Order Number 9521289

An analysis of the adjustable rate preferred stock

Lee, Kwok Yu, Ph.D.

City University of New York, 1995

U·M·I
300 N. Zeeb Rd.
Ann Arbor, MI 48106

An Analysis of the Adjustable Rate Preferred Stock

by

Kwok Y. Lee

A dissertation submitted to the Graduate Faculty in Business in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York.

1995

ABSTRACT

An Analysis of the Adjustable Rate Preferred Stock

by

Kwok Y. Lee

Adviser: Professor Ashok Vora

In this dissertation, the distinctive characteristics of the Adjustable Rate Preferred Stocks (ARPS) are identified and analyzed. The most intricate aspect is the determination of quarterly dividends. The dividend rate is indexed to the maximum of three interest rates and is subject to a floor and a ceiling. Thus, the dividend is a "collared" option on the maximum of three values. In addition, the firm has an option to redeem the ARPS five years after the issuing date. Two valuation models, the benchmark model and the option-based valuation model, are developed. The benchmark model values the ARPS like fixed rate preferred stocks while the option-based valuation model synthesizes the expected dividend of the ARPS as a portfolio of options and incorporates the option on the maximum of three "assets." Empirical tests of the cross-sectional and time-series ARPS implied risk premia reveal that the rating of the ARPS, the tax regime, the industry of the ARPS issuer, the level of the risk free rate, and the volatility of the risk free rate have significant effect on the risk premium, thus the price of the ARPS. Tests of model prices versus market price show that the option-based valuation model performs slightly better than the benchmark model.

This manuscript has been read and accepted for the Graduate Faculty in Business in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

January 17, 1995

Date

Chair of Examining Committee

January 23, 1995

Date

Executive Officer

Shulamith Gross

Giora Harpaz

George Papaioannou

Supervisory Committee

The City University of New York

ABSTRACT

An Analysis of the Adjustable Rate Preferred Stock

by

Kwok Y. Lee

Adviser: Professor Ashok Vora

In this dissertation, the distinctive characteristics of the Adjustable Rate Preferred Stocks (ARPS) are identified and analyzed. The most intricate aspect is the determination of quarterly dividends. The dividend rate is indexed to the maximum of three interest rates and is subject to a floor and a ceiling. Thus, the dividend is a "collared" option on the maximum of three values. In addition, the firm has an option to redeem the ARPS five years after the issuing date. Two valuation models, the benchmark model and the option-based valuation model, are developed. The benchmark model values the ARPS like fixed rate preferred stocks while the option-based valuation model synthesizes the expected dividend of the ARPS as a portfolio of options and incorporates the option on the maximum of three "assets." Empirical tests of the cross-sectional and time-series ARPS implied risk premia reveal that the rating of the ARPS, the tax regime, the industry of the ARPS issuer, the level of the risk free rate, and the volatility of the risk free rate have significant effect on the risk premium, thus the price of the ARPS. Tests of model prices versus market price show that the option-based valuation model performs slightly better than the benchmark model.

ACKNOWLEDGMENTS

I would like to thank Professor Ashok Vora for suggesting the topic, and providing helpful comments. Without his patient guidance, this dissertation would not be possible. I would also like to thank Professor Shulamith Gross, Professor Giora Harpaz, and Professor George Papaioannou for their valuable comments.

Mr. John Roman of Citicorp provided valuable information on the institutional aspects of adjustable rate preferred stock. I have benefited from discussions with Professor Larry Huckins and Professor Frank Tansey. I would also like to thank Mr. David Falk for reviewing the manuscript.

TABLE OF CONTENTS

LIST OF TABLES

List of Tables (Continued)

List of Tables (Continued)

List of Tables (Continued)

List of Tables (Continued)

List of Tables (Continued)

List of Tables (Continued)

List of Tables (Continued)

List of Tables (Continued)

CHAPTER ONE
Introduction

Adjustable Rate Preferred Stocks (ARPS) first appeared on the market in May 1982. At that time, they were hailed as the panacea for corporate cash managers. Between 1982 and 1984, firms raised over $9 billion via the ARPS market, which accounted for approximately 70% of all funds raised via preferred stocks. What appears to make the ARPS most attractive is that its dividend rate is indexed to the highest of three current interest rates. The three are the three-month, the ten-year, and the twenty-year U.S. Treasury interest rates. As a direct result of this feature, the market price of any individual ARPS should be very stable over time. This adjustable dividend is particularly important to investors of ARPS at times when the overall interest rate structure exhibits too much volatility. The reason is that the interest rate risk is shifted from the ARPS investors to the ARPS issuers. In addition, by tying the dividend rate of an ARPS to the highest of three market interest rates, the ARPS investors are provided with some level of protection against wide swings on the term structure of interest rates (i.e.; from upward sloping to downward sloping, and vice versa). Moreover, because the dividend rate is adjustable, firms are not reluctant to issue the ARPS even at times when the market interest rates are abnormally high. The reason is that the dividend rate is not locked at a high rate indefinitely.

Despite their thoughtful design innovation, the ARPS have several faulty features. The market price of an ARPS issue is not completely insulated from interest rate fluctuations. This shortcoming, coupled with the fact that the interest rate structure had stabilized at a bearable level by the mid 1980s, has compromised the continual success of ARPS. As a result, the market for new issues of ARPS completely collapsed by the end of 1986.

Although the issue of new ARPS has declined precipitously, about 50 of the 115 ARPS issued from 1982 to 1986 are still traded in the secondary market. As of December 31, 1992, there were 39 ARPS listed on the NYSE. In addition, new variations of the ARPS have resurfaced periodically. In fact, as recently as June 7, 1994, ConAgra Capital had issued $175 million worth of monthly dividend ARPS. Therefore, it is important for us to know how to value ARPS. Furthermore, if we know how to value ARPS, we should also be able to apply the same techniques to similar financial instruments such as the commodity linked index bonds and the adjustable rate mortgages with conversion provision.

A survey of the literature shows that there has been no comprehensive study focused on the subject of ARPS valuation. The only major prior work was a paper by Winger, Chen, Martin, Petty, and Hayden [23] in 1986. In that paper, the authors began by describing the nature of ARPS. They proceeded to empirically investigate the determinants of the spread of each ARPS. The spread, which is set at the issuing time of the ARPS, is a fixed addition or subtraction to the highest of the three market interest rates. The authors then analyzed and compared the performance of ARPS and of ARPS mutual funds with the performance of money market investments. Their study, however, did not develop any valuation model for the ARPS.

Their empirical results indicated that the spread was negatively related to the quality rating, the interest rate level, and the chronological order of issuing date of the ARPS. Clearly, a lower quality rated ARPS should have a higher yield. Therefore, the spread was higher for lower quality rated ARPS. Counter-intuitively, however, a higher spread was also associated with a lower interest rate. The authors provided no explanation for this result. As for their third result, that the spread of newly issued ARPS decreased over time, the study suggested that the early ARPS issuers had over-paid dividends by setting a higher spread. As the ARPS issuers learned from the market over time, the spread on the ARPS became narrower. This is a common process followed by innovative financial strategies that are initially characterized as being inefficient in the markets. Over time, the inefficiencies dissipate due to learning by market participants. Lastly, the authors found that the holding period volatilities of the ARPS and of the ARPS mutual funds were higher than that of money market investments while all three investments had approximately the same after tax returns. They concluded that the performance of ARPS and of ARPS mutual funds tended to be inferior to the performance of money market investments.

This dissertation is organized into five chapters. In the next chapter, a detailed description of ARPS is provided. An example is used to illustrate the determination of ARPS quarterly dividend rates. Then the features that are vital to both the investors and the issuers of ARPS are presented. Factors that influence the market price of ARPS are also discussed.

In Chapters III and IV, the "benchmark" model and the "option-based" model are developed to value the ARPS. The benchmark model values ARPS as though they were fixed rate preferred stocks. The option-based model synthesizes the expected dividends of the ARPS as a portfolio of options and incorporates the option on the maximum of three "assets" for valuation purposes. Empirical tests of the cross-sectional and time-series ARPS implied risk premia show that the rating of the ARPS, the tax regime, the industry of the ARPS issuer, the level of the risk free rate, and the volatility of the risk free rate are significant determinants of the implied risk premia. These determinants, therefore, would also apply to the market price of the ARPS. Chapter V will compare actual market prices with model prices derived from both of the aforementioned models using forecast risk premia. The tests reveal that the option-based model performs slightly better than the benchmark model.

CHAPTER TWO

Institutional Aspects of ARPS

I. Description

Like most preferred stocks, ARPS pay dividends on a quarterly basis. Although many possible dividend cycles exist, three conventional cycles are popular among the ARPS. These cycles are the January cycle, which begins on the first days of January, April, July, and October; the February cycle, which begins on the first days of February, May, August, and November; and the March cycle, which begins on the first days of March, June, September, and December. Several ARPS, however, begin their dividend cycle on the fifteenth day of the dividend cycle month, while a few others choose the twenty-ninth day of the dividend cycle month as the first day of the dividend period. The dividend payment date for each dividend period is either the last day of the pertinent dividend period or the first day of the subsequent dividend period. Unlike the fixed rate preferred stocks, however, the dividend rate of the ARPS may change for each dividend period. Each new dividend rate will be determined according to a pre-specified formula which will reflect changing market conditions. The majority of ARPS follow a standard format. These are the ARPS which we will address in this study.

The adjustable dividend rate:

The adjustable dividend rate for the dividend period in question, also called the applicable rate, is the highest of three rates plus a fixed spread that is pre-determined at the issuing time of the ARPS. The fixed spread could be positive or negative. The three rates, to be defined later, are the Treasury Bill Rate, the Ten Year Constant Maturity Rate, and the Twenty Year Constant Maturity Rate. These three rates, however, do not actually reflect the market conditions immediately prior to the new dividend period. They do, however, accurately reflect the market conditions three to four weeks prior to the beginning of the new dividend period. This is true because all three rates represent averages of ten daily values published by the Federal Reserve Board three to four weeks earlier.

To be more precise, the definitions of the three rates are reproduced here as they appear in most prospectuses:

> *..., the Treasury Bill Rate for each dividend period will be the arithmetic average of two most recent weekly per annum market discount rates for three-month U.S. Treasury bills, as published weekly by the Federal Reserve Board during the Calendar Period immediately prior to the last ten calendar days of March, June, September or December, as the case may be, prior to the dividend period for which the dividend rate on the Adjustable Rate Preferred Stock is being determined. ..., the Ten Year Constant Maturity Rate for each dividend period shall be the arithmetic average of two most recent weekly per annum Ten Year Average Yields, as published weekly by the Federal Reserve Board during the Calendar Period immediately prior to the last ten calendar days of March, June, September or December, as the case may be, prior to the dividend period for which the dividend rate on the Adjustable Rate Preferred Stock is being determined. ..., the Twenty Year Constant Maturity Rate for each dividend period shall be the arithmetic average of two most recent weekly per annum Twenty Year Average Yields, as published weekly by the Federal Reserve Board during the Calendar Period immediately prior to the last ten calendar days of March, June, September or December, as the case may be, prior to the dividend period for which the dividend rate on the Adjustable Rate Preferred Stock is being determined. ..., the term Calendar Period means a period of fourteen calendar days.*[1]

The Ten Year Average Yield is commonly known as the ten-year constant maturity yield, and the Twenty Year Average Yield is commonly known as twenty-year constant maturity yield.

The highlight of these definitions is that the three rates are based on two weekly per annum values which must be published by the Federal Reserve Board during a fourteen calendar day period immediately prior to the ten calendar day interval preceding the new dividend period. Because the Federal Reserve Board releases interest rate statistics for each week only on Monday of the following week, it is possible for the new dividend rate to be partially based on market data that are thirty-one days old.

[1] These definitions are extracted from the Chemical Bank ARPS prospectus. Chemical Bank ARPS belongs to the January/April/July/October dividend cycle. Therefore, March, June, September, and December are the appropriate months to be applied in the definitions.

To cover possible breakdowns in the determination of the adjustable dividend rate, there are contingent plans. For example, if the Federal Reserve Board publishes only one value rather than two during the fourteen calendar day period, then only that value will be used. And if any one (or two) of the three rates can not be determined, then the applicable rate will be the maximum of the remaining two rates (or one rate) plus the aforementioned fixed spread.

In fact, after 1986, the Federal Reserve Board stopped publishing the twenty-year constant maturity yield. According to the contingent plans, the issuer of an ARPS must survey at least three recognized U.S. Government securities dealers for certain relevant data in order to be able to determine the Twenty Year Constant Maturity Rate. The relevant data are the daily closing bid yields for the fourteen calendar day period of each actively traded marketable fixed interest rate security issued by the U.S. Treasury. These securities must have a maturity between eighteen and twenty-two years. Special securities and flower bonds are excluded. From the survey of securities dealers, the Twenty Year Constant Maturity Rate will be the arithmetic average of all the daily closing bid yields. For example, assume that there are only three dealers, a regular five business day work week, and six actively traded marketable fixed interest rate securities issued by the U.S. Treasury that satisfy the above conditions. This equals 180 daily closing bid yields since each security will have ten daily closing bid yields from each dealer. Then the Twenty Year Constant Maturity Rate will be the average of these 180 daily closing bid yields.

This unforeseeable problem has somewhat complicated the process of determining the new dividend rate. The worst complication is that the Twenty Year Constant Maturity Rate could be different for ARPS having the same dividend cycle since each issuer of ARPS could end up surveying a very different group of dealers. A preliminary examination of the data, however, indicates that the differences are small, generally within one-tenth of one percent. Another related observation is that there appears to be an upward bias of about four-tenths of one percent over the "market" twenty-year yield. If this bias persists and the yield curve is upward sloping then the issuers of ARPS will suffer slightly from having to pay a higher dividend rate.

Generally, the three rates are rounded to the nearest five one-hundredths of one percent by the issuers. In some cases, however, they are rounded to the nearest one-hundredth of one percent. The actual dividend per share for the dividend period is computed by dividing the applicable dividend rate by four and multiplying this quarterly figure by the stated value of the ARPS. Any shorter or longer dividend period (i.e.; not a regular quarterly dividend period due to action such as early redemption) will be pro-rated based on 90 days per quarter or 360 days per year.

Collar:

Although the dividend rates of ARPS are intended to change in accordance with changing market conditions, they can do so only up to a certain limit. The reason for the limit is that the ARPS come with a collar (i.e.; a floor rate and a ceiling rate). The collar prohibits the applicable dividend rate from being lower than the floor rate or higher than the ceiling rate.

The reason for the incorporation of a collar in ARPS is rather interesting. The first issuer of ARPS was Chemical Bank. Commercial banks, like Chemical Bank, are regulated by the Federal Reserve Board. The Federal Reserve Board recognized that Chemical Bank's financial health could be jeopardized if it were forced to pay excessively high dividends due to a high interest rate environment. Therefore, the Federal Reserve Board stipulated that Chemical Bank's ARPS must include a ceiling rate. Because the inclusion of a ceiling rate was a negative feature to investors, Chemical Bank also included a floor rate which in effect guaranteed ARPS buyers a minimum dividend. Since then, all issuers of ARPS have followed the same format even though many of them neither belonged to the banking industry nor subject to Federal Reserve Regulation.

As to how the issuer determines the collar, the process seems to be rather ad hoc in nature as inferred from prospectuses of ARPS. It appears that the issuer first applies the adjustment formula to the previous ten years' market interest rates assuming no collar. Then from the hypothetical time-series of dividend rates, the entity picks a rate near the all time low as the floor rate and chooses a rate near the all time high as the ceiling rate, thus establishing the ARPS collar.

The initial dividend rate:

The ARPS will begin to accrue dividends, at the initial dividend rate, from the date of issue until the end of the first regular dividend period.[2] There is, however, no indication as to how the initial dividend rate is set by the issuer. It is likely that the same adjustment formula, which is used to determine the subsequent quarterly adjustable dividend rate, is being applied to data published prior to the issuing date in order for the issuer to establish the initial dividend rate.

Cumulative dividend:

All ARPS include a cumulative dividend provision.

Call feature:

ARPS are not callable for the first five years. From year six to year ten the ARPS can be called, in whole or in part, at the option of the issuers, with 3% call premium above the stated value. After ten years ARPS are callable without a premium at their stated value (i.e.; at par). Obviously, if a cumulative dividend has not been paid, then the issuer can not call back the ARPS. Some issues of ARPS contain a sinking fund provision, but most issues do not have such a provision.

To illustrate the aforementioned features, Table II–1 shows the dividend rate history of Chemical Bank ARPS for the period January 1983 through July 1992. The spread is 0.5% above the maximum of the three rates. For the dividend period beginning January 1983, the highest of the three rates was 10.56% which came from either the Ten Year Constant Maturity Rate (column E) or the Twenty Year Constant Maturity Rate (column F). By adding the 0.5% spread to 10.56% and

[2] A regular dividend period means the full three months of the dividend cycle. Thus, the dividend rate for the first regular dividend period is fixed at the initial dividend rate. One ARPS even fixed the first four regular dividend periods at the initial dividend rate.

rounding the sum to the nearest five one-hundredths of one percent, the applicable dividend rate became 11.05% (column C).

Throughout this ten year dividend history of Chemical Bank ARPS, the highest of the three interest rates came from the twenty-year constant maturity with just two exceptions. Those two exceptions arose in October of 1984 and July of 1986. For the dividend period of October 1984, the Ten Year Constant Maturity Rate was 12.67%. By adding 0.5% to 12.67% and rounding the sum to the nearest five one-hundredths of one percent, the applicable dividend rate became 13.15%. Notice that after January 1987, there were no data on the twenty-year constant maturity yield published by the Federal Reserve to determine the Twenty Year Constant Maturity Rate. The yield curve, however, was upward sloping for the period January 1987 to July 1992 and the dividend rate appeared to be strictly related to the twenty-year bond. To prove this, suppose the Ten Year Constant Maturity Rate had been the highest of the three interest rates during this period, then the calculated dividend rate would have been significantly lower than the actual applicable dividend rate reported by Moody's. Therefore, we can conclude that the highest of the three rates must have come from the twenty-year bonds.

Chemical Bank ARPS has a floor rate of 7.5% and a ceiling rate of 16.25%. Throughout the ten year dividend history, the applicable dividend rate reached neither the floor nor the ceiling at any time. In addition, Chemical Bank ARPS was not callable before May 1, 1987. From May 1, 1987 to April 30, 1992 it was callable at $51.50, which represented a premium of 3% above the stated value of $50.00. On or after May 1, 1992 the ARPS was callable at $50.00. In fact, the entire issue was called on August 25, 1992 at $50.00. The Moody's rating of Chemical Bank ARPS was downgraded four times, from a rating of aa2 to a rating of ba2. Thereafter, it was upgraded twice to a final rating of baa2 before being called.

II. Who Invests in ARPS

The corporations that seek corporate income tax exclusion associated with dividends generally invest in preferred stocks. Prior to the Tax Reform Act of 1986, 85% of dividend income was exempt from corporate income taxes, while interest income was fully taxable (the maximum marginal corporate tax rate was 46%). The Tax Reform Act of 1986 lowered the dividend income exclusion from 85% to 80%, effective January 1987. The Act simultaneously lowered the maximum marginal corporate tax rate from 46% to 34%. By January 1988, the dividend income exclusion was further reduced from 80% to 70%, while the maximum marginal corporate tax rate was maintained at 34%. Because of the dividend income exclusion feature, preferred stocks were generally sold at yields lower than bonds exhibiting a comparable risk. In spite of the lower yield, however, corporations in the highest tax brackets still preferred dividend income over interest income because of the higher after-tax yield on dividend income. For example, prior to 1987, a corporation with a maximum marginal corporate tax rate of 46% would have paid only 6.9% tax on each additional dollar of preferred stock dividend. If the bond yield had been less than the dividend yield by a factor of 1.7241 (i.e.; $(1-.069)/(1-.46)$) the after-tax yield on preferred stock dividend would have been higher.

Unfortunately, fixed rate preferred stock prices are not very stable since they vary inversely with the interest rate. An upward movement in interest rates will cause investors in such financial instruments to suffer capital losses. This will pose a great degree of risk to corporations, since they only intend to temporarily "park" their idle funds in preferred stocks. The ARPS, whose dividend rate floated in tandem with the market interest rates and limited only by their collar, and thereby, exhibiting greater price stability, seem to overcome the interest rate risk dilemma inherent in fixed rate preferred stocks. As a consequence, ARPS appear to be a perfect financial innovation for many corporate cash managers.

III. Who Issues ARPS

In general, firms prefer to issue debt rather than equity if they can take advantage of the interest tax shield. On the other hand, the pre-tax yields paid on preferred stocks are lower as a result of the dividend income exclusion feature mentioned earlier. This would suggest that firms in lower tax brackets, which would not be able to use the interest tax shield as effectively as firms in higher tax brackets, would be the main issuers of preferred stocks. Surprisingly, a survey of the data showed that the issuers of ARPS were concentrated in two industries: 1) banking and financial institutions, and 2) public utilities. Of the financial institutions, life insurance firms are probably the only tax clientele group because historically these firms have had low corporate income tax rates. As for banks and other financial institutions, their major concern would be the management of interest rate risk. To immunize against the interest rate risk, banks and financial institutions need to fund their floating rate assets such as corporate loans and adjustable rate mortgages, with adjustable rate instruments such as ARPS. Therefore, banks and financial institutions do not mind the tax deficiency of ARPS. Furthermore, ARPS are considered to be Tier I capital for bank holding companies.[3]

As for public utilities, there is no sound economic motivation for them to issue preferred stocks. The only plausible explanation is that such financing does not hurt the utilities' balance sheet. The reason is that public utilities are regulated by state governments to "ensure" that common shareholders receive a fair rate of return. Thus, the preferred dividend can be viewed as part of the cost which can be passed on to the consumers via higher billing rates. In addition, the preferred stocks are considered equity. A firm can lower its cost of debt without dilution on its common stocks when issuing preferred stocks. For this reason, public utilities rely heavily on the preferred stock market. Finally, while a default on one coupon payment of a bond will trigger bankruptcy, an omission of a preferred stock dividend payment will not cause such undesirable legal consequence. Therefore, if a firm is very sensitive to financial risk, it will opt for the preferred stock financing rather

[3] Normally, only common stocks and noncumulative perpetual preferred stocks are Tier I capital for banks. But the ARPS is approved by the Federal Reserve as Tier I capital for bank holding companies with the stipulation that the issuer must have the Federal Reserve's approval before calling back the ARPS for it will reduce the company's capital base. On the other hand, Auction Rate Preferred Stock is only consider to be Tier II capital for bank holding companies because its dividend rate does not just depend on the market interest rates but also depends on the condition of its issuer. Tier I capital requirement is governed by the F.D.I.C.

than debt financing.

IV. Factors that Affect ARPS Price

The spread, collar, initial dividend rate, and call feature of an issue of ARPS will determine the initial price of that issue of ARPS. After the public offering, there is no guarantee that the price of the ARPS will remain constant in the secondary market. Several factors will have vital impacts on the ARPS price.

Credit risk:

At the initial issuance, the fixed spread is set to a level that compensates the credit risk inherent in the issuing firm and reflects the tax advantage associated with the ARPS. Subsequently, if the quality of the issuer declines, holding other variables constant, the fixed spread will not provide sufficient compensation for the higher risk. Hence, the market price of the ARPS will fall. Conversely, an improved quality of the issuer will result in a higher market price of the ARPS.

Direction of tax law:

The trend in the U.S. tax code for corporations has been toward lower dividend income exclusion, from 85% to 80%, then to the current 70%. A lower dividend income exclusion will translate into higher pre-tax required rates of return, resulting in lower ARPS prices. Fortunately, the effect of the Tax Reform Act of 1986 was negligible for the year 1987, assuming the ARPS investor was already at the maximum marginal corporate tax rate, because the Act also lowered the maximum marginal corporate tax rate from 46% to 34%. In fact, the maximum marginal corporate tax rate on dividend income was lowered to 6.8% from 6.9%. But the tax code of 1987 has further reduced the dividend income exclusion from 80% to 70%, effective January 1988, while maintaining the maximum marginal corporate tax rate at 34%. As a result, the maximum marginal corporate tax rate on dividend income has increased from 6.8% to 10.2%. Thus, the tax statutes will have significant effects on ARPS prices.

Volatile interest rates:

Holding other variables fixed, if the applicable dividend rate is fluctuating within the collar, then the ARPS price will be affected modestly. But if the interest rates are very volatile, it increases the probability that the dividend rate will be restricted by the collar, then the ARPS will be riskier.

Thin market:

There are no more than 115 issues of ARPS outstanding in the market at any one time. As previously mentioned, these issues are all concentrated in two industries. As for listing, only 62 issues have been listed on the New York Stock Exchange. Furthermore, the investors in ARPS are mainly corporations. Therefore, the selection of ARPS is narrow and the trading volume of ARPS is very low. One way to alleviate the thin market problem is to invest in mutual funds that specialize in ARPS. Pilgrim and Vanguard are examples of such funds.

Conditions for the ARPS to be called:

ARPS price should not fluctuate too much as long as the resulting dividend rate is within the boundary of its collar. If the interest rates should decline sufficiently, such that in the absence of the floor rate restriction, the resulting dividend rate would have been below the floor rate, then the ARPS price would start to rise. And if the ARPS price should rise above the call price, then the ARPS should be called immediately. This is similar to the case of callable bond in which it should be called if the interest rate were to decline substantially. The second possible condition for the ARPS to be called is when the credit rating of the ARPS has improved substantially. It is impossible to price the value of this callability feature explicitly, since this call value is a function of nonquantifiable and discrete variables.

Table II–1
Dividend History of Chemical Banking Corp. ARPS
(Original Series)

Stated value = $50.00
Callable from May 1, 1987 to April 30, 1992 at $51.50,
Callable from May 1, 1992 on at $50.00
Adjustment spread = +0.5%
Floor rate = 7.5%
Ceiling rate = 16.25%

(A): Closing price or average bid/ask on the first day of the dividend period.
(B): Moody's rating.
(C): Annual dividend rate.
(D): Treasury Bill Rate.
(E): Ten Year Constant Maturity Rate.
(F): Twenty Year Constant Maturity Rate.
(G): Source of the highest of the three rates.
(H): Call status.

yy	mm	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
83	01	$61.8750	aa2	11.05%	7.880%	10.560%	10.560%	10/20yr	no
83	04	57.0000	aa2	11.35	8.280	10.515	10.845	20yr	no
83	07	56.8750	aa2	11.55	8.730	10.790	11.055	20yr	no
83	10	57.3750	aa2	12.40	9.105	11.725	11.885	20yr	no
84	01	55.3750	aa2	12.55	9.030	11.875	12.070	20yr	no
84	04	56.5000	aa2	12.90	9.360	12.235	12.405	20yr	no
84	07	49.2500	aa2	13.95	9.880	13.450	13.460	20yr	no
84	10	52.0000	aa2	13.15	10.495	12.670	12.570	10yr	no
85	01	53.2500	aa2	12.20	8.355	11.595	11.720	20yr	no
85	04	54.5000	aa2	12.60	8.620	11.860	12.075	20yr	no
85	07	55.1250	aa2	11.00	7.020	10.060	10.495	20yr	no
85	10	56.0000	aa2	11.30	7.185	10.385	10.800	20yr	no
86	01	54.4375	aa2	10.45	7.170	9.480	9.970	20yr	no
86	04	53.1250	aa2	8.70	6.690	7.865	8.200	20yr	no
86	07	52.5625	aa2	8.60	6.355	8.105	7.950	10yr	no
86	10	52.3750	aa2	7.95	5.205	7.320	7.450	20yr	no
87	01	51.5000	aa2	7.75	5.455	7.090	7.260	20yr	no
87	04	51.6250	aa2	8.15	5.600	7.200	—*	20yr	no
87	07	52.2500	a3	9.20	5.625	8.540	—	20yr	y1
87	10	52.1875	a3	10.25	6.630	9.305	—	20yr	y1

Table II–1 (Continued)

yy	mm	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)
88	01	49.0000	a3	9.85	5.880	9.095	—	20yr	y1
88	04	41.5000	baa2	9.30	5.685	8.325	—	20yr	y1
88	07	42.0000	baa2	9.75	6.395	8.900	—	20yr	y1
88	10	43.6250	baa2	9.70	7.240	8.955	—	20yr	y1
89	01	43.5000	baa2	9.75	8.025	9.095	—	20yr	y1
89	04	45.0000	baa2	9.95	8.690	9.310	—	20yr	y1
89	07	43.0000	baa2	9.10	8.160	8.270	—	20yr	y1
89	10	44.1250	baa2	9.00	7.710	8.150	—	20yr	y1
90	01	38.0000	ba1	8.80	7.630	7.830	—	20yr	y1
90	04	36.8750	ba1	9.55	7.935	8.630	—	20yr	y1
90	07	36.5000	ba2	9.35	7.700	8.450	—	20yr	y1
90	10	28.6250	ba2	9.85	7.380	8.845	—	20yr	y1
91	01	29.7500	ba2	9.15	6.910	8.065	—	20yr	y1
91	04	37.0000	ba2	9.30	5.940	8.080	—	20yr	y1
91	07	40.7500	ba2	9.45	5.580	8.255	—	20yr	y1
91	10	43.2500	ba2	8.90	5.275	7.755	—	20yr	y1
92	01	44.7500	ba2	8.60	4.240	7.230	—	20yr	y1
92	04	48.8750	baa3	8.90	4.030	7.495	—	20yr	y1
92	07	49.7500	baa2	8.70	3.690	7.335	—	20yr	y2

Called on August 25, 1992 at $50.00

* Federal Reserve Board stopped publishing the twenty-year constant maturity yield after January 1987.

no = not callable at this time.

y1 = callable at 3% premium.

y2 = callable at par.

CHAPTER THREE
The Benchmark Model

I. Introduction

The major focus of this study is the valuation of ARPS. ARPS are difficult to value because the dividend rate of the ARPS is adjustable. Furthermore, the adjustment involves some implied option features. One obvious approach to develop a valuation model is to capture the value of the implied option features in the expected dividend rates. But a naive valuation model, based on the fixed rate preferred stock, might also work. The naive valuation model would capture the implied option features in the risk premium rather than in the expected dividend rates. The analogy here is akin to a comparison between the risk adjusted discount rate method and the certainty equivalent method. Both of these methods will yield the same present value if the adjustments are done correctly. Such a naive fixed rate valuation model shall be called the benchmark model. Notice that the benchmark model should capture the implied option features of the ARPS by having a lower risk premium. In the rest of the dissertation, we will refer to "implied option" as simply "option."

The virtue of the benchmark model is its simplicity. Therefore, it is natural to choose the benchmark model as the base for evaluating other "sophisticated" valuation models. An option-based model will be presented in the next chapter. In this chapter, an empirical investigation is conducted on the implied risk premia of the benchmark model. The major finding is that the rating of the ARPS, the tax regime, the industry of the ARPS issuer, the level of the risk free rate, and the volatility of the risk free rate are significant determinants of the risk premium of the ARPS.

The rest of the chapter is organized as follows. In the next section the benchmark model is developed. In section III possible determinants of the risk premium are discussed. Section IV presents the empirical methodology and the regression model used in the study. Section V analyzes the results of the empirical findings.

Finally, section VI provides a summary.

II. The Model

The benchmark model assumes that the latest dividend rate is the best estimate of all future dividend rates. All of the special features inherent in the ARPS, such as the option on the maximum of three interest rates, the collar, the callability, and the tax effect, are presumed to be captured in the risk premium. Thus, the ARPS will be valued like fixed rate preferred stocks. For the benchmark model to be valid, however, the risk free rate, the risk premium, and the dividend rate must be updated every quarter. That is, at the beginning of each dividend period

$$ARPS = \frac{\frac{Divrate}{4} \cdot SV}{r + RP} \tag{3.1}$$

where *Divrate* is the per annum dividend rate for the current dividend period, SV is the stated value of the ARPS, r is the per quarter risk free rate, and RP is the per quarter risk premium.

If we could observe the risk premium directly in the marketplace, or if we could infer it from some observable parameters, then we would be able to calculate the benchmark model price easily, and thereby, comparing it with the actual market price. Unfortunately, the risk premium is not directly observable in the marketplace. As a result, a direct test of the benchmark model is not possible. To circumvent this obstacle, we hypothesize that the market is efficient and proceed to calculate the implied risk premium for each observed ARPS market price. The implied risk premia will then be regressed on a set of variables that we believe to be the determinants of the risk premium. If this regression model produces a high coefficient of determination and theoretically sensible regression coefficients, then it will indirectly confirm the validity of the benchmark model.

