office of
The Attorney General for the Commonwealth of Kentucky
Utility and Rate Intervention Division

June 21, 2000

Q. What do you conclude from you analysis of the CAPM results?

A. The CAPM results indicate that the true cost of equity is in a range from 9.~~0~~5% to 10.~~0~~5%. There were eighteen outcomes below this range and ~~sixteen~~ 18 outcomes above this range.

Q. Dr. Weaver, why do you use so many combinations of data in the CAPM model?

A. Recall that our purpose is to determine investor thinking regarding the values of the investment alternatives in the capital market. It is the investors in the capital market who determine the cost of equity capital when they make their buy and sell decisions. The various combinations of variables reflect the risk-free rate, market return, and Beta assumptions that investors might use in CAPM to estimate the cost of equity.

Q. Dr. Weaver, what did the bond-yield-equity-risk-premium model show?

A. An equity risk premium is required for this approach. I performed a study of the equity risk premiums for the four gas distribution companies. To determine the risk premiums, I subtracted the realized returns on equity for the period 1990 through 1999 from the composite (over ten-year) interest rate on long-term government securities. In this determination, I examined combinations of one-year, two-year, through nine-year annual holding periods. Schedules 26 through 29 show how that study was made and provide the results of that study. The average four gas distribution company risk premium was 4.7%.

Q. How did you use the risk premiums?

A. I added this premium to the current and forecasted 10-year government bond rates to obtain an estimate for the cost of equity.

Q. **What current and forecasted rates did you use?**

A. I used three rates: a current 10-year government bond rate @ 6.23%; the 2000 forecasted 10-year treasury bond rate @6.35%; and the long-term projected 10-year bond rate @ 5.76%.

Q. **Where did you obtain these rates?**

A. The current rate was taken for the Federal Reserve's Statistical Release H:15 dated June 5, 2000. The long-term forecasts were from the Congressional Budget Office forecast dated January, 2000.

Q. **What results did you obtain using these rates?**

A. When the current bond rate of 6.23% is added to the 4.71% risk premium, the resulting cost rate is 10.94%. The near-term forecasted 6.35% rate, when added to the risk premium results in a 11.06% rate. When the 5.76% long-term projected rate is used, the resulting cost estimate is 10.47%.

The range that contains the rates obtained using the bond-yield-risk-premium method is from 10.47% to 11.06% and its average is 10.77%.

Q. **Please provide a summary of the results of the three methods.**

A. The average results for the four methods for the selected companies are:

	Selected Companies		
	Low	Average	High
DCF - constant growth	9.50%	10.05%	10.60%
DCF - two-stage growth		10.00%	
CAPM	9.00%	9.50%	10.00%
Bond-Yield-Risk-Premium	10.47%	10.77%	11.06%

COMMONWEALTH OF KENTUCKY

BEFORE THE PUBLIC SERVICE COMMISSION

In the Matter of:

In the Matter of the Gas)
Rates of Louisville Gas) Case No. 2000-080
and Electric Company)

Testimony of Carl G. K. Weaver
Appearing on behalf of the Office of
The Attorney General for the Commonwealth of Kentucky
Utility and Rate Intervention Division

June 21, 2000

Sch. 25

Notes to CAPM analysis

1. The 6.23% risk free rate is the June 5, 2000 Composite Over 10 Years (Long-term) rate that was reported in the Federal Reserve Statistical Release H.15, Selected Interest Rates, Release Date 6/06/2000, page 2 of 3.

2. The 5.88% risk free rate is average of the forecast of the 30-year Treasury Bond Rate for the years 1999-2004, Value Line Forecast for the U.S. Economy, Value Line Selection & Opinion, March 3, 2000, p. 5037.

3. The 6.35% risk free rate is the long-term forecasted 2000 and 2001 10-year Treasury Note rate from The Economic Outlook, by the Congressional Budget Office, p. 3 of 31.

4. The 6.32% risk free rate is the constant maturity 6-month Treasury Bill rate for June 5, 2000 reported in the Federal Reserve Statistical Release H.15, Selected Interest Rates, Release Date 6/06/2000, page 2 of 3.

5. The 5.27% risk free rate is average of the forecast of the 3 month Treasury Bill Rate for the years 1999-2004, Value Line Forecast for the U.S. Economy, Value Line Selection & Opinion, March 3, 2000, p. 5037.

6. The 5.5% Short-term rate is the average of the forecast of the 3-month Treasury Bill rate for the years 2000 and 2001 rate from The Economic Outlook by the Congressional Budget Office, p. 3 of 31.