III. Possible Determinants of the Risk Premium

Moody's rating:

Ex-ante, the default risk of the ARPS, which is firm specific, should be the most important factor in determining the risk premium. Such risk would most likely be captured by Moody's preferred stock rating. According to financial theory, a higher rating should result in a lower risk premium.

Tax regime:

There are three relevant tax regimes associated with the ARPS. Tax regime 82 covers the period from January 1982 to December 1986, the era prior to the effective date of the Tax Reform Act of 1986. Tax regime 87 covers the full calendar year 1987. It represents the period in which the Tax Reform Act of 1986 was in effect. And the tax regime 88 covers the time span from January 1988 to December 1992,[4] i.e.; the period in which the tax code of 1987 has been in effect.

The tax law, which is a macro factor, should have the same level of influence on the risk premium during its regime. Different tax laws, however, should have different influences on the risk premium. For instance, if the ARPS investors are not subject to the maximum marginal corporate tax rate, then the tax regime of 1987 should induce a higher premium than the pre-1987 level in order to offset the lower dividend income exclusion. If this does not occur, the after-tax return on dividend for 1987 will be lower than the after-tax return on dividend prior to 1987.

On the other hand, if the ARPS investors are subject to the maximum marginal corporate tax rate, then the tax regime of 1987 should have no net effect on the risk premium vis-a-vis the pre-1987 level. The reason is that the maximum marginal corporate tax rate was lowered from 46% to 34% in 1987 so that the maximum marginal corporate tax rate on dividend income was remained almost constant from tax regime of 1982 to tax regime of 1987.

Lastly, the tax regime of 1988 should induce a higher premium than the 1987 level, regardless whether the ARPS investors are subject to the maximum marginal corporate tax rate or not. The reason is that even though the tax code of 1987 reduced the dividend income exclusion from 80% to 70%, effective January 1988, it left the maximum marginal corporate tax rate untouched at 34%. Notice that the tax effect could result in an overall negative premium so that a less negative

[4] Our data end in December 1992 even though tax regime 88 covers time period beyond December 1992.

premium would be equivalent to an increase in the risk premium.

Call Status:

At the beginning of each dividend period, whether the ARPS is callable at par, callable at a premium, or not callable for the time being, could have an effect on the risk premium. Ex-ante, it is most likely that the risk premium would be highest for callable at par, lower for callable at a premium, and still lower for not callable for the time being.

Relation to the collar:

If the dividend rate reaches the floor rate or the ceiling rate, the risk premium could be affected in some way. An examination of the sample data showed that the dividend rate never reached the ceiling but it did hit the floor many times. Hitting the floor might increase the risk premium due to the accompanying greater degree of interest rate and callability risk. In the option-based model to be introduced in the next chapter, we would expect the collar effect to be captured explicitly in the expected dividend. As such, hitting the floor should have a minimal effect on the risk premium in the option-based model.

Industry:

It is possible that the Moody's rating is not uniform for all industries. This is indeed the case for corporate debt. This would imply that there is actually an industry effect, whereby, industries command higher of lower risk premia. Thus, the risk premium could also be a function of the industry to which the issuing firm of the ARPS belongs. A survey of the sample data showed that the issuers of ARPS came from three industries: banking and financial, industrial, and utility. There is no prior knowledge of how the industry effect, if it actually exists, will behave. We do hope that the empirical results of this study will shed some light on this matter.

Interest rate level and its volatility:

Ball [2] and Golob [8] showed that higher level of inflation caused greater inflation uncertainty. From financial theory, it is well established that the volatility of interest rate is a measure of risk. Thus, the risk premium could also be affected by the level of interest rates and the volatility of interest rates. The volatility, in this case, is defined as the standard deviation of the rate of change of the spot interest rate over the preceding 52 week period.[5] Ex-ante, a positive relationship is expected. That is, a higher level of interest rate should cause a higher risk premium, and a higher volatility of interest rate should also have the same effect. In the option-based model of next chapter, the interest rates and the volatility of the interest rates are captured in the expected dividend rates of the ARPS. Thus, we do not have any theoretical prediction on the effects of the interest rate level and its volatility on the risk premium.

We have discussed seven factors that we expect to be determinants of the risk premium. Therefore, the basic regression model for the implied risk premium will have five categories of qualitative variables and two quantitative variables (interest rate level, and its volatility). Each category of qualitative variable will consist of several dummy variables. The complete regression model will be described in the next section.

IV. The Empirical Methodology

The market prices of ARPS are assumed to be "fair" at all times, with the possible exception of the first three to six months after the public offering. With this assumption, we can calculate the implied risk premium embedded in the benchmark model. Since this model is discrete and based on quarterly dividends, we will only calculate the implied risk premium of each issue of ARPS on the first day of each dividend period. The empirical tests will cover the period from January 1983 to December 1992 since the first ARPS was issued in May 1982. We will incorporate pooled cross-sectional and time-series data. Each issue of ARPS included in the sample can have a maximum of 40 quarterly implied risk premia. Most of the ARPS, however, will have less than the full 40 time-series implied risk premia for a

[5] The correlations between the volatility based on 52 weeks and the volatility based on 26 weeks are 0.71 for the three-month Treasury discount rate, and 0.75 for the thirty-year constant maturity yield. We use the volatility based on 52 weeks rather than the volatility based on 26 weeks in the benchmark model.

variety of reasons, including early call back, missing relevant data, or having been issued after January 1983.

A. Data

From a list of 115 ARPS (see Table III–1) that we have collected from the Moody's Bond Record, and other sources such as the Wall Street Journal and ARPS mutual fund prospectuses,[6] 62 ARPS have market prices published in the NYSE Daily Stock Record. Of these 62 ARPS, we eliminate three ARPS because they are not rated by Moody's. Of the remaining 59 ARPS, 29 belong to the January (January/April/July/October) dividend cycle, 7 belong to the February (February/May/August/November) dividend cycle, 15 belong to the March (March/June/September/December) dividend cycle, and 8 belong to a mixed bag of uncommon dividend cycles. We discard those eight ARPS that do not belong to one of the three conventional dividend cycles and concentrate our study on the remaining 51 ARPS (see Table III–2). With 51 ARPS over a ten year sampling period, we have a potential of 2040 pooled observations. After some careful screening, however, the actual number of observations is reduced to 1571. The screening criteria for inclusion are that for the corresponding dividend period the ARPS issue has: 1) Moody's rating; 2) at least one market price or the bid/ask quote within the first 3 days of the dividend period;[7] 3) no dividend in arrears, that the issuing firm is not in default or bankruptcy; 4) a reasonable reported dividend rate, and specifically, within 0.005% deviation, in absolute terms from the prescribed rule.[8] After employing all these screening criteria, we find there is only one observation with a Moody's rating of Caa. Therefore, we can drop that observation and reduce the total to 1570 pooled observations.

In order to minimize possible data errors, the quarterly dividend rate of each

---

[6] Pilgrim and Vanguard ARPS mutual funds.

[7] The first day is defined as the first business day of the new dividend period in case the first calendar day of the new dividend period falls on a holiday or weekend.

[8] Two observations were dropped due to this criterion.

issue of ARPS found in Moody's Bond Record is cross-referenced with Moody's Annual Dividend Record, whenever possible. Unfortunately, the Moody's Bond Record has a tendency of not updating the new dividend rate in a timely manner. Occasionally, the Moody's rating seems to be misprinted, because for a given issue of ARPS, the previous quarter and the subsequent quarter report the same rating, while the quarter in between reports a different rating. Meanwhile, the Moody's Preferred Stock Rating Change Section does not indicate such a rating change has occurred. If this type of inconsistency exists, we assume it is a misprint and make the appropriate correction.

Overall, we have collected 1570 observations of pooled ARPS data. For each observation, we have the corresponding market price, dividend rate, Moody's rating, floor rate, ceiling rate, call status, industry of the issuer, stated value of the ARPS, and month and year of the dividend period.

B. The Regression Model

In order to determine the implied risk premium using the benchmark model, we must determine which risk free rate is appropriate. Should we use the short rate or the long rate? Some researchers would argue that the ARPS are long assets, requiring that the long rate be used. On the other hand, the ARPS have adjustable dividends. To reflect the short life feature of each quarter's dividend rate, the short rate might be more appropriate. Since we do not know with certainty which approach is correct, we will try both. We will use the three-month Treasury discount rate as the short rate, and the thirty-year constant maturity yield as the long rate to derive two different implied risk premia. For clarification, the benchmark model that uses the three-month Treasury discount rate will be called the benchmark 3-month (BM3M) model, and the implied risk premium of this model will be denoted as RPBM3M. The benchmark model that uses the thirty-year constant maturity yield will be called the benchmark 30-year (BM30Y) model, and the implied risk premium of this model will be denoted as RPBM30Y.

With this framework, we collect the weekly average of the three-month Treasury discount rates and the thirty-year constant maturity yields from January 1982 to December 1992. These figures are published in the Federal Reserve Bulletin. If the first day of the dividend period falls on Friday then we have a perfect match with that week's weekly average interest rates.[9] If the first day of the dividend period falls on any other day then we must use the latest Friday's weekly average interest rates to determine the implied risk premia.

To get the per quarter yields from the three-month Treasury discount rate and the thirty-year constant maturity yield we use the following two standard conversions:

$$1 + y_{1/4} = \frac{1}{1 - R_{1/4} \cdot \frac{91}{360}} \tag{3.2}$$

where $R_{1/4}$ is the three-month Treasury discount rate and $y_{1/4}$ is the per quarter yield derived from the three-month Treasury discount rate; and

$$1 + y_{30} = (1 + \frac{Y_{30}}{2})^{1/2} \tag{3.3}$$

where Y_{30} is the thirty-year constant maturity yield and y_{30} is the per quarter yield derived from the thirty-year constant maturity yield. The constant maturity yield is the bond-equivalent yield of a "current coupon" bond.

A special note is that the RPBM3M should not be regressed on the three-month Treasury discount rate since this would be like regressing a variable to itself. Likewise, the RPBM30Y should not be regressed on the thirty-year constant maturity yield.

Before setting up the regression model, it would help to know the distribution of the data. Table III–4 displays the summary statistics of the variables. For the five categories of qualitative variables, the dummy variables that are having the highest frequency of occurrence within each category are: a rating of baa2, a tax regime of 1988, a status of noncallability, a dividend rate above the floor rate, and an issuer in the banking industry. If the sample is random, then the highest joint

9 The Federal Reserve Board releases the weekly average statistics on the following Monday. But investors should have a good idea of these weekly averages by Friday.

occurrence should also coincide with these five highest frequency of occurrence of the overall data. Table III–5 displays the joint distributions of the five categories. It shows that the highest joint occurrence, with 116 observations, is a slightly different case. The dummy variables of this highest joint occurrence are: a rating of baa2, a tax regime of 1988, a status of callable at a premium, a dividend rate above the floor rate, and an issuer in the utility industry. Therefore, we expect certain data will have a greater impact on our empirical study.

In a regression using dummy variables, the estimated parameters are meaningful only relative to the base case. Therefore, we would like to choose a base case that can present the result efficiently. A rule of thumb is to choose the middle dummy variable assuming the category has some logical order. Thus, for the rating category we choose baa2 since it is approximately located in the middle, and it has the largest number of observations. For the tax regime category it is most logical to choose the tax regime of 1987 as the base since it is in the middle. And for the same reason we pick callable at a premium as the base for the call status category. As for the collar category the choice of base becomes a toss up. We arbitrarily pick the case of dividend rate above the floor rate rather than the case of hitting the floor rate as the base. The industry category is a matter of trial and error. From several of the preliminary regressions, we find that using the utility industry as the base is more efficient in explaining the results.

Thus, our general regression model for the implied risk premium of the benchmark model is:

$$\begin{aligned} RPBM = {} & \beta_1 + \beta_2\,AAA + \beta_3\,AA1 + \beta_4\,AA2 + \beta_5\,AA3 + \beta_6\,A1 + \beta_7\,A2 + \beta_8\,A3 \\ & + \beta_9\,BAA1 + \beta_{10}\,BAA3 + \beta_{11}\,BA1 + \beta_{12}\,BA2 + \beta_{13}\,BA3 + \beta_{14}\,B1 \\ & + \beta_{15}\,B3 + \beta_{16}\,TAXREG82 + \beta_{17}\,TAXREG88 + \beta_{18}\,CALLNONE \\ & + \beta_{19}\,CALLPAR + \beta_{20}\,HITFL + \beta_{21}\,BANKING \\ & + \beta_{22}\,INDUSTRIAL + \beta_{23}\,INTRATE + \beta_{24}\,VOLATILITY + \tilde{\varepsilon} \end{aligned}$$

where

$$RPBM = \text{the implied risk premium of the benchmark model (two possible sets)}$$

$AAA = 1$ if the Moody's rating is aaa, 0 otherwise

$AA1 = 1$ if the Moody's rating is aa1, 0 otherwise

$AA2 = 1$ if the Moody's rating is aa2, 0 otherwise

$AA3 = 1$ if the Moody's rating is aa3, 0 otherwise

$A1 = 1$ if the Moody's rating is a1, 0 otherwise

$A2 = 1$ if the Moody's rating is a2, 0 otherwise

$A3 = 1$ if the Moody's rating is a3, 0 otherwise

$BAA1 = 1$ if the Moody's rating is baa1, 0 otherwise

$BAA3 = 1$ if the Moody's rating is baa3, 0 otherwise

$BA1 = 1$ if the Moody's rating is ba1, 0 otherwise

$BA2 = 1$ if the Moody's rating is ba2, 0 otherwise

$BA3 = 1$ if the Moody's rating is ba3, 0 otherwise

$B1 = 1$ if the Moody's rating is b1, 0 otherwise

$B3 = 1$ if the Moody's rating is b3, 0 otherwise

$TAXREG82 = 1$ if the tax regime is before January 1987, 0 otherwise

$TAXREG88 = 1$ if the tax regime is after January 1988, 0 otherwise

$CALLNONE = 1$ if the ARPS is not callable at this time, 0 otherwise

$CALLPAR = 1$ if the ARPS is callable at par, 0 otherwise

$HITFL = 1$ if the dividend rate is equal the floor rate, 0 otherwise

$BANKING = 1$ if the ARPS issuer belongs to the banking industry, 0 otherwise

$INDUSTRIAL = 1$ if the ARPS issuer belongs to the industrial sector, 0 otherwise

$INTRATE$ = the level of the interest rate (two possible sets)

$VOLATILITY$ = the volatility of the interest rate (two possible sets)

β_i = the regression coefficient for variable i

$\tilde{\varepsilon}$ = the error term

Depending on how the implied risk premium of the benchmark model $RPBM$ is derived, different $INTRATE$ will be used. If $RPBM$ is RPBM3M then $INTRATE$ is the thirty-year constant maturity yield. If $RPBM$ is RPBM30Y then $INTRATE$ is the three-month Treasury discount rate. As for the $VOLATILITY$, there are two potential volatilities; one from the three-month Treasury discount rate and the other from the thirty-year constant maturity yield. We will try both volatilities for each case of the implied risk premium. Thus, we will have a total of four regressions, two for RPBM3M and two for RPBM30Y.

V. The Results

Table III–7 reports the results of the regression in which the implied risk premium of the benchmark model $RPBM$ is derived using the thirty-year constant maturity yield, an $INTRATE$ equal to the three-month Treasury discount rate, and a $VOLATILITY$ based on the thirty-year constant maturity yield. The R-square is 0.6080. The F-statistic is 104.24, indicating that the regression structure is highly significant. This means that our overall regression model explains the risk premium well. Now if we look at the intercept, which represents our base case, we see an estimate of −0.00404364 per quarter risk premium with a significant t-statistic. Note that this risk premium should be lower than an otherwise identical fixed rate preferred stock in order to capture the option to have the maximum of three rates. As for the other rating variables, we do see a general trend that higher rating tends to be associated with lower risk premium with the exception of AA and B rating groups. We do not have a good explanation for the AA rating group's behavior. As for the B rating variable, we believe it could be due to problem rooted in the small sample, since the $B1$ rating variable has 14 observations and the $B3$

rating variable includes only 7 observations out of a total of 1570 observations. The t-statistics for the rating variables are all significant at 1% level with the exception of the $BAA1, BAA3$, and $B3$ rating variables. The $BAA1$ rating variable is not statistically different from the base case, ($BAA2$ rating variable). Hence, it does not present any major problem with interpreting the results. The $BAA3$ rating variable's t-statistic is almost significant and the estimated coefficients have the expected sign and relative magnitude.

The risk premium of tax regime 87 is 0.00169177 lower than the risk premium of tax regime 88 and this difference is found to be statistically significant. The risk premium of tax regime 82 is 0.00045909 lower than, but not significantly different from, the risk premium of tax regime 87. This shows that the risk premium has not increased significantly as the dividend income exclusion decreased from 85% to 80%. The risk premium has increased substantially, however, as the dividend income exclusion decreased from 80% to 70%. We can infer from this result that most ARPS investors are at the maximum marginal corporate tax rate, since the Tax Reform Act of 1986 had little effect on the maximum marginal corporate tax rate on dividend income. In fact, it was actually lowered from 6.9% to 6.8%. On the other hand, the tax code of 1987 increased the maximum marginal corporate tax rate on dividend income to 10.2% effective January 1988.

The categories of call status and relation to the collar have no significant influence on the risk premium as indicated by the associated t-statistics. As for the industry effect, the banking industry does command a higher risk premium, 0.00216117 per quarter above the utility industry. This behavior could be attributed to the tighter regulation of the utility industry by government agencies. Thus, even though they have the same Moody's rating, banking industry's ARPS will require a higher risk premium than utility industry's ARPS. The industrial sector is not statistically different from the utility industry which implies that the industrial sector is statistically different from the banking industry and, therefore, commands a lower risk premium ($0.00216117 - 0.00016516 = 0.00199601$ per quarter). We do not know the reason for this behavior. It might be due to the small sample size of the industrial sector, 58 out of 1570. Lastly, as expected, a higher level of interest rate causes a higher risk premium, and a greater volatility of interest rate also has the same effect.

Table III–8 reports the results of the regression in which the risk premium of the benchmark model *RPBM* is derived using the thirty-year constant maturity yield, the *INTRATE* is the three-month Treasury discount rate, and the *VOLATILITY* is based on the three-month Treasury discount rate. The R-square of this regression is 0.6207, which is slightly higher than the R-square from the previous regression. The estimated coefficients and associated t-statistics are also very similar to those from the previous regression. The sign of the volatility coefficient is negative, however, which suggests a more volatile interest rate will result in a lower risk premium. This is contrary to the intuitive concept that investors demand a greater return (higher risk premium) when facing greater uncertainty (higher volatility).

Table III–9 reports the results of the regression in which the risk premium of the benchmark model *RPBM* is derived using the three-month Treasury discount rate, the *INTRATE* is the thirty-year constant maturity yield, and the *VOLATILITY* is based on the three-month Treasury discount rate. The R-square of this regression is 0.4834, which is substantially lower than the R-square from the first regression. The low R-square indicates that this regression model is less explanatory than the first one. The two R-squares are not comparable directly, however, since the two dependent variables are different. The next best comparison is to examine the estimated coefficients. Clearly, the relative order of the rating coefficients are not so smoothly as those from the first regression. Furthermore, the tax regime effect has vanished completely here. Therefore, we reject this regression model.

Table III–10 reports the results of a regression similar to the previous one with the exception that *VOLATILITY* is based on the thirty-year constant maturity yield. The results are very close to the results shown in Table III–9. Therefore, we can also reject this regression model.

Just to be sure that our analysis of the regression results is on track, we remove the two less important categories of call status and relation to the collar from the first regression (Table III–7) and regress the restricted model again. Table III–11 reports the result of this restricted regression. The R-square is 0.6063, which is not much lower than 0.6080, the R-square of Table III–7. The estimated coefficients of the variables are similar to those seen in Table III–7. Thus, unless we have missed a significant explanatory variable, we have found a regression model that is capable of explaining the implied risk premium of the benchmark model well. Consequently, we believe the benchmark model can be used to value the ARPS.

VI. Conclusions

In this chapter we developed a benchmark model for the ARPS and empirically tested the model. The benchmark model valued the ARPS like fixed rate preferred stocks, and assumed that the risk premium was able to capture all the implied option features embedded in the ARPS. The regression results revealed that the rating of the ARPS, the tax regime, the industry of the ARPS issuer, the level of the risk free rate, and the volatility of the risk free rate are the prime determinants of the risk premium, and therefore, the market price of the ARPS. The empirical results also suggested that most of the ARPS investors were at the maximum marginal corporate tax rate. Although the results of the benchmark model were surprisingly good, we believe a more "sophisticated" option-based model would enable us to capture all of the option features explicitly in the expected dividends. In this manner, the risk premium would just reflect the rating, the tax regime, and the call status. In the next chapter we will explore such a model.

Table III–1
List of all ARPS

		issuing date yy	mm	dd
1	Aetna Life & Casualty	82	7	28
2	Alabama Power class A 83 series	83	9	21
3	Allied Corp series F	83	1	31
4	Arizona Public Service series Q	83	3	11
5	Banc Ohio 1983 series	83	2	14
6	Bank of Boston series A	84	3	30
7	Bank of Boston series B	85	6	20
8	Bank of Boston series C	85	11	14
9	Bank of Ireland Holdings	88	10	13
10	Bank of New England 1982 series	82	12	2
11	Bank of New England 1984 series	84	9	13
12	Bank of New York	83	2	15
13	BankAmerica series A	82	10	22
14	BankAmerica series B	83	2	14
15	Banks of Mid-America series A (Liberty National)	83	4	—
16	Baxter International	85	11	25
17	Boatmen's Bancshares series A	82	12	14
18	Burlington Northern, Inc series D	83	12	13
19	Capital Holding series F	82	11	19
20	Central Hudson Gas & Electric series A	83	3	23
21	Central Louisiana Electric series 1984	84	9	12
22	Centrust Capital Corp	84	9	26
23	Chase Manhattan Corp series E	82	5	25
24	Chemical Banking Corp	82	5	11
25	Chemical Banking Corp series B	82	8	12
26	Citicorp 2nd series	83	2	18
27	Citicorp 3rd series	83	9	27
28	Cleveland Electric Illuminating series L	83	11	29
29	Cleveland Electric Illuminating series M	85	11	3
30	Coast Capital Corp	84	2	28
31	Columbia Gas series D	83	7	19
32	Comerica series A	83	7	14
33	Conneticut Light & Power dep series N	83	10	4
34	Continental Bank series 1	83	9	7
35	Continental Bank series 2	89	8	8

Table III–1 (Continued)

		yy	mm	dd
36	Crestar Financial series B (United Virginia)	85	12	4
37	Decatur Capital Corp	85	—	—
38	Empire Capital Corp	—	—	—
39	Enserch series D	82	9	2
40	Enserch series E	84	1	27
41	Equitable Bancorp series A	82	11	24
42	Equitable Bancorp series B	83	3	17
43	Financial Corp of America series A	—	—	—
44	First Arkansas Capital Corp	84	7	31
45	First Atlanta Corp series A	82	10	27
46	First Bank System series 1983A	83	9	12
47	First Bank System series 1989B	89	4	11
48	First Chicago	82	10	15
49	First Chicago series B	83	2	17
50	First Chicago series C	84	2	17
51	First City Bancorp of Texas series A	82	8	24
52	First City Bancorp of Texas series B	84	4	10
53	First Fidelity Bancorp series D	83	3	25
54	First Home Capital Corp	84	8	31
55	First RepublicBank Corp	84	3	29
56	First RepublicBank Corp series B	86	—	—
57	First RepublicBank Corp series C	87	5	27
58	Firstar Corp series B (First Wisconsin)	86	6	6
59	Fleet/Norstar Financial (Fleet Financial)	83	2	15
60	Fleet/Norstar Financial series A (Norstar)	83	2	3
61	Georgia Power class A 84 series	84	11	28
62	Georgia Power class A 1st 85 series	85	9	25
63	Georgia Power class A 2nd 85 series	85	12	5
64	Gulf States Utilities series A	83	5	5
65	Gulf States Utilities series B	84	1	24
66	Hartford National Corp (Shawmut National)	83	2	18
67	Horizon Bancorp	83	—	—
68	Houston Lighting & Power series A	84	3	21
69	Houston Lighting & Power series B	85	8	7
70	Illinois Power series A	83	2	24
71	Illinois Power series B	85	4	24
72	Integrated Resources, Inc	83	3	8
73	Iowa American Capital Corp	—	—	—
74	Irving Bank (Bank of NY)	82	11	18
75	JPS Textile senior exch series A	—	—	—

Table III–1 (Continued)

		yy	mm	dd
76	Key Banks series A (Keycorp)	83	7	21
77	Manufacturers Hanover (Chemical series E)	82	5	28
78	Manufacturers Hanover series B (Chemical series F)	82	7	22
79	Marine Midland Bank series A	83	3	2
80	Morgan JP series A	83	2	23
81	New York State Electric & Gas series A	83	9	14
82	Niagara Mohawk Power series A	83	1	19
83	Niagara Mohawk Power series B	84	8	24
84	Niagara Mohawk Power series C	85	4	11
85	Northeast Financial Resources Corp	84	8	14
86	Northern Indiana Public Service series A	83	2	17
87	Northern Trust Corp series A	84	5	1
88	Northwest Bancorp series A (Norwest series A)	82	7	20
89	Northwest Bancorp series B (Norwest series B)	82	7	30
90	Ohio Edison class A series B	85	7	31
91	Orion Capital	86	1	31
92	PSFS Finance, Inc	84	4	19
93	Puget Sound Power & Light series A	82	12	14
94	Reading & Bates Corp Fifth series	83	4	15
95	Republic Bank Corp	84	3	29
96	Republic New York floating rate series A	82	5	14
97	Republic New York floating rate series B	84	3	7
98	Sears, Roebuck	84	5	2
99	Student Loan Marketing series A	83	2	16
100	Summit Bancorp	83	2	23
101	Sun Life Group of America series A	—	—	—
102	Texas Eastern Transmission Corp series A	82	10	5
103	Texas Utilities Electric series A	84	5	16
104	Texas Utilities Electric series B	85	5	30
105	Toledo Edison series A	85	10	17
106	Toledo Edison series B	86	3	5
107	Torchmark series A	83	10	28
108	United Bank of Colorado series A	83	1	20
109	United Jersey Banks series A	83	4	28
110	United States Steel Corp (USX Corp)	82	8	25
111	Washington Water Power series G	85	11	6
112	Washington Water Power series H	86	4	16
113	Wells Fargo series A	83	3	8
114	Western Massachusetts Electric series D	83	4	12
115	Williams Natural Gas series A (Norwest Central Pipeline)	82	12	10

Table III–2
List of ARPS in the Sample and the Number of Time-Series Observations for each ARPS

#
1–29: January dividend cycle
30–36: February dividend cycle
37–51: March dividend cycle

#		number of time-series observations
1	Aetna Life & Casualty	18
2	Alabama Power class A 83 series	32
3	Central Hudson Gas & Electric series A	36
4	Chase Manhattan Corp series E	40
5	Chemical Banking Corp	39
6	Chemical Banking Corp series B	39
7	Cleveland Electric Illuminating series L	35
8	Continental Bank series 1	17
9	Continental Bank series 2	13
10	First Chicago	40
11	First Fidelity Bancorp series D	37
12	Georgia Power class A 84 series	30
13	Georgia Power class A 1st 85 series	27
14	Georgia Power class A 2nd 85 series	26
15	Irving Bank (Bank of NY)	30
16	Manufacturers Hanover (Chemical series E)	40
17	Marine Midland Bank series A	37
18	Morgan JP series A	38
19	New York State Electric & Gas series A	36
20	Niagara Mohawk Power series A	37
21	Niagara Mohawk Power series C	29
22	Northwest Bancorp series A (Norwest series A)	19
23	Orion Capital	26
24	Reading & Bates Corp Fifth series	6
25	Republic New York floating rate series A	18
26	Republic New York floating rate series B	33
27	Sears, Roebuck	12
28	United States Steel Corp (USX Corp)	40
29	Wells Fargo series A	35
30	Enserch series D	40

Table III–2 (Continued)

		number of time-series observations
31	Enserch series E	35
32	First Atlanta Corp series A	18
33	Illinois Power series A	38
34	Illinois Power series B	30
35	Torchmark series A	36
36	Williams Natural Gas series A (Norwest Central Pipeline)	27
37	Arizona Public Service series Q	38
38	Bank of New England 1982 series	19
39	BankAmerica series A	40
40	BankAmerica series B	39
41	Citicorp 2nd series	38
42	Citicorp 3rd series	37
43	Columbia Gas series D	20
44	First Chicago series B	39
45	First Chicago series C	35
46	Fleet/Norstar Financial (Fleet Financial)	39
47	Fleet/Norstar Financial series A (Norstar)	39
48	Integrated Resources, Inc	23
49	Texas Eastern Transmission Corp series A	21
50	Toledo Edison series A	28
51	Toledo Edison series B	26
	Total	1570

Table III–3
Definition of Variables

RATE3MON	= the **three-month** Treasury discount **rate**.
RATE30YR	= the **thirty-year** constant maturity **yield**.
V3M26WK	= the volatility of **three-month** Treasury discount rate based on 26 weeks of historical data.
V30Y26WK	= the volatility of **thirty-year** constant maturity yield based on 26 weeks of historical data.
V3M52WK	= the volatility of **three-month** Treasury discount rate based on 52 weeks of historical data.
V30Y52WK	= the volatility of **thirty-year** constant maturity yield based on 52 weeks of historical data.
RPBM3M	= the implied risk premium derived from the **benchmark** model that uses the **three-month** Treasury discount rate as the risk free rate.
RPBM30Y	= the implied risk premium derived from the **benchmark** model that uses the **thirty-year** constant maturity yield as the risk free rate.
RPOBRW	= the implied risk premium derived from the **option-based random walk** interest rate model.
RPOBEH	= the implied risk premium derived from the **option-based expectations hypothesis** interest rate model.
AAA	= 1 if the Moody's rating is aaa, 0 otherwise.
AA1	= 1 if the Moody's rating is aa1, 0 otherwise.
AA2	= 1 if the Moody's rating is aa2, 0 otherwise.
AA3	= 1 if the Moody's rating is aa3, 0 otherwise.
A1	= 1 if the Moody's rating is a1, 0 otherwise.
A2	= 1 if the Moody's rating is a2, 0 otherwise.
A3	= 1 if the Moody's rating is a3, 0 otherwise.
BAA1	= 1 if the Moody's rating is baa1, 0 otherwise.
BAA2	= 1 if the Moody's rating is baa2, 0 otherwise.
BAA3	= 1 if the Moody's rating is baa3, 0 otherwise.
BA1	= 1 if the Moody's rating is ba1, 0 otherwise.
BA2	= 1 if the Moody's rating is ba2, 0 otherwise.
BA3	= 1 if the Moody's rating is ba3, 0 otherwise.
B1	= 1 if the Moody's rating is b1, 0 otherwise. (No b2 rating in the sample ARPS.)
B3	= 1 if the Moody's rating is b3, 0 otherwise.

Table III–3 (Continued)

TAXREG82	= 1 if the tax regime is before January 1987, 0 otherwise.
TAXREG87	= 1 if the tax regime is from January 1987 to December 1987, 0 otherwise.
TAXREG88	= 1 if the tax regime is after January 1988, 0 otherwise.
CALLNONE	= 1 if the ARPS is not callable at this time, 0 otherwise.
CALLPREM	= 1 if the ARPS is callable at a premium, 0 otherwise.
CALLPAR	= 1 if the ARPS is callable at par, 0 otherwise.
ABOVEFL	= 1 if the dividend rate is above the floor rate, 0 otherwise.
HITFL	= 1 if the dividend rate is equal to the floor rate, 0 otherwise.
BANKING	= 1 if the ARPS issuer belongs to the banking industry, 0 otherwise.
INDUSTRIAL	= 1 if the ARPS issuer belongs to the industrial sector, 0 otherwise.
UTILITY	= 1 if the ARPS issuer belongs to the utility industry, 0 otherwise.

Table III–4
Summary Statistics for Variables

1570 OBSERVATIONS FOR EACH VARIABLE.

VARIABLE	MEAN	STD DEV	SUM	MINIMUM	MAXIMUM
RATE3MON	0.06808465	0.01703519	—	0.0289	0.1065
RATE30YR	0.09173140	0.01599054	—	0.0724	0.1380
V3M26WK	0.01965646	0.01037602	—	0.00852234	0.05990913
V30Y26WK	0.01361076	0.00353197	—	0.00785989	0.02354062
V3M52WK	0.02074084	0.00929956	—	0.00913459	0.05146425
V30Y52WK	0.01410461	0.00285772	—	0.00977602	0.02033180
RPBM3M	0.00610147	0.00438774	—	−0.00309507	0.02829862
RPBM30Y	0.00096433	0.00418654	—	−0.00895605	0.02457513
RPOBRW	0.00239292	0.00447100	—	−0.00665370	0.02554960
RPOBEH	0.00208305	0.00411247	—	−0.00622570	0.02582270
AAA	0.02356688	0.15174369	37	0	1
AA1	0.03757962	0.19023785	59	0	1
AA2	0.04458599	0.20645878	70	0	1
AA3	0.05796178	0.23374562	91	0	1
A1	0.06305732	0.24314348	99	0	1
A2	0.14777070	0.35498561	232	0	1
A3	0.07961783	0.27078689	125	0	1
BAA1	0.12738854	0.33351393	200	0	1
BAA2	0.19171975	0.39377919	301	0	1
BAA3	0.05350318	0.22510635	84	0	1
BA1	0.05350318	0.22510635	84	0	1
BA2	0.08152866	0.27373247	128	0	1
BA3	0.02547771	0.15762112	40	0	1
B1	0.00891720	0.09403889	14	0	1
B3	0.00382166	0.06172096	6	0	1
TAXREG82	0.38025478	0.48560404	597	0	1
TAXREG87	0.11719745	0.32175791	184	0	1
TAXREG88	0.50254777	0.50015282	789	0	1
CALLNONE	0.53630573	0.49883904	842	0	1
CALLPREM	0.43566879	0.49600221	684	0	1
CALLPAR	0.02802548	0.16509819	44	0	1
ABOVEFL	0.75923567	0.42768373	1192	0	1
HITFL	0.24076433	0.42768373	378	0	1
BANKING	0.58662420	0.49259598	921	0	1
INDUSTRIAL	0.03694268	0.18868118	58	0	1
UTILITY	0.37643312	0.48464506	591	0	1

Table III–5
Joint Distribution of Sample ARPS by Industry

'2 = the tax regime is before January 1982.
'7 = the tax regime is from January 1987 to December 1987.
'8 = the tax regime is after January 1988.

BANKING:

	CALLNONE:						CALLPREM:						CALLPAR:						
	ABOVEFL:			HITFL:			ABOVEFL:			HITFL:			ABOVEFL:			HITFL:			
	'2	'7	'8	'2	'7	'8	'2	'7	'8	'2	'7	'8	'2	'7	'8	'2	'7	'8	Total
AAA	24	0	0	3	2	0	0	0	0	3	4	1	0	0	0	0	0	0	37
AA1	32	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	19	59
AA2	51	3	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	58
AA3	62	2	1	8	8	0	0	0	5	0	0	4	0	0	0	0	0	0	90
A1	32	5	5	8	10	0	0	1	22	0	0	16	0	0	0	0	0	0	99
A2	77	10	6	8	13	2	0	1	23	0	0	35	0	0	0	0	0	4	179
A3	16	6	4	3	7	0	0	6	20	0	0	20	0	0	0	0	0	3	85
BAA1	11	5	1	6	1	0	0	0	31	0	0	23	0	0	0	0	0	0	78
BAA2	1	0	0	3	0	0	0	0	36	0	0	19	0	0	1	0	0	1	61
BAA3	2	1	5	0	0	0	0	0	16	0	0	5	0	0	2	0	0	0	31
BA1	14	4	4	1	0	0	0	0	12	0	0	8	0	0	0	0	0	9	52
BA2	0	3	1	0	0	0	0	0	35	0	0	1	0	0	3	0	0	0	43
BA3	0	0	9	4	2	0	0	0	12	0	0	2	0	0	0	0	0	0	29
B1	0	2	3	0	3	1	0	1	0	0	0	4	0	0	0	0	0	0	14
B3	0	0	0	0	0	0	0	0	2	0	0	4	0	0	0	0	0	0	6
Total	322	↓ 41	39	↓ 54	48	↓ 3	0	↓ 9	214	↓ 3	4	↓ 142	0	↓ 0	6	↓ 0	0	↓ 36	921

Table III–5 (Continued)

UTILITY:

	CALLNONE:						CALLPREM:						CALLPAR:						
	ABOVEFL:			HITFL:			ABOVEFL:			HITFL:			ABOVEFL:			HITFL:			
	'2	'7	'8	'2	'7	'8	'2	'7	'8	'2	'7	'8	'2	'7	'8	'2	'7	'8	Total
AAA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AA1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AA2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AA3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
A1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	25	2	3	7	2	0	0	0	14	0	0	0	0	0	0	0	0	0	53
A3	27	3	1	0	5	0	0	0	0	0	0	2	0	0	0	0	0	0	38
BAA1	44	4	1	2	0	0	10	12	45	1	1	0	0	0	0	0	0	0	120
BAA2	43	23	20	17	11	1	0	1	116	0	0	4	0	0	0	0	0	0	236
BAA3	0	4	6	0	0	0	0	0	18	0	0	17	0	0	1	0	0	0	46
BA1	3	0	1	0	0	1	0	0	3	0	0	2	0	0	0	0	0	0	10
BA2	6	8	25	0	0	1	0	0	35	0	0	4	0	0	0	0	0	0	79
BA3	0	0	0	0	0	1	0	0	3	0	0	4	0	0	0	0	0	0	8
B1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	149	↓	57	↓	18	↓	10	↓	234	↓	1	↓	0	↓	1	↓	0	↓	591
		44		26		4		13		1		33		0		0		0	

Table III–5 (Continued)

INDUSTRIAL:

	CALLNONE:						CALLPREM:						CALLPAR:						
	ABOVEFL:			HITFL:			ABOVEFL:			HITFL:			ABOVEFL:			HITFL:			
	'2	'7	'8	'2	'7	'8	'2	'7	'8	'2	'7	'8	'2	'7	'8	'2	'7	'8	Total
AAA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AA1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AA2	7	0	0	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	12
AA3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
BAA1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
BAA2	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
BAA3	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
BA1	4	1	0	0	0	0	0	0	16	0	0	0	0	0	1	0	0	0	22
BA2	0	2	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	6
BA3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
B1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	29	3	0	3	2	0	0	1	19	0	0	0	0	0	1	0	0	0	58

Table III–6
Correlation Matrix of Variables

PEARSON CORRELATION COEFFICIENTS
PROB > |R| UNDER H_0: CORRELATION = 0,
NUMBER OF OBSERVATIONS = 1570

	RATE-3MON	RATE-30YR	V3M-26WK	V30Y-26WK	V3M-52WK	V30Y-52WK
RATE3MON	1.00000					
	0.0000					
RATE30YR	0.75925	1.00000				
	0.0001	0.0000				
V3M26WK	−0.28551	−0.02715	1.00000			
	0.0001	0.2823	0.0000			
V30Y26WK	−0.07613	−0.09571	0.61091	1.00000		
	0.0025	0.0001	0.0001	0.0000		
V3M52WK	−0.09829	0.10350	0.71067	0.40478	1.00000	
	0.0001	0.0001	0.0001	0.0001	0.0000	
V30Y52WK	−0.03513	−0.03207	0.51692	0.74934	0.65344	1.00000
	0.1642	0.2041	0.0001	0.0001	0.0001	0.0000
RPBM3M	−0.43292	−0.19163	0.08794	−0.08819	−0.03671	−0.15062
	0.0001	0.0001	0.0005	0.0005	0.1460	0.0001
RPBM30Y	−0.09714	−0.32293	−0.18701	−0.08661	−0.24092	−0.16812
	0.0001	0.0001	0.0001	0.0006	0.0001	0.0001
RPOBRW	−0.16715	−0.46672	−0.16131	−0.04102	−0.20759	−0.10389
	0.0001	0.0001	0.0001	0.1042	0.0001	0.0001
RPOBEH	−0.16940	−0.34269	−0.13579	−0.06636	−0.17229	−0.11633
	0.0001	0.0001	0.0001	0.0085	0.0001	0.0001
AAA	0.06656	0.09775	0.01894	0.04702	0.03203	0.06165
	0.0083	0.0001	0.4533	0.0625	0.2046	0.0146
AA1	0.08968	0.10271	−0.00627	0.00763	0.02318	0.01171
	0.0004	0.0001	0.8040	0.7625	0.3586	0.6429
AA2	0.11449	0.15251	0.02578	0.06337	0.07489	0.09909
	0.0001	0.0001	0.3074	0.0120	0.0030	0.0001
AA3	0.17858	0.22507	0.00095	0.01663	0.03577	0.04420
	0.0001	0.0001	0.9701	0.5101	0.1566	0.0800
A1	−0.01466	−0.04705	−0.00962	0.03732	−0.01358	0.03559
	0.5616	0.0624	0.7032	0.1394	0.5907	0.1587
A2	0.08328	0.10138	0.02562	0.03340	0.04197	0.04277
	0.0010	0.0001	0.3104	0.1859	0.0965	0.0902
A3	0.07909	0.08566	0.07595	0.05337	0.05551	0.05298
	0.0017	0.0007	0.0026	0.0345	0.0279	0.0358

Table III–6 (Continued)

	RATE-3MON	RATE-30YR	V3M-26WK	V30Y-26WK	V3M-52WK	V30Y-52WK
BAA1	−0.12497	−0.08364	−0.07621	−0.04648	−0.11360	−0.07084
	0.0001	0.0009	0.0025	0.0656	0.0001	0.0050
BAA2	−0.01611	−0.10040	0.01638	0.00725	0.05527	0.03351
	0.5235	0.0001	0.5167	0.7740	0.0285	0.1845
BAA3	−0.16961	−0.13195	0.02180	−0.08144	−0.04710	−0.15313
	0.0001	0.0001	0.3881	0.0012	0.0620	0.0001
BA1	−0.04996	−0.05134	−0.03488	−0.08013	−0.06097	−0.08523
	0.0478	0.0420	0.1672	0.0015	0.0157	0.0007
BA2	−0.10210	−0.15040	−0.04691	−0.03010	−0.07849	−0.05111
	0.0001	0.0001	0.0631	0.2332	0.0019	0.0429
BA3	−0.01208	−0.06809	−0.05994	−0.03422	−0.04948	−0.03388
	0.6325	0.0070	0.0175	0.1753	0.0500	0.1796
B1	−0.12460	−0.05690	0.05492	−0.00435	0.01752	−0.03448
	0.0001	0.0242	0.0295	0.8633	0.4879	0.1721
B3	−0.01510	−0.00438	0.07275	0.03433	0.13561	0.09896
	0.5500	0.8622	0.0039	0.1739	0.0001	0.0001
TAXREG82	0.43755	0.61049	−0.04060	0.17167	0.01662	0.13458
	0.0001	0.0001	0.1078	0.0001	0.5106	0.0001
TAXREG87	−0.21836	−0.18446	0.15501	0.21789	0.05595	0.32190
	0.0001	0.0001	0.0001	0.0001	0.0266	0.0001
TAXREG88	−0.28435	−0.47407	−0.06030	−0.30684	−0.05213	−0.33775
	0.0001	0.0001	0.0169	0.0001	0.0389	0.0001
CALLNONE	0.31220	0.46211	0.12169	0.29887	0.15231	0.35716
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
CALLPREM	−0.26698	−0.42731	−0.11911	−0.26611	−0.14292	−0.31594
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
CALLPAR	−0.14121	−0.11250	−0.00984	−0.10355	−0.03082	−0.12998
	0.0001	0.0001	0.6968	0.0001	0.2222	0.0001
ABOVEFL	0.35253	0.40837	−0.01364	−0.06083	0.08448	−0.04964
	0.0001	0.0001	0.5892	0.0159	0.0008	0.0492
HITFL	−0.35253	−0.40837	0.01364	0.06083	−0.08448	0.04964
	0.0001	0.0001	0.5892	0.0159	0.0008	0.0492
BANKING	0.06051	0.07673	−0.00350	−0.00743	0.01758	0.00301
	0.0165	0.0023	0.8899	0.7685	0.4864	0.9053
INDUSTRIAL	0.03053	0.04843	0.00573	0.01040	0.00768	0.00662
	0.2266	0.0550	0.8205	0.6804	0.7612	0.7932
UTILITY	−0.07339	−0.09684	0.00132	0.00350	−0.02085	−0.00563
	0.0036	0.0001	0.9582	0.8897	0.4089	0.8235

Table III–6 (Continued)

	RPBM-3M	RPBM-30Y	RPOB-RW	RPOB-EH	AAA	AA1
RPBM3M	1.00000					
	0.0000					
RPBM30Y	0.76660	1.00000				
	0.0001	0.0000				
RPOBRW	0.66851	0.95614	1.00000			
	0.0001	0.0001	0.0000			
RPOBEH	0.80010	0.97651	0.96119	1.00000		
	0.0001	0.0001	0.0001	0.0000		
AAA	−0.18082	−0.20965	−0.19170	−0.20749	1.00000	
	0.0001	0.0001	0.0001	0.0001	0.0000	
AA1	−0.13942	−0.14604	−0.13473	−0.15053	−0.03070	1.00000
	0.0001	0.0001	0.0001	0.0001	0.2241	0.0000
AA2	−0.11356	−0.13910	−0.15974	−0.13457	−0.03356	−0.04269
	0.0001	0.0001	0.0001	0.0001	0.1838	0.0909
AA3	−0.21188	−0.24108	−0.22863	−0.23053	−0.03854	−0.04902
	0.0001	0.0001	0.0001	0.0001	0.1269	0.0522
A1	−0.14740	−0.12680	−0.08527	−0.11606	−0.04030	−0.05126
	0.0001	0.0001	0.0007	0.0001	0.1104	0.0423
A2	−0.21934	−0.23589	−0.22801	−0.24561	−0.06469	−0.08228
	0.0001	0.0001	0.0001	0.0001	0.0103	0.0011
A3	−0.08297	−0.08266	−0.08776	−0.09828	−0.04569	−0.05812
	0.0010	0.0010	0.0005	0.0001	0.0703	0.0213
BAA1	0.09595	0.04567	0.02225	0.04754	−0.05936	−0.07550
	0.0001	0.0704	0.3784	0.0597	0.0187	0.0028
BAA2	0.01596	0.09261	0.10930	0.08091	−0.07566	−0.09624
	0.5273	0.0002	0.0001	0.0013	0.0027	0.0001
BAA3	0.14592	0.09618	0.09767	0.10736	−0.03694	−0.04698
	0.0001	0.0001	0.0001	0.0001	0.1435	0.0627
BA1	0.26081	0.26816	0.24480	0.26577	−0.03694	−0.04698
	0.0001	0.0001	0.0001	0.0001	0.1435	0.0627
BA2	0.31094	0.35695	0.30865	0.35669	−0.04629	−0.05887
	0.0001	0.0001	0.0001	0.0001	0.0667	0.0197
BA3	0.17751	0.23639	0.23670	0.24072	−0.02512	−0.03195
	0.0001	0.0001	0.0001	0.0001	0.3199	0.2058
B1	0.17301	0.10221	0.12295	0.12723	−0.01474	−0.01874
	0.0001	0.0001	0.0001	0.0001	0.5596	0.4580
B3	0.06309	0.05381	0.09179	0.07387	−0.00962	−0.01224
	0.0124	0.0330	0.0003	0.0034	0.7032	0.6280

Table III–6 (Continued)

	RPBM-3M	RPBM-30Y	RPOB-RW	RPOB-EH	AAA	AA1
TAXREG82	−0.32195	−0.43968	−0.54264	−0.43507	0.13779	0.12118
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
TAXREG87	−0.05985	−0.12438	−0.06272	−0.09489	0.02172	−0.07200
	0.0177	0.0001	0.0129	0.0002	0.3898	0.0043
TAXREG88	0.35109	0.50690	0.56721	0.48346	−0.14775	−0.07134
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0047
CALLNONE	−0.29128	−0.40370	−0.47054	−0.38938	0.07710	0.05613
	0.0001	0.0001	0.0001	0.0001	0.0022	0.0261
CALLPREM	0.27039	0.39724	0.45702	0.38230	−0.06876	−0.17362
	0.0001	0.0001	0.0001	0.0001	0.0064	0.0001
CALLPAR	0.06776	0.02635	0.04870	0.02797	−0.02638	0.35201
	0.0072	0.2967	0.0537	0.2681	0.2962	0.0001
ABOVEFL	0.06577	0.06306	−0.08024	0.04224	−0.04018	−0.10023
	0.0091	0.0124	0.0015	0.0943	0.1115	0.0001
HITFL	−0.06577	−0.06306	0.08024	−0.04224	0.04018	0.10023
	0.0091	0.0124	0.0015	0.0943	0.1115	0.0001
BANKING	−0.03758	−0.04624	0.00002	−0.03098	0.13041	0.16588
	0.1366	0.0670	0.9994	0.2199	0.0001	0.0001
INDUSTRIAL	0.05364	0.04359	0.01248	0.04221	−0.03043	−0.03870
	0.0336	0.0842	0.6211	0.0945	0.2282	0.1253
UTILITY	0.01732	0.03003	−0.00488	0.01506	−0.12071	−0.15353
	0.4929	0.2344	0.8468	0.5511	0.0001	0.0001

Table III–6 (Continued)

	AA2	AA3	A1	A2	A3	BAA1
AA2	1.00000					
	0.0000					
AA3	−0.05358	1.00000				
	0.0338	0.0000				
A1	−0.05604	−0.06435	1.00000			
	0.0264	0.0108	0.0000			
A2	−0.08995	−0.10329	−0.10803	1.00000		
	0.0004	0.0001	0.0001	0.0000		
A3	−0.06354	−0.07296	−0.07630	−0.12247	1.00000	
	0.0118	0.0038	0.0025	0.0001	0.0000	
BAA1	−0.08254	−0.09477	−0.09912	−0.15910	−0.11238	1.00000
	0.0011	0.0002	0.0001	0.0001	0.0001	0.0000
BAA2	−0.10521	−0.12081	−0.12635	−0.20280	−0.14324	−0.18608
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
BAA3	−0.05136	−0.05897	−0.06168	−0.09900	−0.06993	−0.09084
	0.0419	0.0194	0.0145	0.0001	0.0056	0.0003
BA1	−0.05136	−0.05897	−0.06168	−0.09900	−0.06993	−0.09084
	0.0419	0.0194	0.0145	0.0001	0.0056	0.0003
BA2	−0.06436	−0.07390	−0.07729	−0.12406	−0.08763	−0.11384
	0.0107	0.0034	0.0022	0.0001	0.0005	0.0001
BA3	−0.03493	−0.04011	−0.04195	−0.06733	−0.04756	−0.06178
	0.1666	0.1122	0.0966	0.0076	0.0596	0.0144
B1	−0.02049	−0.02353	−0.02461	−0.03950	−0.02790	−0.03624
	0.4172	0.3515	0.3299	0.1177	0.2693	0.1512
B3	−0.01338	−0.01536	−0.01607	−0.02579	−0.01822	−0.02367
	0.5963	0.5430	0.5246	0.3071	0.4707	0.3487
TAXREG82	0.23129	0.20437	0.01271	0.10641	0.00227	−0.00020
	0.0001	0.0001	0.6148	0.0001	0.9284	0.9937
TAXREG87	−0.01155	−0.00564	0.03583	0.00452	0.09034	−0.00261
	0.6475	0.8235	0.1559	0.8579	0.0003	0.9177
TAXREG88	−0.21713	−0.19480	−0.03539	−0.10622	−0.06032	0.00187
	0.0001	0.0001	0.1611	0.0001	0.0168	0.9409
CALLNONE	0.20087	0.18145	0.03629	0.11005	0.03285	−0.11593
	0.0001	0.0001	0.1507	0.0001	0.1933	0.0001
CALLPREM	−0.18981	−0.16847	−0.02183	−0.10163	−0.03065	0.13819
	0.0001	0.0001	0.3873	0.0001	0.2249	0.0001
CALLPAR	−0.03668	−0.04212	−0.04405	−0.02721	−0.00717	−0.06488
	0.1463	0.0953	0.0810	0.2813	0.7764	0.0101

Table III–6 (Continued)

	AA2	AA3	A1	A2	A3	BAA1
ABOVEFL	0.05669	0.01217	−0.06230	−0.06357	−0.05451	0.06324
	0.0247	0.6298	0.0136	0.0118	0.0308	0.0122
HITFL	−0.05669	−0.01217	0.06230	0.06357	0.05451	−0.06324
	0.0247	0.6298	0.0136	0.0118	0.0308	0.0122
BANKING	0.10614	0.20269	0.21777	0.15637	0.05577	−0.15256
	0.0001	0.0001	0.0001	0.0001	0.0271	0.0001
INDUSTRIAL	0.15402	−0.04858	−0.05081	−0.08156	−0.03266	−0.05458
	0.0001	0.0543	0.0441	0.0012	0.1959	0.0306
UTILITY	−0.16784	−0.18710	−0.20156	−0.12719	−0.04397	0.17631
	0.0001	0.0001	0.0001	0.0001	0.0816	0.0001

Table III–6 (Continued)

	BAA2	BAA3	BA1	BA2	BA3	B1
BAA2	1.00000					
	0.0000					
BAA3	−0.11579	1.00000				
	0.0001	0.0000				
BA1	−0.11579	−0.05653	1.00000			
	0.0001	0.0251	0.0000			
BA2	−0.14510	−0.07084	−0.07084	1.00000		
	0.0001	0.0050	0.0050	0.0000		
BA3	−0.07875	−0.03844	−0.03844	−0.04817	1.00000	
	0.0018	0.1279	0.1279	0.0563	0.0000	
B1	−0.04620	−0.02255	−0.02255	−0.02826	−0.01534	1.00000
	0.0673	0.3719	0.3719	0.2631	0.5437	0.0000
B3	−0.03017	−0.01473	−0.01473	−0.01845	−0.01001	−0.00588
	0.2323	0.5599	0.5599	0.4650	0.6917	0.8161
TAXREG82	−0.15484	−0.13376	−0.05796	−0.20461	−0.06836	−0.07430
	0.0001	0.0001	0.0216	0.0001	0.0067	0.0032
TAXREG87	−0.00139	−0.04263	−0.04263	−0.00725	−0.03378	0.09182
	0.9561	0.0913	0.0913	0.7742	0.1810	0.0003
TAXREG88	0.15123	0.15729	0.08370	0.20332	0.08811	0.01307
	0.0001	0.0001	0.0009	0.0001	0.0005	0.6049
CALLNONE	−0.12468	−0.11380	−0.06839	−0.10571	−0.01988	0.02027
	0.0001	0.0001	0.0067	0.0001	0.4312	0.4223
CALLPREM	0.14640	0.11076	0.02514	0.10907	0.02913	−0.01502
	0.0001	0.0001	0.3195	0.0001	0.2487	0.5520
CALLPAR	−0.06309	0.01108	0.13112	−0.00828	−0.02746	−0.01611
	0.0124	0.6610	0.0001	0.7430	0.2769	0.5236
ABOVEFL	0.06233	−0.01176	−0.00514	0.13511	−0.03186	−0.07336
	0.0135	0.6416	0.8389	0.0001	0.2071	0.0036
HITFL	−0.06233	0.01176	0.00514	−0.13511	0.03186	0.07336
	0.0135	0.6416	0.8389	0.0001	0.2071	0.0036
BANKING	−0.37975	−0.10505	0.01565	−0.15167	0.04544	0.07963
	0.0001	0.0001	0.5354	0.0001	0.0719	0.0016
INDUSTRIAL	−0.06107	0.05848	0.28356	0.01569	0.03262	−0.01858
	0.0155	0.0205	0.0001	0.5345	0.1964	0.4620
UTILITY	0.40975	0.08401	−0.12631	0.14805	−0.05888	−0.07370
	0.0001	0.0009	0.0001	0.0001	0.0196	0.0035

Table III–6 (Continued)

	B3	TAX-REG82	TAX-REG87	TAX-REG88	CALL-NONE	CALL-PREM
B3	1.00000					
	0.0000					
TAXREG82	−0.04852	1.00000				
	0.0546	0.0000				
TAXREG87	−0.02257	−0.28540	1.00000			
	0.3715	0.0001	0.0000			
TAXREG88	0.06162	−0.78731	−0.36622	1.00000		
	0.0146	0.0001	0.0001	0.0000		
CALLNONE	−0.06661	0.69152	0.22761	−0.81783	1.00000	
	0.0083	0.0001	0.0001	0.0001	0.0000	
CALLPREM	0.07049	−0.65120	−0.20832	0.76627	−0.94493	1.00000
	0.0052	0.0001	0.0001	0.0001	0.0001	0.0000
CALLPAR	−0.01052	−0.13301	−0.06187	0.16894	−0.18262	−0.14920
	0.6771	0.0001	0.0142	0.0001	0.0001	0.0001
ABOVEFL	−0.06170	0.17411	−0.13292	−0.08354	0.13361	−0.05804
	0.0145	0.0001	0.0001	0.0009	0.0001	0.0215
HITFL	0.06170	−0.17411	0.13292	0.08354	−0.13361	0.05804
	0.0145	0.0001	0.0001	0.0009	0.0001	0.0215
BANKING	0.05199	0.07670	−0.02388	−0.05910	0.03388	−0.07630
	0.0394	0.0024	0.3443	0.0192	0.1797	0.0025
INDUSTRIAL	−0.01213	0.06918	−0.00837	−0.06178	0.03991	−0.03588
	0.6310	0.0061	0.7403	0.0143	0.1139	0.1553
UTILITY	−0.04812	−0.10489	0.02753	0.08412	−0.04998	0.09152
	0.0566	0.0001	0.2756	0.0008	0.0477	0.0003

Table III–6 (Continued)

	CALL-PAR	ABOVE-FL	HITFL	BANK-ING	INDUS-TRIAL	UTI-LITY
CALLPAR	1.00000					
	0.0000					
ABOVEFL	−0.22933	1.00000				
	0.0001	0.0000				
HITFL	0.22933	−1.00000	1.00000			
	0.0001	0.0001	0.0000			
BANKING	0.12687	0.20649	−0.20649	1.00000		
	0.0001	0.0001	0.0001	0.0000		
INDUSTRIAL	−0.01280	−0.07080	0.07080	−0.23332	1.00000	
	0.6124	0.0050	0.0050	0.0001	0.0000	
UTILITY	−0.12397	−0.18232	0.18232	−0.92557	−0.15217	1.00000
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000

Table III–7

OLS Regression: Benchmark Model (BM30Y) Full Sample

Dependent Variable: Implied risk premium based on 30-year constant maturity yield (RPBM30Y);

Explanatory Variables: (i) Five categories of qualitative variables, (ii) 3-month Treasury discount rate, (iii) Volatility of 30-year constant maturity yield.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
104.24	0.0	0.607955
ROOT MSE/MEAN	ROOT MSE	RPBM30Y MEAN
2.738440	0.00264077	0.00096433

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	−0.00404364	−6.40	0.0001	0.00063146
AAA	−0.00706657	−14.16	0.0001	0.00049915
AA1	−0.00500506	−11.38	0.0001	0.00043980
AA2	−0.00364335	−9.12	0.0001	0.00039956
AA3	−0.00572374	−15.66	0.0001	0.00036545
A1	−0.00398144	−11.66	0.0001	0.00034138
A2	−0.00382664	−14.71	0.0001	0.00026008
A3	−0.00265889	−8.86	0.0001	0.00030011
BAA1	−0.00007561	−0.30	0.7627	0.00025040
BAA3	0.00086124	2.55	0.0110	0.00033838
BA1	0.00323692	9.01	0.0001	0.00035922
BA2	0.00382408	13.33	0.0001	0.00028685
BA3	0.00410750	8.94	0.0001	0.00045931
B1	0.00334956	4.47	0.0001	0.00074948
B3	−0.00006293	−0.06	0.9548	0.00110921
TAXREG82	−0.00045909	−1.82	0.0689	0.00025219
TAXREG88	0.00169177	5.75	0.0001	0.00029404
CALLNONE	−0.00063256	−2.51	0.0121	0.00025177
CALLPAR	−0.00021238	−0.46	0.6453	0.00046134
HITFL	0.00002369	0.13	0.8955	0.00018030
BANKING	0.00216117	12.09	0.0001	0.00017880
INDUSTRIAL	0.00016516	0.42	0.6777	0.00039732
RATE3MON	0.04873394	9.85	0.0001	0.00494622
V30Y52WK	0.09225874	3.41	0.0007	0.02703550

Table III–8

OLS Regression: Benchmark Model (BM30Y) Full Sample

Dependent Variable: Implied risk premium based on 30-year constant maturity yield (RPBM30Y);

Explanatory Variables: (i) Five categories of qualitative variables, (ii) 3-month Treasury discount rate, (iii) Volatility of 3-month Treasury discount rate.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
110.00	0.0	0.620699
ROOT MSE/MEAN	ROOT MSE	RPBM30Y MEAN
2.693561	0.00259749	0.00096433

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	−0.00080103	−1.66	0.0963	0.00048134
AAA	−0.00677483	−13.78	0.0001	0.00049170
AA1	−0.00476019	−10.99	0.0001	0.00043306
AA2	−0.00342723	−8.71	0.0001	0.00039348
AA3	−0.00559130	−15.54	0.0001	0.00035988
A1	−0.00405737	−12.08	0.0001	0.00033584
A2	−0.00378505	−14.79	0.0001	0.00025588
A3	−0.00251789	−8.52	0.0001	0.00029570
BAA1	−0.00036649	−1.48	0.1381	0.00024704
BAA3	0.00038679	1.17	0.2420	0.00033048
BA1	0.00289982	8.20	0.0001	0.00035358
BA2	0.00340483	11.95	0.0001	0.00028500
BA3	0.00374651	8.28	0.0001	0.00045264
B1	0.00293492	4.00	0.0001	0.00073370
B3	0.00177417	1.62	0.1055	0.00109538
TAXREG82	−0.00071336	−2.94	0.0033	0.00024272
TAXREG88	0.00182905	6.35	0.0001	0.00028797
CALLNONE	−0.00001357	−0.05	0.9565	0.00024855
CALLPAR	−0.00042829	−0.95	0.3433	0.00045181
HITFL	−0.00023270	−1.29	0.1975	0.00018051
BANKING	0.00214681	12.21	0.0001	0.00017585
INDUSTRIAL	0.00031923	0.82	0.4144	0.00039101
RATE3MON	0.03672061	7.39	0.0001	0.00497028
V3M52WK	−0.06183965	−8.00	0.0001	0.00773094

Table III–9

OLS Regression: Benchmark Model (BM3M) Full Sample

Dependent Variable: Implied risk premium based on 3-month Treasury discount rate (RPBM3M);

Explanatory Variables: (i) Five categories of qualitative variables, (ii) 30-year constant maturity yield, (iii) Volatility of 3-month Treasury discount rate.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
62.90	0.0	0.483411
ROOT MSE/MEAN	ROOT MSE	RPBM3M MEAN
0.520698	0.00317702	0.00610147

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00284438	3.80	0.0002	0.00074926
AAA	−0.00679080	−11.28	0.0001	0.00060214
AA1	−0.00532483	−10.06	0.0001	0.00052929
AA2	−0.00354717	−7.37	0.0001	0.00048132
AA3	−0.00547959	−12.38	0.0001	0.00044255
A1	−0.00405530	−9.87	0.0001	0.00041078
A2	−0.00356181	−11.35	0.0001	0.00031395
A3	−0.00244672	−6.73	0.0001	0.00036331
BAA1	0.00072799	2.43	0.0152	0.00029953
BAA3	0.00224898	5.64	0.0001	0.00039898
BA1	0.00368506	8.53	0.0001	0.00043179
BA2	0.00420967	12.14	0.0001	0.00034688
BA3	0.00379506	6.85	0.0001	0.00055365
B1	0.00649139	7.27	0.0001	0.00089307
B3	0.00161888	1.21	0.2274	0.00134051
TAXREG82	−0.00032477	−1.06	0.2913	0.00030765
TAXREG88	0.00015308	0.44	0.6597	0.00034756
CALLNONE	−0.00077923	−2.58	0.0101	0.00030246
CALLPAR	0.00145676	2.65	0.0082	0.00055072
HITFL	−0.00018103	−0.79	0.4281	0.00022839
BANKING	0.00217888	10.13	0.0001	0.00021511
INDUSTRIAL	0.00009475	0.20	0.8429	0.00047814
RATE30YR	0.02989448	4.09	0.0001	0.00731056
V3M52WK	0.02887675	3.15	0.0017	0.00917078

Table III–10

OLS Regression: Benchmark Model (BM3M) Full Sample

Dependent Variable: Implied risk premium based on 3-month Treasury discount rate (RPBM3M);

Explanatory Variables: (i) Five categories of qualitative variables, (ii) 30-year constant maturity yield, (iii) Volatility of 30-year constant maturity yield.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
62.38	0.0	0.481340
ROOT MSE/MEAN	ROOT MSE	RPBM3M MEAN
0.521741	0.00318339	0.00610147

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00211050	2.17	0.0299	0.00097097
AAA	−0.00674983	−11.19	0.0001	0.00060318
AA1	−0.00532053	−10.03	0.0001	0.00053060
AA2	−0.00350803	−7.28	0.0001	0.00048204
AA3	−0.00546321	−12.32	0.0001	0.00044339
A1	−0.00406986	−9.89	0.0001	0.00041156
A2	−0.00354628	−11.27	0.0001	0.00031455
A3	−0.00242507	−6.66	0.0001	0.00036393
BAA1	0.00069857	2.33	0.0201	0.00030011
BAA3	0.00228241	5.65	0.0001	0.00040375
BA1	0.00364698	8.43	0.0001	0.00043270
BA2	0.00412098	11.92	0.0001	0.00034574
BA3	0.00372103	6.72	0.0001	0.00055399
B1	0.00663353	7.38	0.0001	0.00089826
B3	0.00187063	1.39	0.1636	0.00134215
TAXREG82	−0.00032805	−1.05	0.2916	0.00031095
TAXREG88	0.00036596	1.04	0.2986	0.00035195
CALLNONE	−0.00071446	−2.35	0.0189	0.00030400
CALLPAR	0.00154805	2.80	0.0052	0.00055372
HITFL	−0.00023614	−1.04	0.3004	0.00022795
BANKING	0.00218049	10.12	0.0001	0.00021556
INDUSTRIAL	0.00011928	0.25	0.8034	0.00047901
RATE30YR	0.03327238	4.45	0.0001	0.00748524
V30Y52WK	0.06347613	1.92	0.0546	0.03299671

Table III–11

OLS Regression: Benchmark Model (BM30Y) Full Sample

Dependent Variable: Implied risk premium based on 30-year constant maturity yield (RPBM30Y);

Explanatory Variables: (i) Three categories of qualitative variables (without the call status and the relation to the collar), (ii) 3-month Treasury discount rate, (iii) Volatility of 30-year constant maturity yield.