7. The 18.1% market return is for the S&P 500 from I/B/E/S obtained in the April 2000 Compact Disclosure.

8. The 15.2% forecast for the S&P 500 is from Zacks obtained in the Research Report dated May 18, 2000 from YAHOO! Finance.

9. The Value Line forecast for the market return is from the April 28,2000 Value Line Index cover where the expected dividend Yield is 2.2% and the 3 to 5 year price appreciation potential is 90%. A 4 year price appreciation was assumed.

STATE OF NEW YORK DEPARTMENT OF PUBLIC SERVICE
THREE EMPIRE STATE PLAZA, ALBANY, NY 12223

PUBLIC SERVICE COMMISSION

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March 30, 1993

TO ELECTRIC AND GAS INDUSTRY GROUP:

Re: Case 91-M-0509 - Proceeding to Consider Financial Regulatory Policies for New York State Utilities

At our last Electric and Gas Industry Group (EGIG) meeting, the Co-Facilitators asked that we coordinate our cost of equity approaches, to the extent they are similar, with the approaches used by the other industry groups. Staff volunteered to do this since we attend many of the other groups' meetings. We believe that the EGIG can adopt a CAPM version that the Telco Group is using without affecting the results of our backcast analysis or the latest return on equity result.

We propose that the two CAPM analyses that are based on the zero beta formulation be replaced by another zero beta variant. More specifically, while our original zero beta model relied on a treasury bill estimate and 50/50 weighting of the market premium and the company risk premium, our revised approach uses long term treasuries as the riskless rate and weights the market premium by 25% and the company risk premium by 75%. We would compute the market premium in the same manner as originally proposed.

We have attached an article provided by the Telco Group which supports this methodology. We have also provided a revised CAPM calculation showing the traditional model (which remains unchanged) and our proposed revision. A summary table showing the effect of this revision on staff's original generic return approach is also provided. As can be seen, the effect of moving to an approach consistent with the Telco Group is negligible.

Please call us if you have any questions or comments.

Very truly yours,

Doris D. Stout
Gas Group Facilitator

John D. Stewart
Electric Group Facilitator

GENER. FINANCE CASE CASE 91-M-0509

Summar. f CAPM Methods - REVISED 3/30/93

CAPM 25/75 ZERO BETA VERSIONS: IBBOTSON PREMIUMS

	SURROGATE BETA	10/30 TBOND AVERAGE	ARITHMETIC IB ASSOC. PREMIUM	GEOMETRIC IB ASSOC. PREMIUM	AVERAGE PREMIUM	COST OF EQUITY
1980	0.63	11.38	7.34	5.62	6.48	16.06
1981	0.63	13.68	7.34	5.62	6.48	18.36
1982	0.64	12.88	7.34	5.62	6.48	17.61
1983	0.65	11.14	7.34	5.62	6.48	15.92
1984	0.64	12.42	7.34	5.62	6.48	17.15
1985	0.66	10.70	7.34	5.62	6.48	15.53
1986	0.67	7.74	7.34	5.62	6.48	12.62
1987	0.72	8.48	7.40	5.60	6.50	13.62
1988	0.67	8.90	7.40	5.60	6.50	13.79
1989	0.67	8.47	7.50	5.70	6.60	13.44
1990	0.68	8.58	7.20	5.60	6.40	13.44
1991	0.64	8.00	7.30	5.60	6.45	12.71
1992	0.60	7.60	7.30	5.60	6.45	12.12

K = Rf + .25 (Rm - Rf) + .75 BETA (Rm - Rf)

CAPM 25/75 ZERO BETA VERSIONS: IMPLIED PREMIUMS

	SURROGATE BETA	10/30 TBOND AVERAGE	AVERAGE ALLOW. ROE	AVERAGE BETA	IMPLIED PREMIUM	COST OF EQUITY
1980	0.63	11.38	14.23	0.63	3.94	14.23
1981	0.63	13.68	15.22	0.63	2.13	15.22
1982	0.64	12.88	15.78	0.62	4.06	15.84
1983	0.65	11.14	15.36	0.63	5.84	15.45
1984	0.64	12.42	15.32	0.64	3.97	15.32
1985	0.66	10.70	15.20	0.65	6.10	15.25
1986	0.67	7.74	13.93	0.70	7.99	13.75
1987	0.72	8.48	12.99	0.74	5.60	12.91
1988	0.67	8.90	12.79	0.72	4.92	12.61
1989	0.67	8.47	12.97	0.70	5.81	12.84
1990	0.68	8.58	12.70	0.67	5.48	12.74
1991	0.64	8.00	12.55	0.67	6.05	12.41
1992	0.60	7.60	12.10	0.63	6.23	11.96