BASE VARIABLES: BAA2, TAXREG87, UTILITY.

F VALUE	PR > F	R-SQUARE
119.28	0.0	0.606309
ROOT MSE/MEAN	ROOT MSE	RPBM30Y MEAN
2.741522	0.00264374	0.00096433

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	−0.00427786	−7.10	0.0001	0.00060270
AAA	−0.00698087	−14.04	0.0001	0.00049729
AA1	−0.00506436	−12.30	0.0001	0.00041174
AA2	−0.00368369	−9.22	0.0001	0.00039937
AA3	−0.00575347	−15.77	0.0001	0.00036490
A1	−0.00401084	−11.76	0.0001	0.00034111
A2	−0.00385499	−14.88	0.0001	0.00025912
A3	−0.00265622	−8.88	0.0001	0.00029918
BAA1	−0.00000308	−0.01	0.9901	0.00024859
BAA3	0.00079156	2.35	0.0191	0.00033745
BA1	0.00316948	8.89	0.0001	0.00035637
BA2	0.00373253	13.21	0.0001	0.00028259
BA3	0.00398701	8.73	0.0001	0.00045657
B1	0.00315972	4.24	0.0001	0.00074526
B3	0.00007704	0.07	0.9446	0.00110756
TAXREG82	−0.00055438	−2.23	0.0261	0.00024899
TAXREG88	0.00210358	8.71	0.0001	0.00024150
BANKING	0.00218832	12.32	0.0001	0.00017764
INDUSTRIAL	0.00024046	0.61	0.5445	0.00039666
RATE3MON	0.04737638	10.31	0.0001	0.00459408
V30Y52WK	0.07928973	3.01	0.0027	0.02633936

CHAPTER FOUR

The Option-Based Model

I. Introduction

In Chapter III, we developed a benchmark (naive) model for the valuation of ARPS. In the benchmark model, the risk premium captures the default risk, the tax effect, the call status, the implied option on the maximum of three rates, and the collar effect. In this chapter, we will develop an option-based model to value the ARPS. The option-based model will explicitly capture in the expected dividend rates the implicit option on the maximum of three rates and the collar effect. Therefore, the risk premium of the option-based model should only capture the default risk, the tax effect, and the call status. Notice that due to the option on the maximum of three rates, the expected dividend rate will be higher than that of an otherwise identical adjustable rate preferred stock without the option on the maximum of three rates.

Empirical tests of the implied risk premia obtained through the option-based model also reveal that the rating of the ARPS, the tax regime, the call status of the ARPS, the industry of the ARPS issuers, the level of the risk free rate, and the volatility of the risk free rate are the significant determinants of the risk premium. The option-based model appears to be preferable to the benchmark model, if the R-square of regression is the criterion. The dependent variables of the regressions are not the same, however, even though they are almost identical.[10] Therefore, the R-squares are not strictly comparable. In Chapter V we will evaluate the performance of the two models by comparing the actual market prices with model prices. This chapter will proceed as follows. The option-based model is developed

---

[10] From Table III–4 we see that the four average risk premia are 0.006101 (RPBM-3M), 0.000964 (RPBM30Y), 0.002393 (RPOBRW), and 0.002083 (RPOBEH). But more important, the standard deviations are almost the same: the values are 0.004388 (RPBM3M), 0.004187 (RPBM30Y), 0.004471 (RPOBRW), and 0.004112 (RPOBEH). From Table III–6 we see that RPBM30Y, RPOBRW, and RPOBEH have an average correlation of 0.9646 among themselves. Only RPBM3M has a lower average correlation of 0.7451 with the other three measures of risk premia.

in section II. In section III the empirical methodology and the regression model are presented. The empirical findings are analyzed in section IV. Finally, section V provides a summary.

II. The Model

In the option-based model, we employ a unique approach to estimate future dividend rates, since the dividend rates are not fixed. The interpretation of the term structure of interest rates will be very important to this estimation process since expected future dividend rates depend on the expected future interest rates. Let's begin by analyzing the present value of a long term bond, since a preferred stock can be viewed as a perpetual bond. For easy exposition, let's further assume that the bond is default free and there are no taxes. Then,

$$PV = \left\{ \left(\sum_{i=1}^{N} \frac{c_i}{(1+YTM)^i} \right) + \frac{1}{(1+YTM)^N} \right\} \cdot par \tag{4.1}$$

where

$c_i =$ the coupon rate for period i

$N =$ the number of periods left before maturity

$YTM =$ the yield to maturity

$par =$ the par value of the bond

If c_i is constant and equal to YTM, then PV is equal to par. Alternatively, the bond price can be calculated as:

$$PV = \left\{ \left(\sum_{i=1}^{N} \frac{c_i}{(1+r_i)^i} \right) + \frac{1}{(1+r_N)^N} \right\} \cdot par \tag{4.2}$$

where $r_i =$ the yield for a i period zero-coupon risk free bond.

The virtue in expressing the bond price this way is the avoidance of dealing with the coupon reinvestment effect on the yield to maturity of the bond. The yield to maturity (YTM) will equal r_i, $i = 1, \ldots, N$ if and only if the zero-coupon yield curve is flat. The zero-coupon yield, however, is still not a true representation of each period's interest rate. It is only a geometric average of the overall horizon's rates of return. A better expression is:

$$PV = \left\{ \left(\sum_{i=1}^{N} \frac{c_i}{\prod_{j=0}^{i-1}(1 + r_{j,j+1})} \right) + \frac{1}{\prod_{j=0}^{N-1}(1 + r_{j,j+1})} \right\} \cdot par \qquad (4.3A)$$

where $r_{j,j+1}$ = the expected spot interest rate from period j to period $j+1$.[11] To make it clear we write out a few terms as follows:

$$PV = \left\{ \frac{c_1}{1 + r_{0,1}} + \frac{c_2}{(1 + r_{0,1})(1 + r_{1,2})} + \cdots \right.$$
$$\left. + \frac{c_N + 1}{(1 + r_{0,1})(1 + r_{1,2}) \cdots (1 + r_{N-1,N})} \right\} \cdot par \qquad (4.3B)$$

From this expression, we can see that if the coupon rates are adjusted in such a way that the coupon rate of period i will always equal the one period expected spot interest rate of period i (i.e.; $c_1 = r_{0,1},\ c_2 = r_{1,2}, \ldots,\ c_N = r_{N-1,N}$), then PV will equal *par*. Therefore, if our ARPS were issued by the U.S. government, and the dividend rate were adjusted every three months based on the three-month Treasury yield, then we could value it easily.

Although this illustration of ARPS is overly simplified, we will still be able to approach its valuation in a similar fashion. The general valuation formula for ARPS is:

$$ARPS = \sum_{i=1}^{\infty} \frac{E(\tilde{D}_i)}{(1 + r_i + RP_{RW})^i} \qquad (4.4A)$$

or

$$ARPS = \sum_{i=1}^{\infty} \frac{E(\tilde{D}_i)}{\prod_{j=0}^{i-1}(1 + r_{j,j+1} + RP_{EH})} \qquad (4.4B)$$

where $E(\tilde{D}_i)$ is the expected dividend for period i, RP_{RW} is the per period risk premium if the zero-coupon risk free rate is used to discount the dividends, and

[11] Note that $r_{0,1}$ in equations (4.3A) and (4.3B) is identical to r_1 of equation (4.2).

RP_{EH} is the per period risk premium if the expected spot risk free rate for each period is used to discount the dividends. Notice that the two RPs are equal only if the zero-coupon yield curve is flat. Otherwise, they should not be equal, albeit the difference might be extremely small. The two risk premia are also assumed to be constant for all periods. Therefore, if we have information on the yield curve then we know how to evaluate the ith period expected dividend $E(\tilde{D}_i)$.

Let's denote

$$
\begin{aligned}
d_t &= \text{the dividend rate at time } t,\ t = 1/4,\, 1/2, \ldots \\
R_{t,t+1/4} &= \text{the three-month Treasury discount rate at time } t \\
Y_{t,t+10} &= \text{the ten-year constant maturity yield at time } t \\
Y_{t,t+20} &= \text{the twenty-year constant maturity yield at time } t \\
\Delta &= \text{the fixed spread} \\
SV &= \text{the stated value of the ARPS}
\end{aligned}
$$

At time zero, we will have some anticipation on the values of $R_{t,t+1/4}, Y_{t,t+10}$, and $Y_{t,t+20}$, for each t, $t = 1/4, 1/2, 3/4, \ldots$[12] Furthermore, the three expected values, $E(R_{t,t+1/4})$, $E(Y_{t,t+10})$, and $E(Y_{t,t+20})$, will converge to $R_{t,t+1/4}$, $Y_{t,t+10}$, and $Y_{t,t+20}$, respectively, at time t. Denote the base rate as the maximum of three rates, then at time t, the dividend rate is the base rate plus a fixed spread. To simplify matters, let's first examine a single dividend, with no collar, to be declared at time t.

$$
\begin{aligned}
D_t = d_t \cdot SV &= \left\{max(R_{t,t+1/4},\ Y_{t,t+10},\ Y_{t,t+20}) + \Delta\right\} \cdot SV \\
&= \left\{max\left[max(R_{t,t+1/4},\ Y_{t,t+10},\ Y_{t,t+20}),\ 0\right] + \Delta\right\} \cdot SV
\end{aligned}
$$

We assume $E(R_{t,t+1/4})$, $E(Y_{t,t+10})$, and $E(Y_{t,t+20})$ are geometric Brownian processes with log normal distributions. That is, the rates of change of $E(R_{t,t+1/4})$,

[12] To determine the ARPS adjustable dividend rate, we need to know the Treasury Bill Rate, the Ten Year Constant Maturity Rate, and the Twenty Year Constant Maturity Rate. These three rates are tedious to calculate, however. Therefore, the three-month Treasury discount rate is used as the proxy for the Treasury Bill Rate, the ten-year constant maturity yield is used as the proxy for the Ten Year Constant Maturity Rate, and the twenty-year constant maturity yield is used as the proxy for the Twenty Year Constant Maturity Rate.

$E(Y_{t,t+10})$, and $E(Y_{t,t+20})$ are normally distributed. In addition, the rates of change of $E(R_{t,t+1/4})$, $E(Y_{t,t+10})$, and $E(Y_{t,t+20})$ are assumed to be trivariate normally distributed. Thus, we are faced with an option on the maximum of three rates with an "exercise price" equal to zero. This is a three asset case of Margrabe's [13] option to exchange one asset for another. As in Margrabe's model, the risk free rate is irrelevant since the value of the exchange can be enumerated in units of any one of the three assets. This type of option has been further generalized by Johnson [11] in his paper about the option on the maximum of several assets. Following Johnson's model, the specific solution for an option on the maximum of three assets is:

$$\begin{aligned} C_{max} = {} & S_1 \cdot N(d_1(S_1, X, \sigma_1^2), d_1^*(S_1, S_2, \omega_{12}^2), d_1^*(S_1, S_3, \omega_{13}^2), \varphi_{1\cdot 12}, \varphi_{1\cdot 13}, \varphi_{12\cdot 13}) \\ & + S_2 \cdot N(d_1(S_2, X, \sigma_2^2), d_1^*(S_2, S_1, \omega_{12}^2), d_1^*(S_2, S_3, \omega_{23}^2), \varphi_{2\cdot 12}, \varphi_{2\cdot 23}, \varphi_{21\cdot 23}) \\ & + S_3 \cdot N(d_1(S_3, X, \sigma_3^2), d_1^*(S_3, S_1, \omega_{13}^2), d_1^*(S_3, S_2, \omega_{23}^2), \varphi_{3\cdot 13}, \varphi_{3\cdot 23}, \varphi_{31\cdot 32}) \\ & - Xe^{-r_f T} \cdot (1 - N(-d_2(S_1, X, \sigma_1^2), -d_2(S_2, X, \sigma_2^2), -d_2(S_3, X, \sigma_3^2), \\ & \quad \rho_{12}, \rho_{13}, \rho_{23})) \end{aligned} \tag{4.5}$$

where

C_{max} = the call option on the maximum of three assets (the expected value of the maximum of three rates for ARPS)

S_i = the ith underlying asset's value today (the expected values of $R_{t,t+1/4}$, $Y_{t,t+10}$, and $Y_{t,t+20}$)

X = the exercise price (equal to zero if no collar)

σ_i^2 = the variance of asset i's rate of change (variance on the log of S_i)

ω_{ij}^2 = the variance of the difference between asset i's rate of change and asset j's rate of change

$\varphi_{i\cdot ij}$ = the correlation coefficient of (i) asset i's rate of change with (ii) the difference between asset i's rate of change and asset j's rate of change

$\varphi_{ij\cdot ik}$ = the correlation coefficient of (i) the difference between asset i's rate of change and asset j's rate of change with (ii) the difference between asset i's rate of change and asset k's rate of change

ρ_{ij} = the correlation coefficient of asset i's rate of change with asset j's rate of change (correlation of log S_i and log S_j)

r_f = the instantaneous risk free rate (equal to zero)

T = the time to expiration of the option (time to dividend period t)

N = the trivariate standard cumulative normal distribution

$$d_1(S_i, X, \sigma_i^2) = \frac{log\frac{S_i}{X} + \left(r_f + \frac{1}{2}\sigma_i^2\right)T}{\sigma_i\sqrt{T}}$$

$$d_2 = d_1 - \sigma_i\sqrt{T}$$

$$d_1^*(S_i, S_j, \omega_{ij}^2) = \frac{log\frac{S_i}{S_j} + \frac{1}{2}\omega_{ij}^2 T}{\omega_{ij}\sqrt{T}}$$

To obtain ω_{ij}^2, $\varphi_{i\cdot ij}$, and $\varphi_{ij\cdot ik}$, we can use the following formulas:[13]

$$\omega_{ij}^2 = \sigma_i^2 - 2\rho_{ij}\sigma_i\sigma_j + \sigma_j^2$$

$$\varphi_{i\cdot ij} = \frac{\sigma_i - \rho_{ij}\sigma_j}{\omega_{ij}}$$

$$\varphi_{ij\cdot ik} = \frac{\sigma_i^2 - \rho_{ij}\sigma_i\sigma_j - \rho_{ik}\sigma_i\sigma_k + \rho_{jk}\sigma_j\sigma_k}{\omega_{ij}\omega_{ik}}$$

Under the assumption of risk neutrality of the option pricing model, if we set $S_1 = E(R_{t,t+1/4})$, $S_2 = E(Y_{t,t+10})$, $S_3 = E(Y_{t,t+20})$, and the risk free rate equal to zero for ARPS application, then C_{max} can be interpreted as the expected base rate (the expected value of the maximum of three rates) that will be used to determine the adjustable dividend rate for time t. In other words, the expected dividend rate for time t is just C_{max} plus the fixed spread Δ. The option to have the maximum of three rates is captured by the higher expected dividend, thus making the ARPS more valuable.

[13] Johnson [11].

When incorporating the collar, the dividend at time t is:

$$\begin{aligned} D_t &= \{min\left[max\left(R_{t,t+1/4}+\Delta,\ Y_{t,t+10}+\Delta,\ Y_{t,t+20}+\Delta,\ FL\right),\ CL\right]\}\cdot SV \\ &= \{max\left[max\left(R_{t,t+1/4},\ Y_{t,t+10},\ Y_{t,t+20}\right)-(FL-\Delta),\ 0\right]+FL \\ &\qquad - max\left[max\left(R_{t,t+1/4},\ Y_{t,t+10},\ Y_{t,t+20}\right)-(CL-\Delta),\ 0\right]\}\cdot SV \end{aligned}$$

where FL = the floor rate and CL = the ceiling rate. This is simply a portfolio consisting of: (i) a call held long on the maximum of three rates with the "exercise price" equal to the floor rate minus the fixed spread, (ii) a fixed rate equal to the floor rate, and (iii) a call held short on the maximum of three rates with the "exercise price" equal to the ceiling rate minus the fixed spread. The first call can be interpreted as today's expected excess dividend rate above the floor rate for time t. The second option, which is a short call, is today's expected excess dividend rate above the ceiling rate for time t that we are giving up. These two options, together with the fixed floor rate, will give us the expected dividend rate within the collar for time t. In this way we can calculate the $E(\tilde{D}_t)$ for each t. Once we have all the $E(\tilde{D}_t)$s then we can apply equation (4.4A) or equation (4.4B) to value the ARPS.

III. The Empirical Methodology

In order to implement the option-based model, we must determine a method for estimating the three expected values, $E(R_{t,t+1/4})$, $E(Y_{t,t+10})$, and $E(Y_{t,t+20})$, for each t, $t = 1/4, 1/2, 3/4, 1, \ldots$. Two different approaches are available for this. The first approach assumes the **random walk** theory of interest rate movements wherein today's spot values, $R_{1/4}$, Y_{10}, and Y_{20}, are the best estimates of all future three-month Treasury discount rates, ten-year constant maturity yields, and twenty-year constant maturity yields, respectively. This will be called the option-based random walk interest rate (OBRW) model from now on. The other approach adopts the **expectations hypothesis** of interest rate movements wherein the implied forward values, $R^f_{t,t+1/4}$, $Y^f_{t,t+10}$, and $Y^f_{t,t+20}$, which are embedded in today's yield curve, are the best estimates of all the future three-month Treasury discount rates, ten-year constant maturity yields, and twenty-year constant maturity yields, respectively.

This will be called the option-based expectations hypothesis interest rate (OBEH) model from now on.

We must also determine *RP*, the per quarter risk premium (of equations 4.4A&B). Unfortunately, we can not observe the risk premium directly in the marketplace. Therefore, as was the case with the benchmark model, a direct test of the option-based model would not be possible. Again, we resort to the analysis of the implied risk premia of each model. The implied risk premium of the OBRW model will be denoted as RPOBRW, and the implied risk premium of the OBEH model will be denoted as RPOBEH. If a regression of the implied risk premia on some known possible determinants results in a high R-square and reasonable coefficients, then it would indirectly confirm the validity of the option-based model. We have already discussed the possible determinants of the risk premium as well as the data for this study in Chapter III, therefore, we will not repeat them here. Instead, we will focus on the spot yield curve.

A. Spot Yield Curve

The Federal Reserve Board publishes certain significant interest rates on a weekly basis. These interest rates include the Treasury discount rates and the constant maturity yields. The Treasury discount rates are the three-month, six-month, and twelve-month Treasury discount rates. The constant maturity yields are the 1-year, 2-year, 3-year, 5-year, 7-year, 10-year, 20-year, and 30-year constant maturity yields. We collect the weekly figures of these rates and yields from the Federal Reserve Bulletin for the period January 1982 to December 1992. Beginning January 1987, the Federal Reserve Board discontinued the publication of the twenty-year constant maturity yield.

Since the ARPS pay dividends on a quarterly basis, our first task is to find out all the interest rates on a quarterly basis for each yield curve. That is, we need to interpolate 110 values for each yield curve because each yield curve has the longest maturity of 120 quarters but a maximum of ten observed data points provided by the Federal Reserve Board. After trying several techniques such as linear spline, cubic spline, and other ad hoc procedures, we conclude that the natural cubic spline approach (see Exhibit IV–1) is probably the best method for the overall data since it generates the smoothest forward rate series.

Because the Treasury discount rates are not the same as the constant maturity yields, we actually have two different segments of the yield curve. One segment is for the short maturities under one year, and the other segment is for maturities from one year to thirty years. Therefore, instead of fitting the natural cubic spline on each of the two separate segments of the yield curve, we convert the Treasury discount rates to equivalent constant maturity yields. It then becomes possible to fit one natural cubic spline to the extended constant maturity yield curve. The twelve-month Treasury discount rate is not used since the one-year constant maturity yield is already available.

A second problem associated with the yield curve is that constant maturity bonds pay coupons every six months, not every three months. Hence, the k-year constant maturity yield, for $k = 1/4, 3/4, 1\,1/4, \ldots$, can not be determined using the conventional definition of par bond equivalent yield. A modified technique (to be explained shortly) is needed for the interpolation. As a result, two alternate series of the yield curve are generated; one series for $k = 1/4, 3/4, 1\,1/4, \ldots$, the odd quarter series, and another series for $k = 1/2, 1, 1\,1/2, \ldots$, the even quarter series.

To find the three-month and six-month constant maturity yields, we first find the discount factors for $k = 1/4$ and $1/2$, which can be calculated easily from the Treasury discount rates since

$$DF(k) = \frac{1}{1+y_k} \qquad \text{and} \qquad 1 + y_k = \frac{1}{1 - R_k \cdot \frac{91 \cdot 4k}{360}} \qquad \text{for} \quad k = 1/4,\, 1/2 \quad (4.6)$$

where $DF(k)$ is the k-year discount factor, R_k is the k-year Treasury discount rate, and y_k is the k-year yield (not annualized). Knowing that a \$1 par bond will produce one dollar plus one half of the six-month constant maturity yield at maturity, we can determine $Y_{1/2}$, the six-month constant maturity yield, by the following relation:

$$\left(1 + \frac{Y_{1/2}}{2}\right) \cdot DF(1/2) = 1 \qquad (4.7A)$$

To determine the three-month constant maturity yield, imagine that three months has elapsed on a six-month constant maturity yield \$1 par bond, thereby leaving three months to maturity. Holding other variables fixed, our one dollar investment would have grown to $\left(1+\frac{Y_{1/2}}{2}\right)^{1/2}$. By this analogy, a three-month constant maturity yield \$1 par bond, where $Y_{1/4}$ is the three-month constant maturity yield, must worth $\left(1+\frac{Y_{1/4}}{2}\right)^{1/2}$ initially in order for it to be worth $1+\frac{Y_{1/4}}{2}$ three months later at maturity. Therefore, the three-month constant maturity yield can be calculated through the following equation:

$$\left(1+\frac{Y_{1/4}}{2}\right)\cdot DF(1/4)=\left(1+\frac{Y_{1/4}}{2}\right)^{1/2}. \tag{4.7B}$$

For the period from January 1987 to December 1992, the twenty-year constant maturity yield is not available. Therefore, the natural cubic spline algorithm will also have to interpolate the twenty-year constant maturity yield.

Once we have generated the yields at 120 maturities using the natural cubic spline algorithm, we can calculate all the discount factors. The reason that we want to work with the discount factors is because the forward rates and forward constant maturity yields can be derived from the discount factors easily. We already know $DF(1/4)$ and $DF(1/2)$. The remaining discount factors are generated from the following two equations recursively:

$$\frac{Y_k}{2}\cdot\sum_{j=1/4}^{k-1/2}DF(j)+\left(1+\frac{Y_k}{2}\right)\cdot DF(k)=\left(1+\frac{Y_k}{2}\right)^{1/2}$$

$$\text{for}\quad k=3/4,1\,1/4,\ldots,29\,3/4 \tag{4.8A}$$

and

$$\frac{Y_k}{2}\cdot\sum_{j=1/2}^{k-1/2}DF(j)+\left(1+\frac{Y_k}{2}\right)\cdot DF(k)=1$$

$$\text{for}\quad k=1,1\,1/2,\ldots,30 \tag{4.8B}$$

The interpretation of equations (4.8A&B) is that by discounting the semiannual coupons and the par value back to the present time using the appropriate discount factors, then adding them up, the sum must be the present value of the constant maturity bond. The only difference between eq. (4.8A) and eq. (4.8B) is that for the odd quarter series of eq. (4.8A), the present value is $\left(1+\frac{Y_k}{2}\right)^{1/2}$ instead of one dollar. Therefore, if we know the k-year constant maturity yield and all the discount factors up to $k - 1/2$ years, we can solve the k-year discount factor $DF(k)$.

Because there are no data beyond the thirty-year constant maturity yield, we assume that the yield curve is flat after year 30. That is, all yields beyond year 30 will be equal to the thirty-year constant maturity yield. This will cause a kink in the extended yield curve at year 30, with an accompanying jump in the forward rate series. The degree of severity of this jump will depend on the curvature of the yield curve as it approaches year 30. A greater curvature will result in a more severe jump. Unfortunately, there are no better ways to resolve this problem. Despite the jump, the discount factors beyond year 30 can still be expressed as:

$$DF(k) = DF(30)\left(\frac{1}{\left(1+\frac{Y_{30}}{2}\right)^{1/2}}\right)^{4\cdot(k-30)} \qquad \text{for} \quad k = 30\,1/4, 30\,1/2, \ldots \tag{4.9}$$

The only economic restriction on the discount factors $DF(k)$s is that they are monotonic and decreasing with respect to the time horizon k. Therefore, given positive interest rates, a more distant dollar must have a lower present value.

B. The Option-Based Random Walk Interest Rate Model

This model assumes that the current spot interest rates are the best estimates of future spot interest rates. Since the three-month Treasury discount rate, the ten-year constant maturity yield, and the twenty-year constant maturity yield are readily available, then all expected future spot values of these three figures are also known.[14] In order to use Johnson's option model on the maximum of three rates to estimate future dividend rates, we will also need the variance and covariance of the rate of change of the three expected future spot values. The covariance matrix is

[14] After January 1987, the twenty-year constant maturity yield is not directly available but can be interpolated from the yield curve as discussed in the previous section.

used to calculate the trivariate cumulative normal distribution which in turn is used to estimate the expected dividend. The easily available estimate of this covariance matrix would be the historical covariance matrix of the rate of change of the three spot values. We try two covariance matrices, one based on 26 weeks of historical data and the other based on 52 weeks of historical data, on a sub-sample of ARPS, to see which covariance matrix yields preferable result. (Assume we know the rest of this chapter so we can do this exercise here.) The sub-sample we select covers all the ARPS that belong to the February dividend cycle. Table IV–1 provides a summary of these regressions. It shows that the covariance matrix based on 52 weeks of historical data performs marginally better than the covariance matrix based on 26 weeks of historical data.[15] Assuming the regression results of the sub-sample are a fair representation of the full sample, we will use 52 weeks of historical data to calculate the historical covariance matrix of the three rates from here on.

So far, the covariance matrix is consisted of weekly volatilities since it has been constructed using weekly data. To annualize the covariance matrix, we multiply it by 52, the number of weeks per year. If we look further into the future, we are faced with more uncertainty. Therefore, the appropriate covariance matrix for time t should be t times the annualized spot covariance matrix. All option models recognize this fact and embed the t factor implicitly in the valuation formulas. Thus, we only need to input the annualized spot covariance matrix into our valuation formula.

If we assume there is no collar, the expected dividend rate for each future quarter will increase as we go further into the future. This happens because the covariance matrix for the more distant quarter has higher values while the expected future spot values remain unchanged. The intuition is simple. There are greater uncertainties about the three rates as we look further into the future. The result will be a greater chance for one of the two lower rates to end up being higher than

[15] The key result from these 16 regressions is that the R-squares of the regressions that involve the covariance matrix based on 52 weeks of historical data are slightly higher than the R-squares of the regressions that involve the covariance matrix based on 26 weeks of historical data. The reason we do not want to try both covariance matrices on the full sample is due to budget limitation.

the current highest of the three rates. Therefore, the option on the maximum of three rates has higher value as we look further into the future.

Including a collar adds complexity to our study. For similar reasons discussed earlier, the expected dividend rate will rise initially as we go further into the future. The ceiling effect, however, will dominate later on, causing the expected dividend rate to fall. As time approaches infinity, the expected dividend rate will approach the floor rate asymptotically. This may seem strange at first. But it does make sense because the ceiling is equivalent to giving up an option to have a dividend rate above the ceiling rate. When the uncertainties about the interest rates are greater as we look further into the future, we would regret from having to give up this option because the expected dividend rate without the ceiling would be higher. The deduction from having the ceiling is greater than the gain from having an option to have the dividend rate above the floor. The net effect is a lower expected dividend rate. Since the dividend rate can not be lower than the floor rate, in the limit the expected dividend rate must approach the floor rate.

The ARPS has no maturity. To value the ARPS, we truncate the discounting process after a certain time period. We assume that 240 quarters, or 60 years, would be long enough, and that the market value of the ARPS will equal its stated value in year $60^1/_4$. As for discounting, we add a risk premium to the zero-coupon risk free rates embedded in the constant maturity yield curve. The zero-coupon risk free rates can be derived from the discount factor series that we discussed before. The expression is:

$$DF(k) = \frac{1}{(1 + r_k)^{4 \cdot k}} \qquad \text{for} \quad k = {}^1/_4, {}^1/_2, {}^3/_4, 1, \ldots \tag{4.10}$$

where $DF(k)$ is the k-year discount factor, and r_k is the per quarter zero-coupon discount rate for k years.

Once we have determined all the expected dividend rates and the zero-coupon discount rates we can compute the implied risk premia of the entire cross-sectional and time-series ARPS sample.

C. The Option-Based Expectations Hypothesis Interest Rate Model

This model assumes that the expectations hypothesis of interest rate movements holds. The forward rates become the unbiased estimates of the future spot rates. This means that we must determine the three-month forward Treasury discount rates, the ten-year forward and the twenty-year forward constant maturity yields for all future quarters, in order to estimate the expected dividend rates.