K = Rf + .25 (Rm - Rf) + .75 BETA (Rm - Rf)

10. & 12. A myriad of empirical tests of the CAPM have shown that the risk-return tradeoff is not as steeply sloped as that predicted by the CAPM. That is, low-beta securities earn returns somewhat higher than the CAPM would predict, and high-beta securities earn less than predicted. This is one of the most widely known empirical finding of the finance literature. Explanations for these results include the following:

1. The CAPM excludes other important variables which are important in determining security returns.

2. The market index used in the tests excludes important classes of securities, such as bonds, mortgages, and business investment.

3. Constraints on investor borrowing exist contrary to the assumption of the CAPM.

Several finance scholars have developed refined and expanded versions of the standard CAPM, relaxing the above three constraints, and obtained broadly similar expressions for the relationship between risk and expected return. These enhanced CAPMs typically produce a risk-return relationship which is flatter than the CAPM prediction.

This is exactly what the empirical CAPM contained in my testimony accomplishes. It produces a risk-return tradeoff which is flatter than the predicted tradeoff, and approximates the observed relationship between risk and return on capital markets.

The empirical approximation to the CAPM which I develop in my testimony is consistent with both theory and empirical evidence, and has the added advantage of computational simplicity. The traditional version of the CAPM is given by the following:

$$K = R_F + BETA(R_M - R_F)$$

Based on the observed relationship between return and risk, the evidence indicates that the expected return on a security is actually given by:

$$RETURN = .0829 + .0520\ BETA$$

Given that the risk-free rate over the estimation period was approximately 6%, this relationship implies that the intercept of the risk-return relationship is higher than the 6% risk-free rate, contrary to the CAPM's prediction. Given the seminal Ibbotson-Sinquefield result that the average return on an average risk stock exceeds the risk-free rate by about 8.0% in that period, that is, $(R_M - R_F) = 8\%$, the intercept of the observed relationship between return and beta exceeds the risk-free rate by about 2%, or 1/4 of 8%, and that the slope of the relationship, .0520, is close to 3/4 of 8%. Therefore, the empirical evidence suggests that the expected return on a security is related to its risk by the following approximation:

$$K = R_F + 0.25\ (R_M - R_F) + 0.75\ BETA\ (R_M - R_F)$$

This was actually derived by systematically varying the constant "x" in the following equation from 0 to 1 in steps of 0.05 and choosing that value of 'x' which minimized the mean square error between the observed relationship, RETURN = .0829 + .0520 BETA, and the empirical shortcut CAPM formula. The value of x which best explained the observed relationship was x = 0.25.

$$K = R_F + x(R_M - R_F) + (1-x)\,\text{BETA}\,(R_M - R_F)$$

STATE OF NEW YORK

PUBLIC SERVICE COMMISSION

In the Matter Of

Proceeding on Motion of the Commission as to the Rates, Charges, Rules and Regulations of Orange and Rockland Utilities, Inc., for Gas Service

Case 99-G-1695

DIRECT TESTIMONY
AND EXHIBITS
OF
TARIQ N. NIAZI

Dated: April 12, 2000
Albany, New York

DEBRA MARTINEZ
CHAIRWOMAN AND EXECUTIVE DIRECTOR
NYS CONSUMER PROTECTION BOARD
SUITE 2101
5 EMPIRE STATE PLAZA
ALBANY, NEW YORK 12223-1556
1-800-697-1220
http://www.consumer.state.ny.us

Exhibit ____TNN
Schedule 3
Page 2 of 2

ORANGE AND ROCKLAND UTILITIES, INC.

ZERO-BETA CAPM

Formula: Rc = Rf + 3/4(b)(Rp) + 1/4(Rp)

Where:

Rc = Required Return for the Company.

Rf = Risk Free Return = 6.38%, one-month average ending February 2000 of 30-Year and 10-Year Treasury Bond Yields (averages of daily figures), Federal Reserve Statistical Release, (March 7, 2000).

Rm = Market Return = 10.7%, Quantitative Profiles-Monthly Insights for Equity Management, Merrill Lynch, March 2000.

b = Beta = .53, Proxy Group Average Beta for A-Rated Combination Electric & Gas utilities. (The Value Line Investment Survey, Ratings and Reports, December 10, 1999; January 7, 2000; February 18, 2000.

Rp = Risk Premium = 4.32, Market Return minus Risk free rate.

Required Return:

9.18% = 6.38 + .75(.53)(4.32) + .25(4.32)