To estimate the three-month forward Treasury discount rates, we can use the discount factor series. The $t+1/4$-year discount factor is related to the t-year discount factor via this equation:

$$DF(t + 1/4) = DF(t) \cdot \frac{1}{1 + y^f_{t,t+1/4}} \tag{4.11}$$

where $y^f_{t,t+1/4}$ is the three-month forward Treasury yield for time t. The three-month forward Treasury yield can be converted back to the three-month forward Treasury discount rate, $R^f_{t,t+1/4}$, using eq. (4.6). That is,

$$1 - R^f_{t,t+1/4} \cdot \frac{91}{360} = \frac{1}{1 + y^f_{t,t+1/4}}$$

To derive the forward constant maturity yields, we could generate the zero-coupon forward yield curve then convert it back to forward constant maturity yields. Unfortunately, this technique can be cumbersome and time consuming. An alternative is to set up a self-financed portfolio and impose a no arbitrage condition. The portfolio will consist of constant maturity yield \$1 par bonds with various maturities. For example, if we want to find the ten-year forward constant maturity yield 20 years from time zero, the strategy would be to go long a 30-year bond and to go short a 20-year bond at time zero. Also contract at time zero to short a 10-year bond, with a forward constant maturity yield $Y^f_{20,30}$, 20 years later. The \$1 proceed from shorting the 10-year bond will be used to retire the 20-year bond 20 years later. The cash inflow from the 30-year bond is $\frac{Y_{30}}{2}$ every six months. The cash outflow from shorting the 20-year bond is $\frac{Y_{20}}{2}$ every six months. The cash outflow from shorting the 10-year bond 20 years later is $\frac{Y^f_{20,30}}{2}$ every six months from year

$20\,1/2$ on. Thus, for the first twenty years, the net cash flow from the 30-year bond and the 20-year bond is $\frac{Y_{30}}{2} - \frac{Y_{20}}{2}$ every six months. From year $20\,1/2$ to year 30, the net cash flow from the 30-year bond and the 10-year "forward bond" is $\frac{Y_{30}}{2} - \frac{Y^f_{20,30}}{2}$ every six months. The no arbitrage condition requires the present value of this self-financed bond portfolio equal to zero. That is,

$$\left(\frac{Y_{30}}{2} - \frac{Y_{20}}{2}\right) \cdot \left[\sum_{k=1/2}^{20} DF(k)\right] + \left(\frac{Y_{30}}{2} - \frac{Y^f_{20,30}}{2}\right) \cdot \left[\sum_{k=20\,1/2}^{30} DF(k)\right] = 0$$

Since we know all the constant maturity yields and the discount factors, we can solve $\frac{Y^f_{20,30}}{2}$, the 10-year forward constant maturity yield 20 years from time zero.

By varying the terms of the long bond and the short bond, and by always contracting at time zero to short a 10-year par bond t years later, we can calculate all the ten-year forward constant maturity yields. But if t is on the odd quarter series, that is, $t = 1/4, 3/4, 1\,1/4, \ldots$, then a modification will be needed to accommodate the semiannual coupon payment feature of constant maturity bonds. For example, to determine the ten-year forward constant maturity yield $20\,1/4$ years from time zero, we go long a $30\,1/4$-year bond and go short a $20\,1/4$-year bond at time zero. In addition, we would contract at time zero to short a 10-year bond, with a forward constant maturity yield $Y^f_{20\,1/4,30\,1/4}$, $20\,1/4$ years later. The \$1 proceed from shorting the 10-year bond will be used to retire the $20\,1/4$-year bond $20\,1/4$ years later. The cash inflow from the $30\,1/4$-year bond is $\frac{Y_{30\,1/4}}{2}$ every six months. The cash outflow from shorting the $20\,1/4$-year bond is $\frac{Y_{20\,1/4}}{2}$ every six months. The cash outflow from shorting the 10-year bond $20\,1/4$ years later is $\frac{Y^f_{20\,1/4,30\,1/4}}{2}$ every six months from year $20\,3/4$ on. Thus, for the first $20\,1/4$ years, the net cash flow from the $30\,1/4$-year bond and the $20\,1/4$-year bond is $\frac{Y_{30\,1/4}}{2} - \frac{Y_{20\,1/4}}{2}$ every six months. From year $20\,3/4$ to year $30\,1/4$, the net cash flow from the $30\,1/4$-year bond and the 10-year "forward bond" is $\frac{Y_{30\,1/4}}{2} - \frac{Y^f_{20\,1/4,30\,1/4}}{2}$ every six months. The only difference from the previous example is that at time zero we pay $\left(1 + \frac{Y_{30\,1/4}}{2}\right)^{1/2}$, rather than one dollar, for the $30\,1/4$-year bond, and receive $\left(1 + \frac{Y_{20\,1/4}}{2}\right)^{1/2}$, rather than one dollar, for going short the $20\,1/4$-year bond. Again, the no arbitrage condition requires the present value of the self-financed portfolio equal to zero. The resulting relation is:

$$-\left(1+\frac{Y_{30\,1/4}}{2}\right)^{1/2}+\left(1+\frac{Y_{20\,1/4}}{2}\right)^{1/2}+\left(\frac{Y_{30\,1/4}}{2}-\frac{Y_{20\,1/4}}{2}\right)\cdot\left[\sum_{k=1/4}^{20\,1/4}DF(k)\right]$$
$$+\left(\frac{Y_{30\,1/4}}{2}-\frac{Y^f_{20\,1/4,30\,1/4}}{2}\right)\cdot\left[\sum_{k=20\,3/4}^{30\,1/4}DF(k)\right]=0$$

Thus, the 10-year forward constant maturity yield, $Y^f_{20\,1/4,30\,1/4}$, can be solved easily.

In general, the ten-year forward constant maturity yield t years into the future from time zero can be determined by going long a t+10-year par bond, going short a t-year par bond and contracting at time zero to short a 10-year par bond t years later. The procedure can be summarized by these two recursive equations:

$$-\left(1+\frac{Y_{t+10}}{2}\right)^{1/2}+\left(1+\frac{Y_t}{2}\right)^{1/2}+\left(\frac{Y_{t+10}}{2}-\frac{Y_t}{2}\right)\cdot\left[\sum_{k=1/4}^{t}DF(k)\right]$$
$$+\left(\frac{Y_{t+10}}{2}-\frac{Y^f_{t,t+10}}{2}\right)\cdot\left[\sum_{k=t+1/2}^{t+10}DF(k)\right]=0 \qquad \text{for} \quad t={}^1\!/_4,{}^3\!/_4,1{}^1\!/_4,\ldots \qquad (4.12A)$$

and

$$\left(\frac{Y_t+10}{2}-\frac{Y_t}{2}\right)\cdot\left[\sum_{k=1/2}^{t}DF(k)\right]+\left(\frac{Y_t+10}{2}-\frac{Y^f_{t,t+10}}{2}\right)\cdot\left[\sum_{k=t+1/2}^{t+10}DF(k)\right]=0$$
$$\text{for} \quad t={}^1\!/_2,1,1{}^1\!/_2,\ldots \qquad (4.12B)$$

Similarly, the twenty-year forward constant maturity yield t years into the future from time zero can be determined by going long a t+20-year par bond and going short a t-year par bond at time zero, and contracting at time zero to short a 20-year par bond t years later. The following two expressions summarize the recursive procedures:

$$-\left(1+\frac{Y_{t+20}}{2}\right)^{1/2}+\left(1+\frac{Y_t}{2}\right)^{1/2}+\left(\frac{Y_{t+20}}{2}-\frac{Y_t}{2}\right)\cdot\left[\sum_{k=1/4}^{t}DF(k)\right]$$
$$+\left(\frac{Y_{t+20}}{2}-\frac{Y^f_{t,t+20}}{2}\right)\cdot\left[\sum_{k=t+1/2}^{t+20}DF(i)\right]=0 \qquad \text{for} \quad t={}^1\!/_4,{}^3\!/_4,1{}^1\!/_4,\ldots \qquad (4.13A)$$

and

$$\left(\frac{Y_{t+20}}{2} - \frac{Y_t}{2}\right) \cdot \left[\sum_{k=1/2}^{t} DF(k)\right] + \left(\frac{Y_{t+20}}{2} - \frac{Y^f_{t,t+20}}{2}\right) \cdot \left[\sum_{k=t+1/2}^{t+20} DF(k)\right] = 0$$

$$\text{for} \quad t = 1/2, 1, 1\,1/2, \ldots \quad (4.13B)$$

Thus, from each weekly spot yield curve, we generate three series of forward values. Each series is indexed by the years from time zero (i.e.; $t = 1/4, 1/2, 3/4, \ldots$). These forward values are our best estimate of the expected future spot values t years into the future from time zero.

Notice that the ten-year forward constant maturity yields and the twenty-year forward constant maturity yields beyond 30 years will be the same as the thirty-year constant maturity yield since the yield curve is assumed to be flat after the thirtieth year. The three-month forward Treasury discount rates beyond 30 years will also be constant. If we convert these forward rates into forward constant maturity yields, these forward constant maturity yields would be exactly equal to the thirty-year constant maturity yield. As a result, the expected base rates (the expected value of the maximum of three rates) for $t \geq 30$ years will merely be the thirty-year constant maturity yield. Furthermore, the ten-year forward constant maturity yield for the period from $t = 20$ years to $t = 30$ years and the twenty-year forward constant maturity yields for the period from $t = 10$ years to $t = 30$ years are derived from the flat segment of the yield curve, the portion that lies beyond year 30. Assuming that the yield curve is flat after year 30 is the least problematic assumption one can make. The empirical forward rates behave even worse with other assumptions about the shape of the extended yield curve.

Because the spot yield curve varies over time, the three series of forward values will also vary over time. Specifically, we will have weekly variations of the three forward series, since our spot yield curves are derived from weekly data. As was the case with the OBRW model, we can calculate the historical covariance matrix of the rate of change of the three expected future spot values. The difference here is that the historical covariance matrices are based on the forward values rather than the spot values. As a result, there will be 120 different covariance matrices, one for each t, $t = 1/4, 1/2, 3/4, \ldots, 30$. As indicated in Table IV–1, choosing 52 weeks of historical data to estimate the historical covariance matrices is a slightly better choice than choosing 26 weeks of historical data.

Once we have the three forward values and the associated covariance matrix for each t, $t = 1/4, 1/2, 3/4, \ldots, 30$, we can apply Johnson's model to find the expected dividend rate for each t. The expected dividend rates beyond year 30 will be constant and equal to the expected dividend rate for year 30. Since the expected dividend rates beyond year 30 are constant perpetuities, the valuation model has a closed form solution. We do not need to truncate the discounting process after year 60 as was required in the OBRW model.

As for the appropriate discount rate for each quarter, that is, from t to $t + 1/4$, it is determined by adding a per quarter risk premium to the three-month forward Treasury yield, $y^f_{t,t+1/4}$. The three-month forward Treasury yield has already been calculated from the discount factor series.

If we know the risk premia, the procedures described in this section will enable us to find the OBEH model price. Since we do not know the appropriate risk premia but do observe the market prices of ARPS, we will use the OBEH model to estimate the implied risk premia of the ARPS.

D. The Regression Model

Following the procedures of the OBRW model and the OBEH model, we can derive two sets of implied risk premia, one for each model. With each set of implied risk premia, we will perform the type of regression as was done using the benchmark model in Chapter III. The possible determinants of the risk premium have already been discussed in that chapter, and therefore, do not need repeating. The same base case dummy variables will be used. That is, a Moody's rating of baa2, a tax regime of 87, a call status of callable at a premium, a dividend rate above the floor rate, and a utility industry will serve as the base case dummy variables. Each option-based model will be regressed on the five categories of qualitative variables discussed in Chapter III, plus an interest rate of either the three-month Treasury discount rate or the thirty-year constant maturity yield, and a volatility based on either the three-month Treasury discount rate or the thirty-year constant maturity yield. Thus, we will have a total of eight regressions, four regressions for the OBRW model and four regressions for the OBEH model. The general regression equation is:

$$\begin{aligned} RPOB = {} & \beta_1 + \beta_2\, AAA + \beta_3\, AA1 + \beta_4\, AA2 + \beta_5\, AA3 + \beta_6\, A1 + \beta_7\, A2 + \beta_8\, A3 \\ & + \beta_9\, BAA1 + \beta_{10}\, BAA3 + \beta_{11}\, BA1 + \beta_{12}\, BA2 + \beta_{13}\, BA3 + \beta_{14}\, B1 \\ & + \beta_{15}\, B3 + \beta_{16}\, TAXREG82 + \beta_{17}\, TAXREG88 + \beta_{18}\, CALLNONE \\ & + \beta_{19}\, CALLPAR + \beta_{20}\, HITFL + \beta_{21}\, BANKING \\ & + \beta_{22}\, INDUSTRIAL + \beta_{23}\, INTRATE + \beta_{24}\, VOLATILITY + \tilde{\varepsilon} \end{aligned}$$

where:

$RPOB =$ the implied risk premium of the option-based model (two possible sets)

$AAA =$ 1 if the Moody's rating is aaa, 0 otherwise

$AA1 =$ 1 if the Moody's rating is aa1, 0 otherwise

$AA2 =$ 1 if the Moody's rating is aa2, 0 otherwise

$AA3 =$ 1 if the Moody's rating is aa3, 0 otherwise

$A1 =$ 1 if the Moody's rating is a1, 0 otherwise

$A2 =$ 1 if the Moody's rating is a2, 0 otherwise

$A3 =$ 1 if the Moody's rating is a3, 0 otherwise

$BAA1 =$ 1 if the Moody's rating is baa1, 0 otherwise

$BAA3 =$ 1 if the Moody's rating is baa3, 0 otherwise

$BA1 =$ 1 if the Moody's rating is ba1, 0 otherwise

$BA2 =$ 1 if the Moody's rating is ba2, 0 otherwise

$BA3 =$ 1 if the Moody's rating is ba3, 0 otherwise

$B1 = 1$ if the Moody's rating is b1, 0 otherwise

$B3 = 1$ if the Moody's rating is b3, 0 otherwise

$TAXREG82 = 1$ if the tax regime is before January 1987, 0 otherwise

$TAXREG88 = 1$ if the tax regime is after January 1988, 0 otherwise

$CALLNONE = 1$ if the ARPS is not callable at this time, 0 otherwise

$CALLPAR = 1$ if the ARPS is callable at par, 0 otherwise

$HITFL = 1$ if the dividend rate is equal the floor rate, 0 otherwise

$BANKING = 1$ if the ARPS issuer belongs to the banking industry, 0 otherwise

$INDUSTRIAL = 1$ if the ARPS issuer belongs to the industrial sector, 0 otherwise

$INTRATE =$ the level of the interest rate (two possible sets)

$VOLATILITY =$ the volatility of the interest rate (two possible sets)

$\beta_i =$ the regression coefficient for variable i

$\tilde{\varepsilon} =$ the error term

V. The Results

Tables IV–18 through IV–25 present the results for eight sets of regressions. Table IV–22 reports the results of the regression where the implied risk premium is denoted RPOBRW from the option-based random walk interest rate model, the $INTRATE$ is the three-month Treasury discount rate, and the $VOLATILITY$ is based on the thirty-year constant maturity yield. The R-square is 0.6296. The F-statistic is 114.23, highly significant. This means that our overall regression model explains the risk premium well. If we look at the intercept, which represents our base case, we see an estimate of -0.00435095 per quarter risk premium with a significant t-statistic. As for the other rating variables, we see the general trend that a higher rating tends to be associated with a lower risk premium. Exceptions to this overall trend include the AA and B rating groups. We do not know the reason for the AA rating group to exhibit such unexpected, uncharacteristic behavior. The t-statistics for the rating variables are all significant at the 1% level with the exception of the $BAA1, BAA3$, and $B3$ rating variables. The $B1$ rating variable has a slightly lower risk premium than does the $BA3$ rating variable, but it remains within one standard deviation of its error of estimate. Statistically speaking, this does not represent a problem. As for the $B3$ rating variable, the anomaly is probably due to the small sample size problem, since the $B3$ rating variable has only seven observations out of a total of 1570 observations for the study. The $BAA1$ rating variable is not statistically different from our base case $BAA2$ rating variable, thus it does not present any major problem to the interpretation of the results. The $BAA3$ rating variable is almost significant and its estimate has the expected sign and relative magnitude. These results are very similar to the regression results of the benchmark model.

The risk premium of tax regime 87 (base case) is 0.00176115 lower than the risk premium of tax regime 88 and this difference is shown to be statistically significant. The risk premium of tax regime 82 is 0.00146009 lower than the risk premium of tax regime 87 (base case) and this difference is also statistically significant. This shows that the risk premium has increased significantly, each time, as the dividend income exclusion decreased from 85% to 80%, and then decreased again from 80% to 70%. This empirical evidence suggests that most ARPS investors are not at the maximum marginal corporate tax rate. This finding is contrary to the finding of the benchmark 30-year model.

Regarding the category of call status, not callable at this time carries a slightly lower risk premium than callable at a premium (base case). The difference is 0.00096532 per quarter. The t-statistic is significant. This is in agreement with our ex-ante prediction. For those ARPS that are callable at par, the risk premium is lower than for those ARPS that are callable at a premium (base case). This result is contrary to our prediction. The t-statistic, however, is not significant. Hence, statistically speaking, we can not differentiate the callable at par ARPS from the callable at a premium ARPS.

Comparing to the base case where the dividend rate is above the floor rate, hitting the floor rate tends to yield a higher risk premium. Apparently, although the option-based model should be able to capture the collar effect in the expected dividends, hitting the floor rate seems to cause a higher interest rate risk, thus a higher risk premium. This result reflects the negative reaction of ARPS investors to the fixed rate behavior of ARPS, in spite of the possibility of higher ARPS price, when the ARPS dividend rate is bounded by the floor rate.

As for the industry effect, the banking group commands a higher risk premium, 0.00231654 per quarter, than does the utility industry (base case). This behavior could be attributed to the tighter regulation of the utility industry by government agencies. The industrial sector, however, is not statistically different from the utility industry. This result is most likely caused by the small sample size of the industrial sector. Lastly, the effect of either a higher level of interest rate or a greater volatility of interest rate will also result in a higher risk premium. These findings on the industry effect, the interest rate level effect, and the interest rate volatility effect are also in agreement with the findings found in the benchmark model.

Table IV–23 reports the results of the regression when the implied risk premium is denoted RPOBEH from the option-based expectations hypothesis interest rate model. All explanatory variables are the same as those in the previous regression. The R-square of this regression is 0.5963, slightly lower than the R-square from the previous regression. The two R-squares are not directly comparable, however, since the two dependent variables are not exactly the same. Nonetheless, the estimated parameters and t-statistics are also very similar to those from the previous regression with the following exceptions. First, the risk premium of tax regime 82 is not significantly different from the risk premium of tax regime 87 (base case). This shows that the risk premium has not increased as the dividend income exclusion decreased from 85% to 80%, but it has increased as the dividend income exclusion decreased from 80% to 70%. This suggests that most ARPS investors are at the maximum marginal corporate tax rate. This result is the opposite of the result obtained via the OBRW model, but similar to the result obtained via the benchmark

30-year model.

The other difference with this regression is that compared to the base case in which the dividend rate is above the floor rate, hitting the floor rate has no significant effect on the risk premium. This is indicated by the low t-statistic of hitting the floor rate variable. This means that there is no significant change in the interest rate risk, whether the dividend rate is above or hitting the floor rate, when using the OBEH model

Of the six remaining regressions (Tables IV–18 to IV–21, and Tables IV–24 and IV–25), the explanatory variables include either an interest rate equal to the thirty-year constant maturity yield, or a volatility based on the three-month Treasury discount rate, or both. Their R-squares are slightly lower than the R-squares of the corresponding option-based model regressions that we have just discussed.

These aforementioned regression results provide no clear evidence favoring one theory of interest rate movements over another. The only definitive conclusions we can draw are that the Moody's rating of the ARPS, the tax regime, the call status of the ARPS, the industry of the ARPS issuer, the level of the risk free rate, and the volatility of the risk free rate are factors that influence the risk premium.

VI. Conclusions

In this chapter, a sophisticated option-based valuation model was developed, in which the expected dividend rate of the ARPS was synthesized as a portfolio of options, and the option on the maximum of three "assets" was incorporated. Empirical tests of the cross-sectional and time-series implied risk premia of the ARPS showed that the rating of the ARPS, the tax regime, the call status of the ARPS, the industry of the ARPS issuer, the level of the risk free rate, and the volatility of the risk free rate are determinants of the risk premium. As such, they are also determinants of the price of the ARPS. The empirical results were not conclusive with regard to whether most of the ARPS investors were at the maximum marginal corporate tax rate. This depended on the method used for projecting future interest rates. The random walk theory of interest rate movements did not support the hypothesis that most ARPS investors were at the maximum marginal corporate tax rate. The expectations hypothesis of interest rate movements supported this hypothesis vis-a-vis the corporate tax rate of the ARPS investors. Although the regression results of the option-based model were surprisingly good, we are not sure that the option-based model is substantially better than the benchmark model. In the next chapter we will compare the performance of these two models using different methodology.

Table IV–1

Summary of Option-Based Models and Regressions

Dependent Variable: Implied risk premium based on either random walk (RW), or expectations hypothesis (EH) of interest rate movements.
Explanatory Variable - Rate: It can be either 3-month Treasury discount rate (3MON), or 30-year constant maturity yield (30YR).
Explanatory Variable - Volatility: It can be determined by either 3-month Treasury discount rate (3MON), or 30-year constant maturity yield (30YR).
Estimation Period for Volatility: The period used to estimate both the volatility of the interest rate, and the covariance matrix which used to determine the implied risk premium. It can be either 52 weeks (52WK) or 26 weeks (26WK).
Tables IV–2 through IV–17 are based on only the ARPS with February/May/August/November dividend cycle. Tables IV–18 through IV–25 are based on the full sample of 1570 observations. + & – are signs of the estimated coefficients.
* Significant at 5% level. ** Significant at 1% level.

Table	Estimation Period for Volatility	Dependent Variable based on	Explanatory Variable - Rate	Explanatory Variable - Volatility	R-Square
IV–2	52WK	RW	3MON(+)	3MON(–**)	0.770664
IV–3	26WK	RW	3MON(+)	3MON(–**)	0.732503
IV–4	52WK	EH	3MON(–)	3MON(–**)	0.669823
IV–5	26WK	EH	3MON(–)	3MON(–**)	0.656119
IV–6	52WK	RW	30YR(–**)	30YR(–)	0.765667
IV–7	26WK	RW	30YR(–**)	30YR(+)	0.742424
IV–8	52WK	EH	30YR(–**)	30YR(–)	0.658581
IV–9	26WK	EH	30YR(–**)	30YR(+)	0.659901
IV–10	52WK	RW	3MON(+)	30YR(–)	0.743965
IV–11	26WK	RW	3MON(+*)	30YR(+*)	0.728819
IV–12	52WK	EH	3MON(–)	30YR(–)	0.646487
IV–13	26WK	EH	3MON(+)	30YR(+)	0.644907
IV–14	52WK	RW	30YR(–**)	3MON(–**)	0.789735
IV–15	26WK	RW	30YR(–**)	3MON(–**)	0.762986
IV–16	52WK	EH	30YR(–*)	3MON(–**)	0.676968
IV–17	26WK	EH	30YR(–**)	3MON(–**)	0.673403
IV–18	52WK	RW	3MON(+**)	3MON(–**)	0.625207
IV–19	52WK	EH	3MON(+**)	3MON(–**)	0.592290
IV–20	52WK	RW	30YR(–**)	30YR(+**)	0.609833
IV–21	52WK	EH	30YR(–)	30YR(+**)	0.589055
IV–22	52WK	RW	3MON(+**)	30YR(+**)	0.629556
IV–23	52WK	EH	3MON(+**)	30YR(+**)	0.596308
IV–24	52WK	RW	30YR(–**)	3MON(–**)	0.620106
IV–25	52WK	EH	30YR(–*)	3MON(–**)	0.590526

Table IV–2
OLS Regression: Option-Based Model (OBRW)
February Dividend Cycle ARPS Only
Volatility is based on 52 Week Historical Data

Dependent Variable: Implied risk premium based on random walk theory of interest rate movements (RPOBRW);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 3-month Treasury discount rate, (iii) Volatility of 3-month Treasury discount rate.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
40.72	0.0001	0.770664
ROOT MSE/MEAN	ROOT MSE	RPOBRW MEAN
0.981267	0.00179189	0.00182610

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00329920	3.20	0.0016	0.00103005
AA3	−0.00266276	−1.42	0.1568	0.00187389
A1	−0.00016410	−0.18	0.8568	0.00090829
A2	−0.00214896	−4.64	0.0001	0.00046316
A3	−0.00306993	−6.74	0.0001	0.00045566
BAA1	−0.00138254	−2.76	0.0062	0.00050027
BAA3	−0.00408372	−7.09	0.0001	0.00057601
BA1	0.00062978	0.63	0.5297	0.00100041
BA2	−0.00014874	−0.19	0.8511	0.00079154
BA3	0.00117758	1.64	0.1024	0.00071773
TAXREG82	−0.00129437	−2.76	0.0063	0.00046865
TAXREG88	0.00302881	5.24	0.0001	0.00057797
CALLNONE	−0.00012020	−0.25	0.8063	0.00048959
CALLPAR	0.00247979	1.32	0.1868	0.00187239
HITFL	0.00164247	4.64	0.0001	0.00035386
BANKING	−0.00076393	−1.96	0.0508	0.00038879
RATE3MON	0.00390354	0.33	0.7426	0.01187154
V3M52WK	−0.07927313	−4.94	0.0001	0.01604407

Table IV–3
OLS Regression: Option-Based Model (OBRW)
February Dividend Cycle ARPS Only
Volatility is based on 26 Week Historical Data

Dependent Variable: Implied risk premium based on random walk theory of interest rate movements (RPOBRW);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 3-month Treasury discount rate, (iii) Volatility of 3-month Treasury discount rate.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
33.18	0.0001	0.732503
ROOT MSE/MEAN	ROOT MSE	RPOBRW MEAN
1.081065	0.00190825	0.00176516

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00297612	2.48	0.0139	0.00119927
AA3	−0.00445498	−2.28	0.0234	0.00195051
A1	−0.00002504	−0.03	0.9794	0.00096725
A2	−0.00226121	−4.59	0.0001	0.00049308
A3	−0.00269264	−5.43	0.0001	0.00049574
BAA1	−0.00121625	−2.29	0.0232	0.00053164
BAA3	−0.00370756	−6.07	0.0001	0.00061077
BA1	0.00153959	1.44	0.1503	0.00106629
BA2	0.00075944	0.91	0.3657	0.00083776
BA3	0.00136894	1.80	0.0738	0.00076184
TAXREG82	−0.00105781	−2.11	0.0358	0.00050065
TAXREG88	0.00232872	3.83	0.0002	0.00060741
CALLNONE	−0.00081939	−1.63	0.1040	0.00050177
CALLPAR	0.00241305	1.21	0.2276	0.00199385
HITFL	0.00175545	4.62	0.0001	0.00038030
BANKING	−0.00065256	−1.57	0.1170	0.00041454
RATE3MON	0.00443730	0.33	0.7399	0.01334712
V3M26WK	−0.04694864	−2.97	0.0033	0.01578824

Table IV–4
OLS Regression: Option-Based Model (OBEH)
February Dividend Cycle ARPS Only
Volatility is based on 52 Week Historical Data

Dependent Variable: Implied risk premium based on expectations hypothesis of interest rate movements (RPOBEH);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 3-month Treasury discount rate, (iii) Volatility of 3-month Treasury discount rate.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
24.58	0.0001	0.669823
ROOT MSE/MEAN	ROOT MSE	RPOBEH MEAN
1.245543	0.00168965	0.00135656

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00365010	3.76	0.0002	0.00097128
AA3	−0.00250438	−1.42	0.1579	0.00176697
A1	−0.00077480	−0.90	0.3667	0.00085647
A2	−0.00246760	−5.65	0.0001	0.00043673
A3	−0.00269236	−6.27	0.0001	0.00042966
BAA1	−0.00135200	−2.87	0.0046	0.00047172
BAA3	−0.00268206	−4.94	0.0001	0.00054314
BA1	0.00069117	0.73	0.4646	0.00094333
BA2	0.00028745	0.39	0.7005	0.00074638
BA3	0.00171234	2.53	0.0121	0.00067677
TAXREG82	0.00017138	0.39	0.6986	0.00044191
TAXREG88	0.00211049	3.87	0.0001	0.00054499
CALLNONE	−0.00044269	−0.96	0.3387	0.00046166
CALLPAR	0.00256809	1.45	0.1473	0.00176555
HITFL	0.00042070	1.26	0.2088	0.00033367
BANKING	−0.00033171	−0.90	0.3666	0.00036661
RATE3MON	−0.01113887	−1.00	0.3209	0.01119417
V3M52WK	−0.05912342	−3.91	0.0001	0.01512863

Table IV–5
OLS Regression: Option-Based Model (OBEH)
February Dividend Cycle ARPS Only
Volatility is based on 26 Week Historical Data

Dependent Variable: Implied risk premium based on expectations hypothesis of interest rate movements (RPOBEH);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 3-month Treasury discount rate, (iii) Volatility of 3-month Treasury discount rate.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
23.12	0.0001	0.656119
ROOT MSE/MEAN	ROOT MSE	RPOBEH MEAN
1.322622	0.00173117	0.00130890

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00386824	3.56	0.0005	0.00108799
AA3	−0.00436414	−2.47	0.0145	0.00176951
A1	−0.00069209	−0.79	0.4312	0.00087749
A2	−0.00251511	−5.62	0.0001	0.00044733
A3	−0.00243897	−5.42	0.0001	0.00044974
BAA1	−0.00131007	−2.72	0.0072	0.00048231
BAA3	−0.00263816	−4.76	0.0001	0.00055409
BA1	0.00142632	1.47	0.1419	0.00096734
BA2	0.00080540	1.06	0.2905	0.00076002
BA3	0.00190467	2.76	0.0064	0.00069114
TAXREG82	0.00063451	1.40	0.1639	0.00045419
TAXREG88	0.00194038	3.52	0.0005	0.00055104
CALLNONE	−0.00090790	−1.99	0.0474	0.00045521
CALLPAR	0.00240114	1.33	0.1858	0.00180883
HITFL	0.00037003	1.07	0.2848	0.00034501
BANKING	−0.00032149	−0.85	0.3936	0.00037608
RATE3MON	−0.01906725	−1.57	0.1169	0.01210857
V3M26WK	−0.04162443	−2.91	0.0041	0.01432317

Table IV–6
OLS Regression: Option-Based Model (OBRW)
February Dividend Cycle ARPS Only
Volatility is based on 52 Week Historical Data

Dependent Variable: Implied risk premium based on random walk theory of interest rate movements (RPOBRW);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 30-year constant maturity yield, (iii) Volatility of 30-year constant maturity yield.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
39.59	0.0001	0.765667
ROOT MSE/MEAN	ROOT MSE	RPOBRW MEAN
0.991899	0.00181131	0.00182610

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00968397	5.62	0.0001	0.00172389
AA3	−0.00319794	−1.71	0.0885	0.00186862
A1	−0.00023538	−0.26	0.7984	0.00092041
A2	−0.00214644	−4.64	0.0001	0.00046304
A3	−0.00231755	−4.72	0.0001	0.00049062
BAA1	−0.00097538	−1.93	0.0554	0.00050622
BAA3	−0.00411753	−7.06	0.0001	0.00058311
BA1	0.00194309	1.93	0.0554	0.00100838
BA2	0.00079555	0.99	0.3219	0.00080126
BA3	0.00248548	3.43	0.0007	0.00072567
TAXREG82	0.00002309	0.05	0.9635	0.00050336
TAXREG88	0.00248703	4.33	0.0001	0.00057497
CALLNONE	−0.00055609	−1.13	0.2584	0.00049067
CALLPAR	0.00090165	0.48	0.6345	0.00189371
HITFL	0.00053006	1.29	0.1997	0.00041197
BANKING	−0.00078212	−2.00	0.0464	0.00039031
RATE30YR	−0.06835625	−4.68	0.0001	0.01461739
V30Y52WK	−0.09600082	−1.73	0.0858	0.05561887

Table IV–7
OLS Regression: Option-Based Model (OBRW)
February Dividend Cycle ARPS Only
Volatility is based on 26 Week Historical Data

Dependent Variable: Implied risk premium based on random walk theory of interest rate movements (RPOBRW);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 30-year constant maturity yield, (iii) Volatility of 30-year constant maturity yield.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
34.93	0.0001	0.742424
ROOT MSE/MEAN	ROOT MSE	RPOBRW MEAN
1.060827	0.00187253	0.00176516

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00780498	4.24	0.0001	0.00183882
AA3	−0.00371559	−1.94	0.0534	0.00191277
A1	−0.00026234	−0.28	0.7830	0.00095127
A2	−0.00218221	−4.55	0.0001	0.00047984
A3	−0.00201217	−3.97	0.0001	0.00050696
BAA1	−0.00091881	−1.76	0.0805	0.00052303
BAA3	−0.00353598	−6.09	0.0001	0.00058018
BA1	0.00271539	2.66	0.0083	0.00101918
BA2	0.00137943	1.67	0.0964	0.00082602
BA3	0.00263131	3.54	0.0005	0.00074407
TAXREG82	0.00054320	1.08	0.2814	0.00050291
TAXREG88	0.00251821	4.18	0.0001	0.00060291
CALLNONE	−0.00097783	−2.00	0.0472	0.00048989
CALLPAR	0.00085700	0.44	0.6620	0.00195745
HITFL	0.00042929	1.01	0.3115	0.00042313
BANKING	−0.00066283	−1.64	0.1025	0.00040413
RATE30YR	−0.06615676	−4.17	0.0001	0.01586958
V30Y26WK	0.01262815	0.30	0.7678	0.04270726

Table IV–8
OLS Regression: Option-Based Model (OBEH)
February Dividend Cycle ARPS Only
Volatility is based on 52 Week Historical Data

Dependent Variable: Implied risk premium based on expectations hypothesis of interest rate movements (RPOBEH);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 30-year constant maturity yield, (iii) Volatility of 30-year constant maturity yield.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
23.37	0.0001	0.658581
ROOT MSE/MEAN	ROOT MSE	RPOBEH MEAN
1.266570	0.00171817	0.00135656

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00624393	3.82	0.0002	0.00163525
AA3	−0.00327992	−1.85	0.0657	0.00177254
A1	−0.00081234	−0.93	0.3532	0.00087309
A2	−0.00257241	−5.86	0.0001	0.00043923
A3	−0.00238888	−5.13	0.0001	0.00046540
BAA1	−0.00112892	−2.35	0.0197	0.00048019
BAA3	−0.00249821	−4.52	0.0001	0.00055313
BA1	0.00118298	1.24	0.2176	0.00095653
BA2	0.00081477	1.07	0.2850	0.00076007
BA3	0.00230992	3.36	0.0009	0.00068835
TAXREG82	0.00071761	1.50	0.1344	0.00047748
TAXREG88	0.00162496	2.98	0.0032	0.00054541
CALLNONE	−0.00080403	−1.73	0.0856	0.00046544
CALLPAR	0.00189200	1.05	0.2935	0.00179634
HITFL	0.00004907	0.13	0.9002	0.00039078
BANKING	−0.00026636	−0.72	0.4727	0.00037024
RATE30YR	−0.03745657	−2.70	0.0075	0.01386579
V30Y52WK	−0.06271357	−1.19	0.2359	0.05275905

Table IV–9
OLS Regression: Option-Based Model (OBEH)
February Dividend Cycle ARPS Only
Volatility is based on 26 Week Historical Data

Dependent Variable: Implied risk premium based on expectations hypothesis of interest rate movements (RPOBEH);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 30-year constant maturity yield, (iii) Volatility of 30-year constant maturity yield.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
23.51	0.0001	0.659901

ROOT MSE/MEAN	ROOT MSE	RPOBEH MEAN
1.315329	0.00172163	0.00130890

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00546410	3.23	0.0014	0.00169064
AA3	−0.00417734	−2.38	0.0184	0.00175862
A1	−0.00089106	−1.02	0.3095	0.00087461
A2	−0.00259272	−5.88	0.0001	0.00044117
A3	−0.00217638	−4.67	0.0001	0.00046611
BAA1	−0.00115949	−2.41	0.0168	0.00048088
BAA3	−0.00214900	−4.03	0.0001	0.00053342
BA1	0.00170188	1.82	0.0708	0.00093705
BA2	0.00110081	1.45	0.1487	0.00075946
BA3	0.00246728	3.61	0.0004	0.00068411
TAXREG82	0.00141808	3.07	0.0025	0.00046239
TAXREG88	0.00194415	3.51	0.0006	0.00055433
CALLNONE	−0.00106584	−2.37	0.0189	0.00045041
CALLPAR	0.00173294	0.96	0.3367	0.00179971
HITFL	−0.00017744	−0.46	0.6488	0.00038903
BANKING	−0.00022118	−0.60	0.5523	0.00037157
RATE30YR	−0.04399443	−3.02	0.0029	0.01459072
V30Y26WK	0.01181320	0.30	0.7638	0.03926566

Table IV–10
OLS Regression: Option-Based Model (OBRW)
February Dividend Cycle ARPS Only
Volatility is based on 52 Week Historical Data

Dependent Variable: Implied risk premium based on random walk theory of interest rate movements (RPOBRW);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 3-month Treasury discount rate, (iii) Volatility of 30-year constant maturity yield.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
35.21	0.0001	0.743965
ROOT MSE/MEAN	ROOT MSE	RPOBRW MEAN
1.036812	0.00189332	0.00182610

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00160891	1.10	0.2711	0.00145810
AA3	−0.00448082	−2.29	0.0231	0.00195706
A1	−0.00008004	−0.08	0.9337	0.00096160
A2	−0.00246144	−5.07	0.0001	0.00048537
A3	−0.00326342	−6.77	0.0001	0.00048172
BAA1	−0.00123250	−2.34	0.0205	0.00052773
BAA3	−0.00396467	−5.89	0.0001	0.00067364
BA1	0.00084114	0.79	0.4327	0.00106989
BA2	0.00024778	0.30	0.7665	0.00083330
BA3	0.00144786	1.91	0.0577	0.00075846
TAXREG82	−0.00124217	−2.45	0.0151	0.00050706
TAXREG88	0.00251491	4.16	0.0001	0.00060506
CALLNONE	−0.00076775	−1.50	0.1364	0.00051343
CALLPAR	0.00237267	1.20	0.2318	0.00197825
HITFL	0.00204269	5.56	0.0001	0.00036707
BANKING	−0.00056865	−1.38	0.1681	0.00041113
RATE3MON	0.01983071	1.60	0.1115	0.01240767
V30Y52WK	−0.03727649	−0.62	0.5348	0.05995947

Table IV–11
OLS Regression: Option-Based Model (OBRW)
February Dividend Cycle ARPS Only
Volatility is based on 26 Week Historical Data

Dependent Variable: Implied risk premium based on random walk theory of interest rate movements (RPOBRW);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 3-month Treasury discount rate, (iii) Volatility of 30-year constant maturity yield.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
32.57	0.0001	0.728819
ROOT MSE/MEAN	ROOT MSE	RPOBRW MEAN
1.088484	0.00192135	0.00176516

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	−0.00138032	−1.02	0.3073	0.00134863
AA3	−0.00482610	−2.46	0.0147	0.00196166
A1	−0.00021219	−0.22	0.8281	0.00097624
A2	−0.00258109	−5.23	0.0001	0.00049334
A3	−0.00299465	−6.15	0.0001	0.00048726
BAA1	−0.00117682	−2.20	0.0291	0.00053542
BAA3	−0.00300508	−4.53	0.0001	0.00066283
BA1	0.00137829	1.29	0.1995	0.00107095
BA2	0.00074257	0.88	0.3797	0.00084350
BA3	0.00145143	1.89	0.0597	0.00076658
TAXREG82	−0.00084762	−1.69	0.0932	0.00050261
TAXREG88	0.00263401	4.26	0.0001	0.00061821
CALLNONE	−0.00114184	−2.27	0.0239	0.00050196
CALLPAR	0.00243515	1.21	0.2265	0.00200754
HITFL	0.00198146	5.34	0.0001	0.00037132
BANKING	−0.00036093	−0.86	0.3884	0.00041758
RATE3MON	0.03184774	2.48	0.0138	0.01281976
V30Y26WK	0.10664300	2.43	0.0158	0.04381585

Table IV–12
OLS Regression: Option-Based Model (OBEH)
February Dividend Cycle ARPS Only
Volatility is based on 52 Week Historical Data

Dependent Variable: Implied risk premium based on expectations hypothesis of interest rate movements (RPOBEH);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 3-month Treasury discount rate, (iii) Volatility of 30-year constant maturity yield.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
22.16	0.0001	0.646487
ROOT MSE/MEAN	ROOT MSE	RPOBEH MEAN
1.288807	0.00174834	0.00135656

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00270707	2.01	0.0457	0.00134644
AA3	−0.00377118	−2.09	0.0381	0.00180720
A1	−0.00069438	−0.78	0.4351	0.00088797
A2	−0.00269064	−6.00	0.0001	0.00044820
A3	−0.00284815	−6.40	0.0001	0.00044483
BAA1	−0.00124493	−2.55	0.0114	0.00048732
BAA3	−0.00267913	−4.31	0.0001	0.00062205
BA1	0.00079683	0.81	0.4209	0.00098797
BA2	0.00056601	0.74	0.4628	0.00076949
BA3	0.00189417	2.70	0.0074	0.00070038
TAXREG82	0.00017776	0.38	0.7046	0.00046823
TAXREG88	0.00170990	3.06	0.0025	0.00055873
CALLNONE	−0.00088374	−1.86	0.0637	0.00047411
CALLPAR	0.00248770	1.36	0.1747	0.00182676
HITFL	0.00073018	2.15	0.0324	0.00033896
BANKING	−0.00020095	−0.53	0.5972	0.00037965
RATE3MON	−0.00024317	−0.02	0.9831	0.01145754
V30Y52WK	−0.04519688	−0.82	0.4153	0.05536802

Table IV–13
OLS Regression: Option-Based Model (OBEH)
February Dividend Cycle ARPS Only
Volatility is based on 26 Week Historical Data

Dependent Variable: Implied risk premium based on expectations hypothesis of interest rate movements (RPOBEH);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 3-month Treasury discount rate, (iii) Volatility of 30-year constant maturity yield.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
22.01	0.0001	0.644907
ROOT MSE/MEAN	ROOT MSE	RPOBEH MEAN
1.344010	0.00175917	0.00130890

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00091020	0.74	0.4619	0.00123480
AA3	−0.00466184	−2.60	0.0101	0.00179608
A1	−0.00079172	−0.89	0.3768	0.00089384
A2	−0.00275514	−6.10	0.0001	0.00045170
A3	−0.00271411	−6.08	0.0001	0.00044613
BAA1	−0.00128689	−2.63	0.0093	0.00049022
BAA3	−0.00225807	−3.72	0.0003	0.00060688
BA1	0.00124992	1.27	0.2038	0.00098055
BA2	0.00079346	1.03	0.3054	0.00077231
BA3	0.00197695	2.82	0.0053	0.00070188
TAXREG82	0.00079332	1.72	0.0862	0.00046019
TAXREG88	0.00211963	3.74	0.0002	0.00056603
CALLNONE	−0.00115049	−2.50	0.0131	0.00045959
CALLPAR	0.00241345	1.31	0.1906	0.00183809
HITFL	0.00059417	1.75	0.0820	0.00033998
BANKING	−0.00011640	−0.30	0.7611	0.00038234
RATE3MON	0.00114888	0.10	0.9221	0.01173767
V30Y26WK	0.05191156	1.29	0.1971	0.04011745

Table IV–14
OLS Regression: Option-Based Model (OBRW)
February Dividend Cycle ARPS Only
Volatility is based on 52 Week Historical Data

Dependent Variable: Implied risk premium based on random walk theory of interest rate movements (RPOBRW);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 30-year constant maturity yield, (iii) Volatility of 3-month Treasury discount rate.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
45.51	0.0001	0.789735
ROOT MSE/MEAN	ROOT MSE	RPOBRW MEAN
0.939580	0.00171577	0.00182610

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00873218	6.48	0.0001	0.00134685
AA3	−0.00201655	−1.13	0.2587	0.00178052
A1	−0.00036734	−0.42	0.6736	0.00087090
A2	−0.00196058	−4.45	0.0001	0.00044022
A3	−0.00228171	−4.92	0.0001	0.00046363
BAA1	−0.00116459	−2.42	0.0164	0.00048109
BAA3	−0.00376847	−7.28	0.0001	0.00051753
BA1	0.00151034	1.60	0.1114	0.00094476
BA2	0.00033559	0.44	0.6612	0.00076459
BA3	0.00199404	2.88	0.0044	0.00069323
TAXREG82	−0.00025984	−0.55	0.5816	0.00047084
TAXREG88	0.00295583	5.45	0.0001	0.00054242
CALLNONE	−0.00008983	−0.19	0.8475	0.00046665
CALLPAR	0.00139124	0.77	0.4396	0.00179664
HITFL	0.00045295	1.17	0.2438	0.00038754
BANKING	−0.00086014	−2.33	0.0207	0.00036898
RATE30YR	−0.05974303	−4.34	0.0001	0.01377771
V3M52WK	−0.07604160	−5.19	0.0001	0.01466120

Table IV–15
OLS Regression: Option-Based Model (OBRW)
February Dividend Cycle ARPS Only
Volatility is based on 26 Week Historical Data

Dependent Variable: Implied risk premium based on random walk theory of interest rate movements (RPOBRW);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 30-year constant maturity yield, (iii) Volatility of 3-month Treasury discount rate.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
39.01	0.0001	0.762986
ROOT MSE/MEAN	ROOT MSE	RPOBRW MEAN
1.017605	0.00179623	0.00176516

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.01003653	6.82	0.0001	0.00147187
AA3	−0.00354884	−1.93	0.0545	0.00183489
A1	−0.00028570	−0.31	0.7543	0.00091172
A2	−0.00198564	−4.31	0.0001	0.00046066
A3	−0.00166308	−3.38	0.0009	0.00049192
BAA1	−0.00096847	−1.93	0.0550	0.00050181
BAA3	−0.00325428	−5.95	0.0001	0.00054706
BA1	0.00254752	2.61	0.0097	0.00097580
BA2	0.00131220	1.66	0.0993	0.00079242
BA3	0.00227222	3.16	0.0018	0.00071870
TAXREG82	0.00010891	0.22	0.8253	0.00049267
TAXREG88	0.00220336	3.88	0.0001	0.00056781
CALLNONE	−0.00069778	−1.48	0.1407	0.00047183
CALLPAR	0.00116085	0.62	0.5374	0.00187907
HITFL	0.00026501	0.65	0.5162	0.00040748
BANKING	−0.00079938	−2.07	0.0398	0.00038628
RATE30YR	−0.07468729	−5.16	0.0001	0.01447607
V3M26WK	−0.05714923	−4.24	0.0001	0.01348284

Table IV–16
OLS Regression: Option-Based Model (OBEH)
February Dividend Cycle ARPS Only
Volatility is based on 52 Week Historical Data

Dependent Variable: Implied risk premium based on expectations hypothesis of interest rate movements (RPOBEH);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 30-year constant maturity yield, (iii) Volatility of 3-month Treasury discount rate.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
25.39	0.0001	0.676968
ROOT MSE/MEAN	ROOT MSE	RPOBEH MEAN
1.231993	0.00167127	0.00135656

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00564436	4.30	0.0001	0.00131192
AA3	−0.00245979	−1.42	0.1576	0.00173434
A1	−0.00090016	−1.06	0.2899	0.00084831
A2	−0.00244430	−5.70	0.0001	0.00042881
A3	−0.00236616	−5.24	0.0001	0.00045161
BAA1	−0.00125905	−2.69	0.0078	0.00046862
BAA3	−0.00227027	−4.50	0.0001	0.00050410
BA1	0.00087611	0.95	0.3422	0.00092026
BA2	0.00049755	0.67	0.5048	0.00074476
BA3	0.00196963	2.92	0.0039	0.00067525
TAXREG82	0.00051778	1.13	0.2602	0.00045863
TAXREG88	0.00194078	3.67	0.0003	0.00052835
CALLNONE	−0.00047874	−1.05	0.2935	0.00045455
CALLPAR	0.00222795	1.27	0.2044	0.00175004
HITFL	−0.00000111	−0.00	0.9977	0.00037749
BANKING	−0.00032159	−0.89	0.3719	0.00035941
RATE30YR	−0.03166865	−2.36	0.0192	0.01342037
V3M52WK	−0.05192242	−3.64	0.0004	0.01428095

Table IV–17
OLS Regression: Option-Based Model (OBEH)
February Dividend Cycle ARPS Only
Volatility is based on 26 Week Historical Data

Dependent Variable: Implied risk premium based on expectations hypothesis of interest rate movements (RPOBEH);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 30-year constant maturity yield, (iii) Volatility of 3-month Treasury discount rate.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
24.99	0.0001	0.673403
ROOT MSE/MEAN	ROOT MSE	RPOBEH MEAN
1.288956	0.00168711	0.00130890

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00700924	5.07	0.0001	0.00138245
AA3	−0.00406596	−2.36	0.0192	0.00172342
A1	−0.00090281	−1.05	0.2930	0.00085633
A2	−0.00246143	−5.69	0.0001	0.00043267
A3	−0.00194671	−4.21	0.0001	0.00046204
BAA1	−0.00119229	−2.53	0.0122	0.00047132
BAA3	−0.00197702	−3.85	0.0002	0.00051383
BA1	0.00158664	1.73	0.0849	0.00091652
BA2	0.00105835	1.42	0.1565	0.00074428
BA3	0.00223337	3.31	0.0011	0.00067504
TAXREG82	0.00113426	2.45	0.0151	0.00046274
TAXREG88	0.00172821	3.24	0.0014	0.00053332
CALLNONE	−0.00087967	−1.98	0.0485	0.00044317
CALLPAR	0.00192968	1.09	0.2755	0.00176491
HITFL	−0.00028531	−0.75	0.4568	0.00038272
BANKING	−0.00031382	−0.86	0.3881	0.00036281
RATE30YR	−0.04997998	−3.68	0.0003	0.01359662
V3M26WK	−0.03715988	−2.93	0.0037	0.01266374

Table IV–18
OLS Regression: Option-Based Model (OBRW) Full Sample
Volatility is based on 52 Week Historical Data

Dependent Variable: Implied risk premium based on random walk theory of interest rate movements (RPOBRW);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 3-month Treasury discount rate, (iii) Volatility of 3-month Treasury discount rate.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
112.13	0.0	0.625207
ROOT MSE/MEAN	ROOT MSE	RPOBRW MEAN
1.152336	0.00275745	0.00239292

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00046755	0.92	0.3603	0.00051098
AAA	−0.00655484	−12.56	0.0001	0.00052198
AA1	−0.00470969	−10.24	0.0001	0.00045972
AA2	−0.00351226	−8.41	0.0001	0.00041771
AA3	−0.00540557	−14.15	0.0001	0.00038204
A1	−0.00376588	−10.56	0.0001	0.00035652
A2	−0.00397467	−14.63	0.0001	0.00027164
A3	−0.00295987	−9.43	0.0001	0.00031391
BAA1	−0.00059964	−2.29	0.0224	0.00026225
BAA3	0.00018484	0.53	0.5984	0.00035083
BA1	0.00261927	6.98	0.0001	0.00037536
BA2	0.00285594	9.44	0.0001	0.00030256
BA3	0.00374667	7.80	0.0001	0.00048051
B1	0.00326907	4.20	0.0001	0.00077888
B3	0.00332213	2.86	0.0043	0.00116283
TAXREG82	−0.00192363	−7.47	0.0001	0.00025767
TAXREG88	0.00164023	5.37	0.0001	0.00030571
CALLNONE	−0.00021725	−0.82	0.4104	0.00026386
CALLPAR	−0.00094609	−1.97	0.0487	0.00047963
HITFL	0.00100144	5.23	0.0001	0.00019162
BANKING	0.00228973	12.27	0.0001	0.00018667
INDUSTRIAL	0.00022589	0.54	0.5864	0.00041509
RATE3MON	0.04141549	7.85	0.0001	0.00527635
V3M52WK	−0.04912051	−5.99	0.0001	0.00820702

Table IV–19
OLS Regression: Option-Based Model (OBEH) Full Sample
Volatility is based on 52 Week Historical Data

Dependent Variable: Implied risk premium based on expectations hypothesis of interest rate movements (RPOBEH);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 3-month Treasury discount rate, (iii) Volatility of 3-month Treasury discount rate.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
97.65	0.0	0.592290
ROOT MSE/MEAN	ROOT MSE	RPOBEH MEAN
1.269945	0.00264537	0.00208305

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00117476	2.40	0.0167	0.00049021
AAA	−0.00679049	−13.56	0.0001	0.00050076
AA1	−0.00479982	−10.88	0.0001	0.00044104
AA2	−0.00342553	−8.55	0.0001	0.00040073
AA3	−0.00533342	−14.55	0.0001	0.00036652
A1	−0.00387778	−11.34	0.0001	0.00034203
A2	−0.00383590	−14.72	0.0001	0.00026059
A3	−0.00269160	−8.94	0.0001	0.00030115
BAA1	−0.00034515	−1.37	0.1703	0.00025159
BAA3	0.00060109	1.79	0.0743	0.00033657
BA1	0.00290116	8.06	0.0001	0.00036010
BA2	0.00353181	12.17	0.0001	0.00029026
BA3	0.00399237	8.66	0.0001	0.00046098
B1	0.00358337	4.80	0.0001	0.00074722
B3	0.00255282	2.29	0.0223	0.00111557
TAXREG82	−0.00056706	−2.29	0.0219	0.00024719
TAXREG88	0.00132387	4.51	0.0001	0.00029328
CALLNONE	−0.00022547	−0.89	0.3732	0.00025313
CALLPAR	−0.00041515	−0.90	0.3671	0.00046013
HITFL	−0.00021046	−1.14	0.2525	0.00018383
BANKING	0.00224290	12.52	0.0001	0.00017909
INDUSTRIAL	0.00028300	0.71	0.4774	0.00039821
RATE3MON	0.01824492	3.60	0.0003	0.00506188
V3M52WK	−0.03246786	−4.12	0.0001	0.00787343

Table IV–20

OLS Regression: Option-Based Model (OBRW) Full Sample
Volatility is based on 52 Week Historical Data

Dependent Variable: Implied risk premium based on random walk theory of interest rate movements (RPOBRW);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 30-year constant maturity yield, (iii) Volatility of 30-year constant maturity yield.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
105.06	0.0	0.609833
ROOT MSE/MEAN	ROOT MSE	RPOBRW MEAN
1.175734	0.00281344	0.00239292

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00293753	3.42	0.0006	0.00085813
AAA	−0.00630330	−11.82	0.0001	0.00053308
AA1	−0.00418429	−8.92	0.0001	0.00046894
AA2	−0.00348721	−8.19	0.0001	0.00042602
AA3	−0.00475896	−12.14	0.0001	0.00039186
A1	−0.00372985	−10.25	0.0001	0.00036373
A2	−0.00370049	−13.31	0.0001	0.00027800
A3	−0.00250701	−7.79	0.0001	0.00032164
BAA1	−0.00072810	−2.75	0.0061	0.00026524
BAA3	0.00004401	0.12	0.9019	0.00035683
BA1	0.00278448	7.28	0.0001	0.00038241
BA2	0.00276643	9.05	0.0001	0.00030556
BA3	0.00402405	8.22	0.0001	0.00048961
B1	0.00306094	3.86	0.0001	0.00079387
B3	0.00214038	1.80	0.0714	0.00118617
TAXREG82	−0.00032953	−1.20	0.2307	0.00027481
TAXREG88	0.00218270	7.02	0.0001	0.00031105
CALLNONE	−0.00054363	−2.02	0.0432	0.00026867
CALLPAR	−0.00104346	−2.13	0.0331	0.00048937
HITFL	0.00007783	0.39	0.6993	0.00020146
BANKING	0.00236170	12.40	0.0001	0.00019051
INDUSTRIAL	0.00024206	0.57	0.5675	0.00042334
RATE30YR	−0.03500784	−5.29	0.0001	0.00661535
V30Y52WK	0.13466466	4.62	0.0001	0.02916205

Table IV–21
OLS Regression: Option-Based Model (OBEH) Full Sample
Volatility is based on 52 Week Historical Data

Dependent Variable: Implied risk premium based on expectations hypothesis of interest rate movements (RPOBEH);

Explanatory Variables: (i) Five categories of qualitative variables, (ii) 30-year constant maturity yield, (iii) Volatility of 30-year constant maturity yield.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
96.35	0.0	0.589055
ROOT MSE/MEAN	ROOT MSE	RPOBEH MEAN
1.274973	0.00265584	0.00208305

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00061482	0.76	0.4480	0.00081006
AAA	−0.00677603	−13.47	0.0001	0.00050322
AA1	−0.00464869	−10.50	0.0001	0.00044267
AA2	−0.00348130	−8.66	0.0001	0.00040216
AA3	−0.00509158	−13.76	0.0001	0.00036991
A1	−0.00383756	−11.18	0.0001	0.00034336
A2	−0.00372726	−14.20	0.0001	0.00026243
A3	−0.00253683	−8.36	0.0001	0.00030362
BAA1	−0.00032130	−1.28	0.1996	0.00025038
BAA3	0.00070403	2.09	0.0368	0.00033684
BA1	0.00307754	8.53	0.0001	0.00036099
BA2	0.00360461	12.50	0.0001	0.00028845
BA3	0.00422785	9.15	0.0001	0.00046218
B1	0.00364516	4.86	0.0001	0.00074940
B3	0.00140252	1.25	0.2106	0.00111973
TAXREG82	0.00023969	0.92	0.3557	0.00025942
TAXREG88	0.00163698	5.58	0.0001	0.00029363
CALLNONE	−0.00057532	−2.27	0.0234	0.00025362
CALLPAR	−0.00037131	−0.80	0.4217	0.00046196
HITFL	−0.00054738	−2.88	0.0041	0.00019018
BANKING	0.00228097	12.68	0.0001	0.00017984
INDUSTRIAL	0.00024393	0.61	0.5417	0.00039963
RATE30YR	−0.01000878	−1.60	0.1092	0.00624479
V30Y52WK	0.12441427	4.52	0.0001	0.02752852

Table IV–22
OLS Regression: Option-Based Model (OBRW) Full Sample
Volatility is based on 52 Week Historical Data

Dependent Variable: Implied risk premium based on random walk theory of interest rate movements (RPOBRW);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 3-month Treasury discount rate, (iii) Volatility of 30-year constant maturity yield.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
114.23	0.0	0.629556
ROOT MSE/MEAN	ROOT MSE	RPOBRW MEAN
1.145632	0.00274140	0.00239292

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	−0.00435095	−6.64	0.0001	0.00065552
AAA	−0.00685767	−13.23	0.0001	0.00051817
AA1	−0.00497549	−10.90	0.0001	0.00045656
AA2	−0.00374056	−9.02	0.0001	0.00041479
AA3	−0.00549858	−14.49	0.0001	0.00037938
A1	−0.00368295	−10.39	0.0001	0.00035439
A2	−0.00398421	−14.76	0.0001	0.00026999
A3	−0.00307467	−9.87	0.0001	0.00031154
BAA1	−0.00026796	−1.03	0.3028	0.00025994
BAA3	0.00083084	2.37	0.0181	0.00035128
BA1	0.00302396	8.11	0.0001	0.00037291
BA2	0.00328259	11.02	0.0001	0.00029778
BA3	0.00414471	8.69	0.0001	0.00047682
B1	0.00397225	5.11	0.0001	0.00077804
B3	0.00116555	1.01	0.3116	0.00115148
TAXREG82	−0.00146009	−5.58	0.0001	0.00026180
TAXREG88	0.00176115	5.77	0.0001	0.00030525
CALLNONE	−0.00096532	−3.69	0.0002	0.00026136
CALLPAR	−0.00055788	−1.16	0.2443	0.00047892
HITFL	0.00118329	6.32	0.0001	0.00018717
BANKING	0.00231654	12.48	0.0001	0.00018562
INDUSTRIAL	0.00005822	0.14	0.8878	0.00041246
RATE3MON	0.05429367	10.57	0.0001	0.00513471
V30Y52WK	0.20698601	7.38	0.0001	0.02806576

Table IV–23
OLS Regression: Option-Based Model (OBEH) Full Sample
Volatility is based on 52 Week Historical Data

Dependent Variable: Implied risk premium based on expectations hypothesis of interest rate movements (RPOBEH);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 3-month Treasury discount rate, (iii) Volatility of 30-year constant maturity yield.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
99.29	0.0	0.596308
ROOT MSE/MEAN	ROOT MSE	RPOBEH MEAN
1.263672	0.00263230	0.00208305

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	−0.00229479	−3.65	0.0003	0.00062943
AAA	−0.00699968	−14.07	0.0001	0.00049755
AA1	−0.00498456	−11.37	0.0001	0.00043839
AA2	−0.00358362	−9.00	0.0001	0.00039828
AA3	−0.00539335	−14.81	0.0001	0.00036428
A1	−0.00382010	−11.23	0.0001	0.00034028
A2	−0.00383922	−14.81	0.0001	0.00025925
A3	−0.00276783	−9.25	0.0001	0.00029914
BAA1	−0.00011314	−0.45	0.6504	0.00024960
BAA3	0.00106224	3.15	0.0017	0.00033730
BA1	0.00318603	8.90	0.0001	0.00035807
BA2	0.00382570	13.38	0.0001	0.00028593
BA3	0.00426959	9.33	0.0001	0.00045784
B1	0.00409560	5.48	0.0001	0.00074707
B3	0.00103886	0.94	0.3476	0.00110565
TAXREG82	−0.00022747	−0.90	0.3657	0.00025138
TAXREG88	0.00143298	4.89	0.0001	0.00029310
CALLNONE	−0.00075247	−3.00	0.0028	0.00025096
CALLPAR	−0.00013105	−0.28	0.7757	0.00045986
HITFL	−0.00009302	−0.52	0.6048	0.00017972
BANKING	0.00226257	12.69	0.0001	0.00017823
INDUSTRIAL	0.00016642	0.42	0.6744	0.00039605
RATE3MON	0.02718048	5.51	0.0001	0.00493035
V30Y52WK	0.15378049	5.71	0.0001	0.02694875

Table IV–24
OLS Regression: Option-Based Model (OBRW) Full Sample
Volatility is based on 52 Week Historical Data

Dependent Variable: Implied risk premium based on random walk theory of interest rate movements (RPOBRW);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 30-year constant maturity yield, (iii) Volatility of 3-month Treasury discount rate.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
109.72	0.0	0.620106
ROOT MSE/MEAN	ROOT MSE	RPOBRW MEAN
1.160152	0.00277615	0.00239292

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00660927	10.09	0.0001	0.00065472
AAA	−0.00601483	−11.43	0.0001	0.00052616
AA1	−0.00399133	−8.63	0.0001	0.00046250
AA2	−0.00326193	−7.76	0.0001	0.00042059
AA3	−0.00468160	−12.11	0.0001	0.00038671
A1	−0.00381552	−10.63	0.0001	0.00035894
A2	−0.00367946	−13.41	0.0001	0.00027433
A3	−0.00240176	−7.57	0.0001	0.00031747
BAA1	−0.00098942	−3.78	0.0002	0.00026174
BAA3	−0.00040710	−1.17	0.2431	0.00034864
BA1	0.00242859	6.44	0.0001	0.00037731
BA2	0.00236020	7.79	0.0001	0.00030311
BA3	0.00360870	7.46	0.0001	0.00048379
B1	0.00272420	3.49	0.0005	0.00078039
B3	0.00426296	3.64	0.0003	0.00117137
TAXREG82	−0.00077542	−2.88	0.0040	0.00026883
TAXREG88	0.00215645	7.10	0.0001	0.00030371
CALLNONE	0.00014049	0.53	0.5951	0.00026430
CALLPAR	−0.00122307	−2.54	0.0111	0.00048123
HITFL	−0.00009080	−0.45	0.6492	0.00019957
BANKING	0.00233839	12.44	0.0001	0.00018797
INDUSTRIAL	0.00039794	0.95	0.3410	0.00041781
RATE30YR	−0.04041407	−6.33	0.0001	0.00638812
V3M52WK	−0.06396246	−7.98	0.0001	0.00801362

Table IV–25
OLS Regression: Option-Based Model (OBEH) Full Sample
Volatility is based on 52 Week Historical Data

Dependent Variable: Implied risk premium based on expectations hypothesis of interest rate movements (RPOBEH);
Explanatory Variables: (i) Five categories of qualitative variables, (ii) 30-year constant maturity yield, (iii) Volatility of 3-month Treasury discount rate.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
96.94	0.0	0.590526
ROOT MSE/MEAN	ROOT MSE	RPOBEH MEAN
1.272689	0.00265108	0.00208305

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00366877	5.87	0.0001	0.00062522
AAA	−0.00656957	−13.07	0.0001	0.00050246
AA1	−0.00450275	−10.19	0.0001	0.00044167
AA2	−0.00332248	−8.27	0.0001	0.00040164
AA3	−0.00503805	−13.64	0.0001	0.00036929
A1	−0.00389806	−11.37	0.0001	0.00034277
A2	−0.00371647	−14.19	0.0001	0.00026197
A3	−0.00246377	−8.13	0.0001	0.00030317
BAA1	−0.00051094	−2.04	0.0411	0.00024995
BAA3	0.00034808	1.05	0.2960	0.00033293
BA1	0.00281859	7.82	0.0001	0.00036031
BA2	0.00332439	11.48	0.0001	0.00028946
BA3	0.00393568	8.52	0.0001	0.00046200
B1	0.00333968	4.48	0.0001	0.00074523
B3	0.00293856	2.63	0.0087	0.00111859
TAXREG82	−0.00009982	−0.39	0.6974	0.00025672
TAXREG88	0.00154469	5.33	0.0001	0.00029003
CALLNONE	−0.00007469	−0.30	0.7673	0.00025239
CALLPAR	−0.00053949	−1.17	0.2406	0.00045955
HITFL	−0.00065750	−3.45	0.0006	0.00019058
BANKING	0.00226262	12.60	0.0001	0.00017950
INDUSTRIAL	0.00035469	0.89	0.3742	0.00039899
RATE30YR	−0.01528505	−2.51	0.0123	0.00610032
V3M52WK	−0.03906194	−5.10	0.0001	0.00765260

Exhibit IV–1
Cubic Splines

From Poirier [15], let $\bar{x}_0 < \bar{x}_1 < \ldots < \bar{x}_k$ be $k+1$ points to be known as knots of the x-axis and $y_0, y_1, \ldots, y_k$ be the associated ordinates of the y-axis. Then a cubic spline interpolated from the $k+1$ knots, denoted $\hat{y}(x)$, is a function satisfying three conditions: a) $\hat{y}(x)$ and its first two derivatives are continuous over $[\bar{x}_0, \bar{x}_k]$, b) $\hat{y}(x)$ is at most a third degree polynomial, c) $\hat{y}(\bar{x}_j) = y_j \quad (j = 0, 1, \ldots, k)$.

Denote $h_j = \bar{x}_j - \bar{x}_{j-1}$ as the interval length, $M_j, \quad (j = 0, 1, \ldots, k)$ as the values of the second derivative at the knots, and define $\lambda_j = \frac{h_{j+1}}{h_j + h_{j+1}}, \quad (j = 1, 2, \ldots, k)$. Then the interpolated $\hat{y}(x), \quad \bar{x}_{j-1} \leq x \leq \bar{x}_j \quad (j = 1, 2, \ldots, k)$ can be written as

$$\hat{y}(x) = a_j + b_j(x - \bar{x}_{j-1}) + c_j(x - \bar{x}_{j-1})^2 + d_j(x - \bar{x}_{j-1})^3,$$

where

$$\begin{aligned} a_j &= y_{j-1}, \\ b_j &= \frac{y_j - y_{j-1}}{h_j} - \frac{h_j(M_j + 2M_{j-1})}{6}, \\ c_j &= \frac{M_{j-1}}{2}, \\ d_j &= \frac{M_j - M_{j-1}}{6h_j}. \end{aligned}$$

In the above expressions, the only unknown parameters are the M_j's. To solve the M_j's we need to impose two end conditions. For simplicity, we assume the followings:

$$\begin{aligned} M_0 &= \pi_0 M_1, & |\pi_0| < 2, \\ M_k &= \pi_k M_{k-1}, & |\pi_k| < 2, \end{aligned}$$

where π_0 and π_k are to be specified. The continuity conditions, together with the end conditions, can be summarized as

$$\Lambda M = \Theta y$$

where

$$\Lambda = \begin{pmatrix} 2 & -2\pi_0 & 0 & \ldots & 0 & 0 & 0 \\ 1-\lambda_1 & 2 & \lambda_1 & \ldots & 0 & 0 & 0 \\ 0 & 1-\lambda_2 & 2 & \ldots & 0 & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & \ldots & 2 & \lambda_{k-2} & 0 \\ 0 & 0 & 0 & \ldots & 1-\lambda_{k-1} & 2 & \lambda_{k-1} \\ 0 & 0 & 0 & \ldots & 0 & -2\pi_k & 2 \end{pmatrix}$$

Exhibit IV–1 (Continued)

$$\Theta = \begin{pmatrix} 0 & 0 & 0 & \cdots & 0 & 0 & 0 \\ \frac{6}{h_1(h_1+h_2)} & \frac{-6}{h_1 h_2} & \frac{6}{h_2(h_1+h_2)} & \cdots & 0 & 0 & 0 \\ 0 & \frac{6}{h_2(h_2+h_3)} & \frac{-6}{h_2 h_3} & \cdots & 0 & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & \cdots & \frac{-6}{h_{k-2}h_{k-1}} & \frac{6}{h_{k-1}(h_{k-2}+h_{k-1})} & 0 \\ 0 & 0 & 0 & \cdots & \frac{6}{h_{k-1}(h_{k-1}+h_k)} & \frac{-6}{h_{k-1}h_k} & \frac{6}{h_k(h_{k-1}+h_k)} \\ 0 & 0 & 0 & \cdots & 0 & 0 & 0 \end{pmatrix}$$

$$M = [M_0, M_1, \ldots, M_k]', \qquad \text{and} \qquad y = [y_0, y_1, \ldots, y_k]'.$$

Then solving for M,

$$M = \Lambda^{-1}\Theta y.$$

We choose $\pi_0 = \pi_k = 0$ so $\hat{y}(x)$ is referred to as a natural cubic spline. Applying the cubic spline method to the constant maturity yield curve for the period of January 1982 to January 1987, we have

$$\bar{x}_0 = 1/4,\ \bar{x}_1 = 1/2,\ \bar{x}_2 = 1,\ \bar{x}_1 = 3,\ \bar{x}_4 = 3,$$
$$\bar{x}_5 = 5,\ \bar{x}_6 = 7,\ \bar{x}_7 = 10,\ \bar{x}_8 = 20,\ \bar{x}_9 = 30$$
$$h_1 = 1/4,\ h_2 = 1/2,\ h_3 = 1,\ h_4 = 1,\ h_5 = 2,\ h_6 = 2,\ h_7 = 3,\ h_8 = 10,\ h_9 = 10$$
$$\lambda_1 = 2/3,\ \lambda_2 = 2/3,\ \lambda_3 = 1/2,\ \lambda_4 = 2/3,\ \lambda_5 = 1/2,\ \lambda_6 = 3/5,\ \lambda_7 = 10/13,\ \lambda_8 = 1/2$$

After January 1987 the Federal Reserve Board stop publishing the 20 year Constant Maturity yield. Thus, for the period of January 1987 to December 1992, we have

$$\bar{x}_0 = 1/4,\ \bar{x}_1 = 1/2,\ \bar{x}_2 = 1,\ \bar{x}_1 = 3,\ \bar{x}_4 = 3,\ \bar{x}_5 = 5,\ \bar{x}_6 = 7,\ \bar{x}_7 = 10,\ \bar{x}_8 = 30$$
$$h_1 = 1/4,\ h_2 = 1/2,\ h_3 = 1,\ h_4 = 1,\ h_5 = 2,\ h_6 = 2,\ h_7 = 3,\ h_8 = 20$$
$$\lambda_1 = 2/3,\ \lambda_2 = 2/3,\ \lambda_3 = 1/2,\ \lambda_4 = 2/3,\ \lambda_5 = 1/2,\ \lambda_6 = 3/5,\ \lambda_7 = 20/23$$

CHAPTER FIVE
Model Comparison

I. Introduction

In the preceding two chapters we developed two models, the benchmark model and the option-based model, to value the ARPS. Within the benchmark model, two different risk free rates can be used to implement the model. They are the three-month Treasury discount rate and the thirty-year constant maturity yield. For the option-based model, two possible interest rate movements can be used to implement the model. The first technique is to assume the random walk theory of interest rate movements, and the second technique is to adopt the expectations hypothesis of interest rate movements. Therefore, each ARPS can have four different implied risk premia that are derived from the corresponding valuation techniques. These four sets of risk premia are regressed on a set of possible determinants (with minor variation for each regression). The results indicate that the option-based random walk interest rate model has the highest R-square. This finding, however, does not necessary prove that the OBRW model is the best valuation model. The reason is that the dependent variable (i.e.; the implied risk premium) is philosophically different among the four models. Furthermore, the independent variables to be included in each regression slightly vary from regression to regression.

The four dependent variables, although they are different, have similar magnitude. They have not been involved in transformation such as log or power function. Therefore, to compare the four models, four different implied risk premia are regressed on exactly the same set of explanatory variables. To do this, we eliminate the interest rate and the volatility variables from the regressions. Tables V–1 to V–4 show the results of the four regressions. The highest R-square still comes from the regression involving the OBRW model. But this R-square is only marginally higher than the R-squares that are of the OBEH model and the BM30YR model. This result does not provide a convincing proof in favoring of the OBRW model over the other two valuation models. Therefore, we need to design better tests to address the model performance issue.

The problem in implementing these four valuation models is that we lack knowledge of the risk premia. Therefore, if we can forecast the risk premia of the ARPS for the corresponding models, then we can calculate the model prices. The derived prices can be compared with the market prices to see how the models perform and which one performs best.

II. Methodology

We will test the four model prices against the market prices for the calendar year of 1992. There are a total of 151 cross-sectional and time-series observations for this period. Of these 151 observations, 87 belong to the January dividend cycle, 20 belong to the February dividend cycle, and 44 belong to the March dividend cycle. There are Moody's rating changes for some of the ARPS during 1992. To be exact, it happens 19 times.

We have three possible ways to forecast the risk premium. The **first** method is to use the prior quarter's implied risk premium as the forecasted risk premium for the current quarter. This is easy to do since we have already calculated the implied risk premia of the ARPS for each quarter from 1983 to 1992 in the two previous chapters. Putting the forecasted risk premia into the corresponding valuation models we can derive the prices. For example, Chemical Bank ARPS belongs to the January dividend cycle. Thus, we compute Chemical Bank's BM3M model price for the quarter beginning January 1992 by applying Chemical Bank's implied risk premium, RPBM3M, derived from the quarter beginning October 1991. Similarly, the BM3M model price for the quarter beginning April 1992 will make use of the implied risk premium, RPBM3M, from the quarter beginning January 1992. Similar procedures will also be applied to the other three valuation models as well.

The **second** method is to take the average of all previous quarters' implied risk premia as the forecasted risk premium for the current quarter. Again, this is not difficult to do since we already have the implied risk premia of the ARPS for each quarter from 1983 to 1992. Using Chemical Bank ARPS as example, the BM3M model price for the quarter beginning January 1992 will make use of the average of all Chemical Bank's implied risk premia, RPBM3M, from January 1983 to October 1991. Similarly, Chemical Bank's BM3M model price for the quarter beginning April 1992 will make use of the average of all Chemical Bank's implied risk premia, RPBM3M, from January 1983 to January 1992. Again, similar procedures will be applied to the other three models. Note that we add the most recent implied risk premium but do not drop the earliest one when updating the average implied risk premium. We prefer this method over the moving average technique in updating the average. The reason is that we do not want to lose information as we are updating the average.

The **third** method is to use regression to forecast the risk premium. We regress all the previous implied risk premia of the ARPS sample on the explanatory variables, similar to what we did in the two previous chapters. Then we use the estimated regression equation and the explanatory variables that belong to the ARPS for the current quarter to determine the forecasted risk premium. The regression is updated monthly to cover ARPS from all three dividend cycles. For example, from January 1983 to December 1991 there are 1,419 observations. To find Chemical Bank's BM3M model price for the quarter beginning January 1992, we first regress 1,419 implied risk premia, RPBM3M, on the set of explanatory variables that appear on Table III–6. Then we use the estimated regression equation and the explanatory variable values of Chemical Bank ARPS on January 1992 to determine the forecasted risk premium. This forecasted risk premium is then used to calculate the BM3M model price. Notice that the estimated regression equation is valid for all other January dividend cycle ARPS for the quarter of January 1992. To find Chemical Bank's BM3M model price for the quarter beginning April 1992, we regress 1,458 implied risk premia, RPBM3M, from January 1983 to March 1992, on the same set of explanatory variables mentioned before, to obtain an updated estimated regression equation. By applying this estimated regression equation to the explanatory variable values of Chemical Bank ARPS on April 1992, we obtain the forecasted risk premium. Then this forecasted risk premium is used to calculate the BM3M model price. Notice that we also do not delete data as we update the regression in this forecast method.

Tables V–5 to V–8 show the estimated regression coefficients of the four models, by month, from December 1991 to November 1992. The estimated regression coefficients exhibit a small degree of instability over time. Since we are only interested in using the estimated regression coefficients for the purpose of forecasting, we will accept a small degree of instability.

Ex-ante, we do not know for certain which forecast method will perform best. Therefore, we must try all three forecast methods on the four models. From a theoretical perspective, we expect the regression method will perform best since the method utilizes the market factors, both temporal and cross-sectional. Obviously, the regression model must be correctly specified and relatively stable over time in order for this assertion to be true. The first forecast method, in which the prior quarter's implied risk premium becomes the forecasted risk premium for the current quarter, might perform well if the risk premia are serially correlated. Otherwise, it would not be a good forecasting method. For example, if there is a rating change in between quarters, then the previous quarter's implied risk premium would not be a good predictor of the current quarter's risk premium. Finally, the second forecast method, in which the average of all previous quarters' implied risk premia is the forecasted risk premium for the current quarter, should be the worst forecast method, since the average reacts slowly to changing market conditions.

III. Statistical Tests

So far we have discussed three forecast methods for the risk premia which can be used to value the ARPS. Since we have four valuation models, we end up having a total of twelve ways to price the ARPS. The questions we would like to answer in the remaining chapter are: 1) which valuation model performs best; 2) which forecast method is superior; 3) which combination of forecast method and valuation model performs best? In order to answer these questions we turn to two tests. The first is the hypothesis test and the second is the mean square error test. The hypothesis test is a stronger test but it may not yield any conclusive result. The mean square error test is a weaker test but it provides informative results most of the time.

A. Hypothesis Test

If we have a perfect valuation model, then the model price will always equal the market price. A regression of the market price on the model price under such a case will yield an intercept of zero, a slope of one, and a R-square of one. Therefore, if we regress the market price on the model price (a total of twelve different model prices), then we should expect that a good model will have a regression intercept not statistically different from zero, a regression slope not statistically different from one, and a high R-square for goodness of fit. Table V–9 provides a summary of the twelve regressions. Formally, the regression model is:

$$MKT = \alpha + \beta\ MDL + \tilde{\varepsilon} \tag{5.1}$$

$$H_0 : \alpha = 0, \quad \text{and} \quad \beta = 1$$

where MKT is the market price and MDL is the model price. Both the market and the model prices are normalized to per dollar of stated value of the ARPS in order to eliminate heteroscedasticity. Since the null hypothesis is a joint test, the appropriate test is the F-statistic.[16]

$$F(q, n-k) = \frac{n\{\hat{\alpha}^2 + 2\hat{\alpha}(\hat{\beta}-1)\overline{MDL} + (\hat{\beta}-1)^2\overline{MDL^2}\}/q}{e'e/(n-k)} \tag{5.2}$$

where $q = 2, k = 2, n = 151$, and $e'e = RSS$, the residual sum of squares. If the F value is low, then we can not reject the null hypothesis. This means that the valuation model is good. Notice that a high R-square will cause a high F value since $RSS = (1 - R^2)\ TSS$ where TSS is the total sum of squares. Thus, a high (low) R-square will make it more (less) likely to reject the null hypothesis.

Tables V–10 to V–21 show the results of the twelve regressions. If we test $\alpha = 0$ and $\beta = 1$ as two independent tests, then three of the twelve models have regression

---

[16] Johnston, *Econometric Methods,* 3rd edition, eq. 5–68.

intercepts that are not statistically different from zero and regression slopes that are not statistically different from one. The statistical test is a two tail t-test at the 1% level of significance. All these three models use forecast method two, the average of past implied risk premia, to determine the appropriate risk premium for the model. The three models are the BM30Y model, the OBRW model, and the OBEH model. Their correlations are not high, however. The R-squares are 0.3315, 0.4192, and 0.5371, respectively.

If F-statistic is used to test the null hypothesis (i.e.; the joint test), then the OBEH model using forecast method two is the only model that is not statistical significant at the 1% level. The F-statistic is 2.64, which is less than the critical value of F(2,149) = 4.75. That is, we may not reject the null hypothesis that $\alpha = 0$ and $\beta = 1$ jointly. As mentioned previously, the R-square of the OBEH model is not very high, only at 0.5371. This indicates a poor fit of the regression (i.e.; the model price is different from the market price). Therefore, even though we may not reject the null hypothesis for the OBEH model based on the F-test, we have no confidence to "accept" the null hypothesis based on the low R-square.

Intuitively, we do not expect a model that uses the average of past implied risk premia (forecast method two) to be a good model because the average does not reflect current pricing factors well most of the time. In fact, we would expect a model that uses the latest quarter's implied risk premium (forecast method one) to be a better model. As the results indicate, the R-squares of regressions involving forecast method one are much higher, ranging from 0.7507 to 0.8419. Overall, we are not confident that we can draw any definite conclusion from the hypothesis test.

B. Mean Square Error Test

A less restrictive test is to analyze the mean square error (MSE) between the model price and the market price, and examine its components. The MSE is defined as:

$$MSE = \frac{1}{n}\sum_{j=1}^{n}(MKT_j - MDL_j)^2 \qquad (5.3A)$$

$$MSE = \left(\overline{MKT} - \overline{MDL}\right)^2 + (1-\beta)^2\ \sigma^2_{MDL} + \left(1 - R^2\right)\ \sigma^2_{MKT} \qquad (5.3B)$$

where β is the slope coefficient of the regression of MKT on MDL, σ_{MDL} and σ_{MKT} are the sample standard deviation of the MDL and MKT, respectively, and R^2 is the R-square of the regression of MKT on MDL.

The MSE is made up of three components. The first one is the bias component due to over- or underestimation of the mean of MKT over the mean of MDL. The second component is the inefficiency component due to positive (or negative) error for low values of MDL and negative (or positive) error for high values of MDL. The third component is due to the random error of the MKT. Notice that a perfect correlation between MKT and MDL, that is, $R^2 = 1$, will reduce the random error to zero but will not necessary yield a zero MSE. The first two components together can be viewed as the systematic error of the model. The MSE will be zero only if the systematic error is also zero. That is, the MDL are identical to the MKT.

Table V–22 presents the MSE and its three components for twelve sets of the test. In general, the option-based models have lower MSE than the benchmark models do. The only exception is the OBRW model using forecast risk premium based on the regression method in which the bias component is very large at 0.03582421. Thus, we can conclude that in general the option-based model is better than the benchmark model.

In term of forecasting the risk premium, method one performs best. That is, the prior quarter's implied risk premium is the most appropriate risk premium for the current quarter. The MSEs related to this forecast method are lower than the MSEs related to the other two forecast methods, across all four models. This indicates that the risk premia of each ARPS are serially correlated over time. This phenomenon can be explained by the fact that there are only 19 Moody's rating changes and no major shocks to the interest rate system during the year of 1992.

Forecast method two produces the highest random variation across all four models. This result is directly related to the low R-square of the regression of MKT on MDL. This is why we did not "accept" the OBEH model using forecast method two as a good model in the hypothesis test.

Overall, the option-based model using forecast method one performs best.

Within the option-based model, the OBRW model performs marginally better than the OBEH model. The MSE of the OBEH model is 0.00291834, 6.68% higher than the MSE of the OBRW model, which is 0.00273563.

If we could correct the systematic error, that is, the tilt and the shift of the regression line, then the random error would be the measure of model performance. From Table V–22, we observe that if forecast method one is used, the OBRW model has the lowest random error, i.e., 0.00184785, among the four models. If forecast method three is used, then the OBEH model will have the lowest random error, 0.00345592, among the four models. Notice that the random error of the BM30Y model in each of the corresponding forecast method is only marginally higher.

In summary, we conclude that the option-based model performs better than the benchmark model. The performance of the benchmark 30-year model is not bad either, considering its easiness of implementation, and low demand on computational resources. The choice is up to the user's preference.

IV. Conclusions

In this chapter, we employed three different methods to forecast the risk premia and used these forecasted risk premia to calculate the four model prices. Then the model prices were compared with the market price in order to determine model performance. Based on the hypothesis test, which is a stronger test, we were not able to draw any definite conclusion. When switched to the mean square error test, we found that the option-based model performed better than the benchmark model. We also found that forecast method one, in which the prior quarter's implied risk premium is the forecasted risk premium for the current quarter, was the best forecast method. In the absence of a powerful computer, the benchmark model with 30-year yield as a base can be used with confidence.

Table V–1
OLS Regression: Benchmark Model (BM3M) Full Sample
Volatility is based on 52 Week Historical Data

Dependent Variable: Implied risk premium based on 3-month Treasury discount rate (RPBM3M);
Explanatory Variables: Five categories of qualitative variables.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
66.52	0.0	0.474356
ROOT MSE/MEAN	ROOT MSE	RPBM3M MEAN
0.524902	0.00320268	0.00610147

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00588997	14.76	0.0001	0.00039898
AAA	−0.00649810	−10.75	0.0001	0.00060429
AA1	−0.00504387	−9.51	0.0001	0.00053030
AA2	−0.00338738	−7.00	0.0001	0.00048419
AA3	−0.00516964	−11.73	0.0001	0.00044067
A1	−0.00410190	−9.91	0.0001	0.00041398
A2	−0.00342136	−10.86	0.0001	0.00031492
A3	−0.00219396	−6.06	0.0001	0.00036222
BAA1	0.00058039	1.93	0.0536	0.00030048
BAA3	0.00206597	5.16	0.0001	0.00040056
BA1	0.00356477	8.21	0.0001	0.00043406
BA2	0.00393745	11.40	0.0001	0.00034536
BA3	0.00361078	6.49	0.0001	0.00055638
B1	0.00652710	7.25	0.0001	0.00090022
B3	0.00259139	1.94	0.0523	0.00133416
TAXREG82	0.00003276	0.11	0.9092	0.00028713
TAXREG88	0.00033284	0.96	0.3395	0.00034839
CALLNONE	−0.00050338	−1.69	0.0915	0.00029807
CALLPAR	0.00148798	2.68	0.0074	0.00055513
HITFL	−0.00065907	−3.20	0.0014	0.00020619
BANKING	0.00219484	10.12	0.0001	0.00021679
INDUSTRIAL	0.00019323	0.40	0.6883	0.00048160

Table V–2
OLS Regression: Benchmark Model (BM30Y) Full Sample
Volatility is based on 52 Week Historical Data

Dependent Variable: Implied risk premium based on 30-year constant maturity yield (RPBM30Y);
Explanatory Variables: Five categories of qualitative variables.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
102.73	0.0	0.582231
ROOT MSE/MEAN	ROOT MSE	RPBM30Y MEAN
2.825025	0.00272427	0.00096433

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00026394	0.78	0.4369	0.00033938
AAA	−0.00677181	−13.17	0.0001	0.00051402
AA1	−0.00452960	−10.04	0.0001	0.00045109
AA2	−0.00349791	−8.49	0.0001	0.00041186
AA3	−0.00536241	−14.31	0.0001	0.00037484
A1	−0.00400755	−11.38	0.0001	0.00035214
A2	−0.00371146	−13.85	0.0001	0.00026788
A3	−0.00237885	−7.72	0.0001	0.00030811
BAA1	−0.00042939	−1.68	0.0932	0.00025560
BAA3	0.00020572	0.60	0.5461	0.00034072
BA1	0.00301614	8.17	0.0001	0.00036922
BA2	0.00348581	11.87	0.0001	0.00029377
BA3	0.00403065	8.52	0.0001	0.00047327
B1	0.00241954	3.16	0.0016	0.00076575
B3	0.00057911	0.51	0.6099	0.00113486
TAXREG82	0.00001354	0.06	0.9558	0.00024424
TAXREG88	0.00193255	6.52	0.0001	0.00029635
CALLNONE	−0.00029360	−1.16	0.2471	0.00025355
CALLPAR	−0.00071636	−1.52	0.1295	0.00047220
HITFL	−0.00052831	−3.01	0.0026	0.00017539
BANKING	0.00217687	11.80	0.0001	0.00018441
INDUSTRIAL	0.00028573	0.70	0.4856	0.00040966

Table V–3
OLS Regression: Option-Based Model (OBRW) Full Sample
Volatility is based on 52 Week Historical Data

Dependent Variable: Implied risk premium based on random walk theory of interest rate movements (RPOBRW);
Explanatory Variables: Five categories of qualitative variables.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
107.92	0.0	0.594171
ROOT MSE/MEAN	ROOT MSE	RPOBRW MEAN
1.198325	0.00286749	0.00239292

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00204148	5.71	0.0001	0.00035723
AAA	−0.00648762	−11.99	0.0001	0.00054105
AA1	−0.00441410	−9.30	0.0001	0.00047480
AA2	−0.00354035	−8.17	0.0001	0.00043352
AA3	−0.00512622	−12.99	0.0001	0.00039455
A1	−0.00372908	−10.06	0.0001	0.00037065
A2	−0.00388156	−13.77	0.0001	0.00028196
A3	−0.00277607	−8.56	0.0001	0.00032431
BAA1	−0.00072460	−2.69	0.0072	0.00026903
BAA3	−0.00008291	−0.23	0.8172	0.00035863
BA1	0.00267835	6.89	0.0001	0.00038863
BA2	0.00284808	9.21	0.0001	0.00030921
BA3	0.00397236	7.97	0.0001	0.00049815
B1	0.00268242	3.33	0.0009	0.00080601
B3	0.00241530	2.02	0.0434	0.00119453
TAXREG82	−0.00117396	−4.57	0.0001	0.00025708
TAXREG88	0.00182781	5.86	0.0001	0.00031193
CALLNONE	−0.00039694	−1.49	0.1371	0.00026688
CALLPAR	−0.00126840	−2.55	0.0108	0.00049703
HITFL	0.00061706	3.34	0.0009	0.00018461
BANKING	0.00232055	11.96	0.0001	0.00019410
INDUSTRIAL	0.00022283	0.52	0.6054	0.00043120

Table V–4
OLS Regression: Option-Based Model (OBEH) Full Sample
Volatility is based on 52 Week Historical Data

Dependent Variable: Implied risk premium based on expectations hypothesis of interest rate movements (RPOBEH);
Explanatory Variables: Five categories of qualitative variables.

BASE VARIABLES: BAA2, TAXREG87, CALLPREM, ABOVEFL, UTILITY.

F VALUE	PR > F	R-SQUARE
102.57	0.0	0.581841
ROOT MSE/MEAN	ROOT MSE	RPOBEH MEAN
1.285285	0.00267732	0.00208305

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.00167240	5.01	0.0001	0.00033353
AAA	−0.00679438	−13.45	0.0001	0.00050516
AA1	−0.00468826	−10.58	0.0001	0.00044331
AA2	−0.00346501	−8.56	0.0001	0.00040477
AA3	−0.00522148	−14.17	0.0001	0.00036838
A1	−0.00385139	−11.13	0.0001	0.00034607
A2	−0.00380020	−14.44	0.0001	0.00026326
A3	−0.00262480	−8.67	0.0001	0.00030280
BAA1	−0.00037183	−1.48	0.1390	0.00025119
BAA3	0.00051649	1.54	0.1232	0.00033485
BA1	0.00296505	8.17	0.0001	0.00036286
BA2	0.00358042	12.40	0.0001	0.00028871
BA3	0.00414156	8.90	0.0001	0.00046511
B1	0.00332776	4.42	0.0001	0.00075255
B3	0.00192179	1.72	0.0851	0.00111531
TAXREG82	−0.00019997	−0.83	0.4049	0.00024003
TAXREG88	0.00136932	4.70	0.0001	0.00029124
CALLNONE	−0.00037610	−1.51	0.1314	0.00024918
CALLPAR	−0.00055850	−1.20	0.2290	0.00046407
HITFL	−0.00035302	−2.05	0.0407	0.00017237
BANKING	0.00225809	12.46	0.0001	0.00018123
INDUSTRIAL	0.00026342	0.65	0.5130	0.00040260

Table V–5
Regression Coefficients to Forecast the Risk Premium of the Benchmark 3-Month Model (BM3M)

REGRESSION	yy mm	yy mm	yy mm	yy mm
UPTO MONTH:	91 12	92 01	92 02	92 03
NUMBER OF OBSERVATIONS:	1419	1442	1447	1458
F VALUE:	52.75	54.64	54.29	55.19
R-SQUARE:	0.465156	0.469855	0.467377	0.469558
INTERCEPT	0.00185603	0.00228186	0.00232514	0.00228558
AAA	−0.00687952	−0.00672744	−0.00674557	−0.00683153
AA1	−0.00554831	−0.00535651	−0.00536308	−0.00544649
AA2	−0.00374315	−0.00361278	−0.00361117	−0.00366523
AA3	−0.00567229	−0.00551911	−0.00552733	−0.00560052
A1	−0.00408886	−0.00400048	−0.00402491	−0.00411342
A2	−0.00375472	−0.00361712	−0.00364293	−0.00366942
A3	−0.00257500	−0.00248965	−0.00248247	−0.00255253
BAA1	0.00047677	0.00065735	0.00061691	0.00058466
BAA3	0.00121848	0.00137373	0.00144062	0.00138076
BA1	0.00378175	0.00380574	0.00378337	0.00376016
BA2	0.00431821	0.00432036	0.00428303	0.00427944
BA3	0.00397964	0.00402497	0.00398511	0.00390026
B1	0.00546465	0.00728685	0.00727188	0.00718788
B3	0.00229244	0.00232249	0.00225791	0.00210700
TAXREG82	−0.00068525	−0.00056319	−0.00053960	−0.00051805
TAXREG88	−0.00028570	−0.00007992	−0.00005379	−0.00002017
CALLNONE	−0.00038523	−0.00040905	−0.00044085	−0.00047098
CALLPAR	0.00123620	0.00125956	0.00117849	0.00111343
HITFL	−0.00039965	−0.00048908	−0.00042789	−0.00032942
BANKING	0.00228961	0.00226139	0.00222722	0.00227417
INDUSTRIAL	0.00013444	0.00016861	0.00013260	0.00014999
RATE30YR	0.04154082	0.03598965	0.03596903	0.03644748
V3M52WK	0.02239020	0.02066507	0.02043202	0.02045414

Table V–5 (Continued)

REGRESSION	yy mm	yy mm	yy mm	yy mm
UPTO MONTH:	92 04	92 05	92 06	92 07
NUMBER OF OBSERVATIONS:	1480	1485	1496	1518
F VALUE:	57.15	57.20	57.88	59.60
R-SQUARE:	0.474447	0.473833	0.474891	0.478509
INTERCEPT	0.00250909	0.00252300	0.00251062	0.00276872
AAA	−0.00680275	−0.00676490	−0.00680789	−0.00680250
AA1	−0.00538484	−0.00534002	−0.00535408	−0.00536040
AA2	−0.00364575	−0.00359352	−0.00361606	−0.00362871
AA3	−0.00557081	−0.00552560	−0.00555827	−0.00555226
A1	−0.00408515	−0.00404804	−0.00409629	−0.00409282
A2	−0.00366908	−0.00363943	−0.00362946	−0.00365249
A3	−0.00255443	−0.00249887	−0.00253575	−0.00256162
BAA1	0.00064504	0.00065341	0.00063050	0.00066794
BAA3	0.00156268	0.00182389	0.00180701	0.00182050
BA1	0.00375285	0.00379006	0.00373843	0.00369008
BA2	0.00421997	0.00423400	0.00424490	0.00415708
BA3	0.00388325	0.00391236	0.00386136	0.00382145
B1	0.00693994	0.00698190	0.00693317	0.00659087
B3	0.00209399	0.00209702	0.00199463	0.00196515
TAXREG82	−0.00051219	−0.00049825	−0.00048191	−0.00047159
TAXREG88	0.00000439	0.00000498	0.00003013	0.00005037
CALLNONE	−0.00051326	−0.00055318	−0.00058457	−0.00061394
CALLPAR	0.00123629	0.00120254	0.00106221	0.00135358
HITFL	−0.00040603	−0.00038897	−0.00032404	−0.00040931
BANKING	0.00227151	0.00222954	0.00225070	0.00224883
INDUSTRIAL	0.00017207	0.00010858	0.00012676	0.00016852
RATE30YR	0.03461460	0.03455632	0.03471450	0.03253970
V3M52WK	0.02008259	0.02052923	0.02079272	0.02096060

Table V–5 (Continued)

REGRESSION	yy mm	yy mm	yy mm	yy mm
UPTO MONTH:	92 08	92 09	92 10	92 11
NUMBER OF OBSERVATIONS:	1523	1534	1554	1559
F VALUE:	59.69	60.38	61.72	61.99
R-SQUARE:	0.478039	0.479095	0.481287	0.481540
INTERCEPT	0.00276923	0.00278425	0.00290107	0.00286624
AAA	−0.00677966	−0.00681589	−0.00673988	−0.00672705
AA1	−0.00532883	−0.00534380	−0.00523582	−0.00523691
AA2	−0.00358985	−0.00360659	−0.00353113	−0.00350421
AA3	−0.00551907	−0.00554166	−0.00545453	−0.00543208
A1	−0.00406909	−0.00411124	−0.00401445	−0.00399537
A2	−0.00363345	−0.00361363	−0.00357068	−0.00355865
A3	−0.00250856	−0.00253885	−0.00244009	−0.00239382
BAA1	0.00067514	0.00065799	0.00073814	0.00074604
BAA3	0.00201693	0.00200639	0.00212662	0.00228760
BA1	0.00371929	0.00367968	0.00370007	0.00371952
BA2	0.00417308	0.00419119	0.00417377	0.00419123
BA3	0.00383987	0.00379677	0.00382566	0.00384409
B1	0.00661548	0.00657036	0.00654557	0.00656089
B3	0.00194205	0.00183563	0.00181011	0.00177389
TAXREG82	−0.00044850	−0.00042023	−0.00038072	−0.00035986
TAXREG88	0.00005832	0.00008312	0.00013185	0.00013619
CALLNONE	−0.00064608	−0.00067975	−0.00071072	−0.00073947
CALLPAR	0.00130604	0.00119684	0.00138489	0.00141289
HITFL	−0.00036744	−0.00030347	−0.00029267	−0.00024896
BANKING	0.00221660	0.00223484	0.00217488	0.00214794
INDUSTRIAL	0.00012164	0.00013625	0.00011775	0.00008019
RATE30YR	0.03234624	0.03196308	0.03007975	0.03014767
V3M52WK	0.02184844	0.02283220	0.02486051	0.02628065

Table V–6
Regression Coefficients to Forecast the Risk Premium of the Benchmark 30-Year Model (BM30Y)

REGRESSION	yy mm	yy mm	yy mm	yy mm
UPTO MONTH:	91 12	92 01	92 02	92 03
NUMBER OF OBSERVATIONS:	1419	1442	1447	1458
F VALUE:	107.58	109.39	109.34	108.29
R-SQUARE:	0.639479	0.639554	0.638637	0.634609
INTERCEPT	0.00105494	0.00032166	0.00015489	−0.00053557
AAA	−0.00702765	−0.00706483	−0.00708698	−0.00708215
AA1	−0.00525318	−0.00532644	−0.00535620	−0.00532687
AA2	−0.00354116	−0.00359002	−0.00362167	−0.00363923
AA3	−0.00559617	−0.00565342	−0.00568189	−0.00568995
A1	−0.00421848	−0.00423529	−0.00424675	−0.00419954
A2	−0.00400435	−0.00401138	−0.00402485	−0.00400423
A3	−0.00261587	−0.00264981	−0.00268599	−0.00267682
BAA1	−0.00024456	−0.00023872	−0.00023485	−0.00018432
BAA3	0.00113989	0.00103933	0.00092120	0.00099377
BA1	0.00332167	0.00331641	0.00330548	0.00317305
BA2	0.00370632	0.00363089	0.00363208	0.00364140
BA3	0.00424305	0.00415706	0.00415301	0.00420495
B1	0.00440789	0.00479814	0.00479457	0.00487702
B3	0.00018066	0.00012391	0.00010503	0.00008275
TAXREG82	0.00007420	0.00001421	−0.00000664	−0.00006480
TAXREG88	0.00202778	0.00202100	0.00200866	0.00197400
CALLNONE	−0.00060504	−0.00056451	−0.00055805	−0.00056083
CALLPAR	0.00059949	0.00062107	0.00066225	0.00060051
HITFL	−0.00007981	−0.00005892	−0.00008216	−0.00009557
BANKING	0.00224538	0.00225282	0.00227317	0.00226963
INDUSTRIAL	0.00008400	0.00008336	0.00011022	0.00017116
RATE3MON	0.00557082	0.01159745	0.01294552	0.01828703
V30Y52WK	−0.06489227	−0.04399409	−0.03826565	−0.01585464

Table V–6 (Continued)

REGRESSION	yy mm	yy mm	yy mm	yy mm
UPTO MONTH:	92 04	92 05	92 06	92 07
NUMBER OF OBSERVATIONS:	1480	1485	1496	1518
F VALUE:	107.29	107.16	105.65	104.89
R-SQUARE:	0.628919	0.627832	0.622754	0.617556
INTERCEPT	−0.00157698	−0.00171805	−0.00226520	−0.00303386
AAA	−0.00713082	−0.00714989	−0.00710370	−0.00711559
AA1	−0.00534537	−0.00537194	−0.00527792	−0.00522216
AA2	−0.00367211	−0.00370136	−0.00367795	−0.00366915
AA3	−0.00573932	−0.00576487	−0.00573209	−0.00574300
A1	−0.00418273	−0.00419261	−0.00411623	−0.00408314
A2	−0.00399796	−0.00400913	−0.00395493	−0.00392818
A3	−0.00270419	−0.00274196	−0.00270364	−0.00270348
BAA1	−0.00019476	−0.00018993	−0.00013488	−0.00012804
BAA3	0.00091616	0.00081278	0.00086345	0.00090761
BA1	0.00325298	0.00324466	0.00317680	0.00326928
BA2	0.00371931	0.00371909	0.00373522	0.00380386
BA3	0.00412226	0.00412049	0.00419319	0.00412694
B1	0.00403667	0.00404406	0.00418189	0.00354395
B3	−0.00001547	−0.00002989	−0.00001209	−0.00007087
TAXREG82	−0.00015456	−0.00017444	−0.00023076	−0.00030353
TAXREG88	0.00187973	0.00186750	0.00184183	0.00177007
CALLNONE	−0.00058614	−0.00058145	−0.00058898	−0.00061815
CALLPAR	0.00045935	0.00050586	0.00037644	0.00016584
HITFL	0.00001182	−0.00002007	−0.00005160	0.00004830
BANKING	0.00224355	0.00226426	0.00223395	0.00219474
INDUSTRIAL	0.00013316	0.00015763	0.00019235	0.00013315
RATE3MON	0.02706327	0.02818752	0.03248407	0.03924675
V30Y52WK	0.01774633	0.02290932	0.04067467	0.06421390

Table V–6 (Continued)

REGRESSION	yy mm	yy mm	yy mm	yy mm
UPTO MONTH:	92 08	92 09	92 10	92 11
NUMBER OF OBSERVATIONS:	1523	1534	1554	1559
F VALUE:	105.08	104.40	103.87	104.17
R-SQUARE:	0.617194	0.613929	0.609590	0.609504
INTERCEPT	−0.00310078	−0.00343184	−0.00386428	−0.00390300
AAA	−0.00712702	−0.00708244	−0.00707754	−0.00708516
AA1	−0.00523785	−0.00512363	−0.00501202	−0.00502095
AA2	−0.00368606	−0.00365604	−0.00363869	−0.00364961
AA3	−0.00575824	−0.00572452	−0.00572572	−0.00573594
A1	−0.00409043	−0.00403106	−0.00400055	−0.00400557
A2	−0.00393539	−0.00388070	−0.00385761	−0.00386246
A3	−0.00272062	−0.00268375	−0.00266085	−0.00267316
BAA1	−0.00012556	−0.00008287	−0.00009878	−0.00009697
BAA3	0.00084369	0.00088649	0.00090665	0.00086368
BA1	0.00326294	0.00322753	0.00329441	0.00329024
BA2	0.00380235	0.00380938	0.00383583	0.00383478
BA3	0.00412385	0.00417728	0.00408857	0.00408602
B1	0.00354844	0.00365863	0.00329505	0.00329914
B3	−0.00007917	−0.00005628	−0.00007029	−0.00007521
TAXREG82	−0.00031464	−0.00036184	−0.00043051	−0.00043828
TAXREG88	0.00176464	0.00174891	0.00169853	0.00169495
CALLNONE	−0.00061481	−0.00062259	−0.00063845	−0.00063585
CALLPAR	0.00019080	−0.00001555	−0.00024485	−0.00023368
HITFL	0.00003129	0.00000627	0.00005369	0.00004379
BANKING	0.00220802	0.00218657	0.00215612	0.00216488
INDUSTRIAL	0.00014889	0.00017308	0.00012206	0.00013242
RATE3MON	0.03982112	0.04266725	0.04724619	0.04761868
V30Y52WK	0.06646319	0.07610843	0.08697799	0.08811575

Table V–7
Regression Coefficients to Forecast the Risk Premium of the Option-Based Random Walk Interest Rate Model (OBRW)

REGRESSION	yy mm	yy mm	yy mm	yy mm
UPTO MONTH:	91 12	92 01	92 02	92 03
NUMBER OF OBSERVATIONS:	1419	1442	1447	1458
F VALUE:	126.07	125.49	125.08	123.10
R-SQUARE:	0.675176	0.670558	0.669059	0.663800
INTERCEPT	0.00240107	0.00099741	0.00076256	−0.00011017
AAA	−0.00678161	−0.00688025	−0.00690902	−0.00688546
AA1	−0.00512738	−0.00528843	−0.00532791	−0.00527602
AA2	−0.00357340	−0.00368104	−0.00372328	−0.00372855
AA3	−0.00530498	−0.00543107	−0.00546876	−0.00546213
A1	−0.00397421	−0.00401746	−0.00403129	−0.00395359
A2	−0.00416013	−0.00419901	−0.00421574	−0.00418375
A3	−0.00299745	−0.00307402	−0.00312124	−0.00309731
BAA1	−0.00050481	−0.00049705	−0.00048991	−0.00042118
BAA3	0.00111657	0.00095809	0.00080042	0.00090394
BA1	0.00305334	0.00305936	0.00304617	0.00292522
BA2	0.00307856	0.00301885	0.00302216	0.00304279
BA3	0.00424672	0.00412593	0.00412266	0.00420502
B1	0.00599975	0.00588493	0.00588222	0.00600511
B3	0.00145959	0.00133617	0.00131207	0.00130323
TAXREG82	−0.00074219	−0.00087174	−0.00090100	−0.00097568
TAXREG88	0.00227549	0.00219778	0.00218016	0.00213224
CALLNONE	−0.00090671	−0.00087056	−0.00086205	−0.00086954
CALLPAR	0.00020024	0.00022034	0.00027910	0.00021772
HITFL	0.00112421	0.00118036	0.00114591	0.00111619
BANKING	0.00241291	0.00243820	0.00246659	0.00244683
INDUSTRIAL	−0.00002399	−0.00002722	0.00000940	0.00006237
RATE3MON	−0.00295726	0.00900146	0.01087904	0.01760786
V30Y52WK	−0.00497871	0.03666766	0.04476194	0.07362709

Table V–7 (Continued)

REGRESSION UPTO MONTH:	yy mm 92 04	yy mm 92 05	yy mm 92 06	yy mm 92 07
NUMBER OF OBSERVATIONS:	1480	1485	1496	1518
F VALUE:	120.73	120.36	117.90	116.52
R-SQUARE:	0.656010	0.654546	0.648151	0.642072
INTERCEPT	−0.00139232	−0.00151925	−0.00219429	−0.00307353
AAA	−0.00695241	−0.00696824	−0.00690889	−0.00692862
AA1	−0.00531675	−0.00534032	−0.00523029	−0.00517892
AA2	−0.00377539	−0.00380240	−0.00377125	−0.00376783
AA3	−0.00552960	−0.00555217	−0.00550948	−0.00552859
A1	−0.00393764	−0.00394530	−0.00384729	−0.00381442
A2	−0.00418045	−0.00418953	−0.00412758	−0.00410125
A3	−0.00313503	−0.00317140	−0.00312248	−0.00312575
BAA1	−0.00043220	−0.00042804	−0.00035907	−0.00035065
BAA3	0.00080819	0.00071420	0.00079896	0.00085143
BA1	0.00301947	0.00301191	0.00294050	0.00304480
BA2	0.00314216	0.00314068	0.00316153	0.00323980
BA3	0.00410234	0.00410274	0.00419730	0.00411405
B1	0.00489021	0.00489891	0.00507401	0.00427056
B3	0.00117775	0.00116803	0.00119568	0.00112380
TAXREG82	−0.00108741	−0.00110722	−0.00117586	−0.00126141
TAXREG88	0.00201187	0.00199879	0.00196392	0.00188068
CALLNONE	−0.00090198	−0.00089857	−0.00090932	−0.00094100
CALLPAR	0.00004764	0.00009801	−0.00002850	−0.00029461
HITFL	0.00124666	0.00120710	0.00116262	0.00127300
BANKING	0.00242207	0.00244154	0.00240051	0.00236370
INDUSTRIAL	0.00001804	0.00004010	0.00007327	0.00001043
RATE3MON	0.02842280	0.02941787	0.03471163	0.04243602
V30Y52WK	0.11510478	0.12008710	0.14228983	0.16927263

Table V–7 (Continued)

REGRESSION	yy mm	yy mm	yy mm	yy mm
UPTO MONTH:	92 08	92 09	92 10	92 11
NUMBER OF OBSERVATIONS:	1523	1534	1554	1559
F VALUE:	116.51	115.07	114.23	114.44
R-SQUARE:	0.641271	0.636714	0.631978	0.631630
INTERCEPT	−0.00317299	−0.00362559	−0.00409406	−0.00414007
AAA	−0.00694527	−0.00688237	−0.00687789	−0.00688562
AA1	−0.00520197	−0.00505962	−0.00497705	−0.00500023
AA2	−0.00379275	−0.00374931	−0.00373878	−0.00375236
AA3	−0.00555097	−0.00550267	−0.00550621	−0.00551772
A1	−0.00382487	−0.00373872	−0.00371755	−0.00372142
A2	−0.00411168	−0.00404674	−0.00402100	−0.00402593
A3	−0.00315198	−0.00309994	−0.00308096	−0.00309680
BAA1	−0.00034693	−0.00028755	−0.00030197	−0.00029955
BAA3	0.00075807	0.00082874	0.00086104	0.00081540
BA1	0.00303566	0.00300956	0.00308924	0.00308081
BA2	0.00323756	0.00326145	0.00329315	0.00329063
BA3	0.00410989	0.00418994	0.00410917	0.00410882
B1	0.00427779	0.00443628	0.00388328	0.00389242
B3	0.00111197	0.00115143	0.00114575	0.00114467
TAXREG82	−0.00127810	−0.00133989	−0.00142168	−0.00143113
TAXREG88	0.00187225	0.00184543	0.00177577	0.00176940
CALLNONE	−0.00093627	−0.00094910	−0.00097073	−0.00096762
CALLPAR	−0.00025676	−0.00048014	−0.00065243	−0.00059046
HITFL	0.00124680	0.00120727	0.00123222	0.00121193
BANKING	0.00238314	0.00234818	0.00231755	0.00232687
INDUSTRIAL	0.00003334	0.00005150	0.00001333	0.00002443
RATE3MON	0.04329035	0.04718152	0.05216946	0.05259518
V30Y52WK	0.17265378	0.18617939	0.19897623	0.20060749

Table V–8
Regression Coefficients to Forecast the Risk Premium of the Option-Based Expectations Hypothesis Interest Rate Model (OBEH)

REGRESSION	yy mm	yy mm	yy mm	yy mm
UPTO MONTH:	91 12	92 01	92 02	92 03
NUMBER OF OBSERVATIONS:	1419	1442	1447	1458
F VALUE:	100.38	103.01	102.95	102.18
R-SQUARE:	0.623346	0.625595	0.624623	0.621047
INTERCEPT	0.00199410	0.00148759	0.00139696	0.00075365
AAA	−0.00702941	−0.00705741	−0.00708327	−0.00707394
AA1	−0.00523160	−0.00530015	−0.00533222	−0.00529360
AA2	−0.00352973	−0.00357076	−0.00360587	−0.00361878
AA3	−0.00534054	−0.00538719	−0.00541854	−0.00542152
A1	−0.00406996	−0.00409365	−0.00411417	−0.00406524
A2	−0.00402819	−0.00403355	−0.00405406	−0.00403297
A3	−0.00279927	−0.00282509	−0.00286122	−0.00284943
BAA1	−0.00028695	−0.00027095	−0.00027906	−0.00023348
BAA3	0.00122748	0.00112328	0.00098381	0.00105303
BA1	0.00334715	0.00333071	0.00330828	0.00317862
BA2	0.00372372	0.00365037	0.00363828	0.00365286
BA3	0.00438091	0.00428674	0.00427138	0.00432356
B1	0.00512890	0.00565189	0.00563577	0.00571815
B3	0.00118709	0.00114226	0.00112107	0.00110504
TAXREG82	0.00023379	0.00019717	0.00018193	0.00012685
TAXREG88	0.00171238	0.00173453	0.00172815	0.00169423
CALLNONE	−0.00072457	−0.00067628	−0.00066831	−0.00067346
CALLPAR	0.00067148	0.00063971	0.00067198	0.00059442
HITFL	−0.00009339	−0.00008526	−0.00010852	−0.00012654
BANKING	0.00237489	0.00239204	0.00241147	0.00240282
INDUSTRIAL	0.00006162	0.00007295	0.00010150	0.00015684
RATE3MON	−0.00875109	−0.00477571	−0.00398910	0.00100461
V30Y52WK	0.01818725	0.03171066	0.03513732	0.05627715

Table V–8 (Continued)

REGRESSION	yy mm	yy mm	yy mm	yy mm
UPTO MONTH:	92 04	92 05	92 06	92 07
NUMBER OF OBSERVATIONS:	1480	1485	1496	1518
F VALUE:	101.30	101.23	99.55	99.39
R-SQUARE:	0.615423	0.614446	0.608678	0.604762
INTERCEPT	−0.00027934	−0.00034447	−0.00090353	−0.00152252
AAA	−0.00712984	−0.00713717	−0.00708809	−0.00710059
AA1	−0.00532648	−0.00533910	−0.00523731	−0.00520360
AA2	−0.00365812	−0.00367414	−0.00364968	−0.00364653
AA3	−0.00547742	−0.00548958	−0.00545440	−0.00546623
A1	−0.00405607	−0.00405961	−0.00397922	−0.00395661
A2	−0.00403193	−0.00403615	−0.00398131	−0.00396232
A3	−0.00288157	−0.00290137	−0.00286100	−0.00286419
BAA1	−0.00024509	−0.00024346	−0.00018928	−0.00018264
BAA3	0.00097474	0.00091767	0.00097834	0.00101484
BA1	0.00325596	0.00325073	0.00316792	0.00324446
BA2	0.00372825	0.00372522	0.00374586	0.00379375
BA3	0.00423094	0.00423264	0.00430878	0.00423611
B1	0.00480576	0.00481156	0.00495586	0.00427850
B3	0.00100031	0.00099859	0.00101933	0.00096917
TAXREG82	0.00003646	0.00002372	−0.00003416	−0.00009880
TAXREG88	0.00159646	0.00158773	0.00155966	0.00149611
CALLNONE	−0.00070165	−0.00070026	−0.00071015	−0.00073522
CALLPAR	0.00043108	0.00046779	0.00032544	0.00013510
HITFL	−0.00001934	−0.00005438	−0.00009112	−0.00001461
BANKING	0.00238168	0.00239440	0.00236040	0.00232806
INDUSTRIAL	0.00012272	0.00013617	0.00017284	0.00012827
RATE3MON	0.00975666	0.01023762	0.01464644	0.02016048
V30Y52WK	0.08978933	0.09276040	0.11113399	0.13049823

Table V–8 (Continued)

REGRESSION	yy mm	yy mm	yy mm	yy mm
UPTO MONTH:	92 08	92 09	92 10	92 11
NUMBER OF OBSERVATIONS:	1523	1534	1554	1559
F VALUE:	99.52	98.70	99.07	99.33
R-SQUARE:	0.604264	0.600542	0.598273	0.598131
INTERCEPT	−0.00156649	−0.00190814	−0.00211175	−0.00212916
AAA	−0.00710841	−0.00705050	−0.00702223	−0.00702538
AA1	−0.00521462	−0.00507338	−0.00499554	−0.00501191
AA2	−0.00365924	−0.00361704	−0.00358797	−0.00359477
AA3	−0.00547721	−0.00543024	−0.00540665	−0.00541186
A1	−0.00396209	−0.00388810	−0.00385215	−0.00385375
A2	−0.00396739	−0.00390514	−0.00387538	−0.00387763
A3	−0.00287435	−0.00282669	−0.00278355	−0.00278778
BAA1	−0.00018134	−0.00013567	−0.00013822	−0.00013743
BAA3	0.00096440	0.00102807	0.00107094	0.00104813
BA1	0.00323903	0.00320076	0.00325588	0.00324953
BA2	0.00379147	0.00382106	0.00382882	0.00382651
BA3	0.00423383	0.00429988	0.00423923	0.00423938
B1	0.00428116	0.00440980	0.00402428	0.00402859
B3	0.00096431	0.00099987	0.00101799	0.00101925
TAXREG82	−0.00010720	−0.00015581	−0.00019996	−0.00020390
TAXREG88	0.00149224	0.00147225	0.00144278	0.00143990
CALLNONE	−0.00073272	−0.00074675	−0.00075469	−0.00075276
CALLPAR	0.00015498	−0.00009103	−0.00019361	−0.00014454
HITFL	−0.00003168	−0.00006254	−0.00005406	−0.00006729
BANKING	0.00233894	0.00230570	0.00226862	0.00227344
INDUSTRIAL	0.00014079	0.00015850	0.00012809	0.00013393
RATE3MON	0.02052428	0.02348545	0.02569019	0.02583522
V30Y52WK	0.13210176	0.14230960	0.14795723	0.14869372

Table V–9

Summary of Actual Market Price and Model Price Regressions

Dependent Variable: Actual market price per $1 stated value (MKT);

Explanatory Variable: Model price per $1 stated value of one of the three models using the forecasted risk premium from one of the three forecast methods as the appropriate risk premium.

Forecast Method One: Prior quarter's implied risk premium is the appropriate risk premium.

Forecast Method Two: Average of previous quarters' implied risk premia is the appropriate risk premium.

Forecast Method Three: Regression of previous implied risk premia is the appropriate risk premium.

Note that low T and F values are good here. It means that we can not reject the null hypothesis.

α = intercept.

β = slope.

 * Not significant at 1% level.

** Also not significant at 5% level.

Table	Forecast Method	Model	T for H_0: $\alpha = 0$	T for H_0: $\beta = 1$	F for H_0: $\alpha = 0$ & $\beta = 1$	R-Square
V–10	ONE	BM3M	6.60	−7.11	30.51	0.750704
V–11	ONE	BM30Y	5.49	−4.49	41.53	0.827151
V–12	ONE	OBRW	5.98	−5.14	35.79	0.841939
V–13	ONE	OBEH	7.22	−6.74	30.46	0.822819
V–14	TWO	BM3M	5.46	−9.14	674.77	0.204141
V–15	TWO	BM30Y	2.14*	−1.79**	10.17	0.331461
V–16	TWO	OBRW	2.19*	−1.67**	17.23	0.419157
V–17	TWO	OBEH	2.19*	−2.10*	2.64**	0.537065
V–18	THREE	BM3M	21.39	−37.52	2771.11	0.453841
V–19	THREE	BM30Y	6.44	−2.93	350.59	0.674626
V–20	THREE	OBRW	4.62	−0.90**	494.30	0.537772
V–21	THREE	OBEH	9.25	−8.68	47.58	0.704386

Table V–10
OLS Regression: Actual Market Price on Benchmark 3-Month Model Price

Dependent Variable: Actual market price per $1 stated value (MKT);
Explanatory Variable: Model price per $1 stated value of BM3M model using the forecasted risk premium from forecast method one, prior quarter's implied risk premium, as the appropriate risk premium (MDLBM3M1).

F VALUE	PR > F	R-SQUARE
448.68	0.0001	0.750704
ROOT MSE/MEAN	ROOT MSE	MKT MEAN
0.060451	0.05434662	0.89901490

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.21517152	6.60	0.0001	0.03258546
MDLBM3M1	0.74872695	21.18	0.0001	0.03534705

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 1	PR > | T |
MDLBM3M1	0.74872695	−7.11	0.0001

JOINT HYPOTHESIS: INTERCEPT = 0 AND MDLBM3M1 = 1

F(2,149)	PR > F
30.51	0.0001

Table V–11
OLS Regression: Actual Market Price on Benchmark 30-Year Model Price

Dependent Variable: Actual market price per $1 stated value (MKT);
Explanatory Variable: Model price per $1 stated value of BM30Y model using the forecasted risk premium from forecast method one, prior quarter's implied risk premium, as the appropriate risk premium (MDLBM30Y1).

F VALUE	PR > F	R-SQUARE
713.03	0.0001	0.827151
ROOT MSE/MEAN	ROOT MSE	MKT MEAN
0.050336	0.04525307	0.89901490

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.15445146	5.49	0.0001	0.02812574
MDLBM30Y1	0.85600350	26.70	0.0001	0.03205699

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 1	PR > | T |
MDLBM30Y1	0.85600350	−4.49	0.0001

JOINT HYPOTHESIS: INTERCEPT = 0 AND MDLBM30Y1 = 1

F(2,149)	PR > F
41.53	0.0001

Table V–12
OLS Regression: Actual Market Price on Option-Based Random Walk Interest Rate Model Price

Dependent Variable: Actual market price per $1 stated value (MKT);
Explanatory Variable: Model price per $1 stated value of OBRW model using the forecasted risk premium from forecast method one, prior quarter's implied risk premium, as the appropriate risk premium (MDLOBRW1).

F VALUE	PR > F	R-SQUARE
793.67	0.0001	0.841939

ROOT MSE/MEAN	ROOT MSE	MKT MEAN
0.048135	0.04327412	0.89901490

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.15868344	5.98	0.0001	0.02651373
MDLOBRW1	0.84576328	28.17	0.0001	0.03002123

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 1	PR > | T |
MDLOBRW1	0.84576328	−5.14	0.0001

JOINT HYPOTHESIS: INTERCEPT = 0 AND MDLOBRW1 = 1

F(2,149)	PR > F
35.79	0.0001

Table V–13
OLS Regression: Actual Market Price on Option-Based Expectations Hypothesis Interest Rate Model Price

Dependent Variable: Actual market price per $1 stated value (MKT);
Explanatory Variable: Model price per $1 stated value of OBEH model using the forecasted risk premium from forecast method one, prior quarter's implied risk premium, as the appropriate risk premium (MDLOBEH1).

F VALUE	PR > F	R-SQUARE
691.95	0.0001	0.822819
ROOT MSE/MEAN	ROOT MSE	MKT MEAN
0.050963	0.04581665	0.89901490

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.19511386	7.22	0.0001	0.02701779
MDLOBEH1	0.79594290	26.30	0.0001	0.03025831

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 1	PR > | T |
MDLOBEH1	0.79594290	−6.74	0.0001

JOINT HYPOTHESIS: INTERCEPT = 0 AND MDLOBEH1 = 1

F(2,149)	PR > F
30.46	0.0001

Table V–14
OLS Regression: Actual Market Price on Benchmark 3-Month Model Price

Dependent Variable: Actual market price per $1 stated value (MKT);
Explanatory Variable: Model price per $1 stated value of BM3M model using the forecasted risk premium from forecast method two, average of previous quarters' implied risk premia, as the appropriate risk premium (MDLBM3M2).

F VALUE	PR > F	R-SQUARE
38.22	0.0001	0.204141
ROOT MSE/MEAN	ROOT MSE	MKT MEAN
0.108011	0.09710313	0.89901490

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.42269412	5.46	0.0001	0.07745177
MDLBM3M2	0.40359671	6.18	0.0001	0.06528407

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 1	PR > | T |
MDLBM3M2	0.40359671	−9.14	0.0001

JOINT HYPOTHESIS: INTERCEPT = 0 AND MDLBM3M2 = 1

F(2,149)	PR > F
674.77	0.0001

Table V–15
OLS Regression: Actual Market Price on Benchmark 30-Year Model Price

Dependent Variable: Actual market price per $1 stated value (MKT);
Explanatory Variable: Model price per $1 stated value of BM30Y model using the forecasted risk premium from forecast method two, average of previous quarters' implied risk premia, as the appropriate risk premium (MDLBM30Y2).

F VALUE	PR > F	R-SQUARE
73.87	0.0001	0.331461

ROOT MSE/MEAN	ROOT MSE	MKT MEAN
0.098995	0.08899765	0.89901490

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.17994454	2.14	0.0337	0.08397433
MDLBM30Y2	0.82742054	8.60	0.0001	0.09626761

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 1	PR > | T |
MDLBM30Y2	0.82742054	−1.79	0.0750

JOINT HYPOTHESIS: INTERCEPT = 0 AND MDLBM30Y2 = 1

F(2,149)	PR > F
10.17	0.0001

Table V–16
OLS Regression: Actual Market Price on Option-Based Random Walk Interest Rate Model Price

Dependent Variable: Actual market price per $1 stated value (MKT);
Explanatory Variable: Model price per $1 stated value of OBRW model using the forecasted risk premium from forecast method two, average of previous quarters' implied risk premia, as the appropriate risk premium (MDLOBRW2).

F VALUE	PR > F	R-SQUARE
107.52	0.0001	0.419157
ROOT MSE/MEAN	ROOT MSE	MKT MEAN
0.092274	0.08295539	0.89901490

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.15745317	2.19	0.0299	0.07183260
MDLOBRW2	0.86125306	10.37	0.0001	0.08305747

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 1	PR > | T |
MDLOBRW2	0.86125306	−1.67	0.0969

JOINT HYPOTHESIS: INTERCEPT = 0 AND MDLOBRW2 = 1

F(2,149)	PR > F
17.23	0.0001

Table V–17
OLS Regression: Actual Market Price on Option-Based Expectations Hypothesis Interest Rate Model Price

Dependent Variable: Actual market price per $1 stated value (MKT);
Explanatory Variable: Model price per $1 stated value of OBEH model using the forecasted risk premium from forecast method two, average of previous quarters' implied risk premia, as the appropriate risk premium (MDLOBEH2).

F VALUE	PR > F	R-SQUARE
172.86	0.0001	0.537065
ROOT MSE/MEAN	ROOT MSE	MKT MEAN
0.082377	0.07405858	0.89901490

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.12871850	2.19	0.0304	0.05889757
MDLOBEH2	0.86217877	13.15	0.0001	0.06557694

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 1	PR > | T |
MDLOBEH2	0.86217877	−2.10	0.0373

JOINT HYPOTHESIS: INTERCEPT = 0 AND MDLOBEH2 = 1

F(2,149)	PR > F
2.64	0.0749

Table V–18
OLS Regression: Actual Market Price on Benchmark 3-Month Model Price

Dependent Variable: Actual market price per $1 stated value (MKT);
Explanatory Variable: Model price per $1 stated value of BM3M model using the forecasted risk premium from forecast method three, regression of previous implied risk premia, as the appropriate risk premium (MDLBM3M3).

F VALUE	PR > F	R-SQUARE
123.81	0.0001	0.453841
ROOT MSE/MEAN	ROOT MSE	MKT MEAN
0.089476	0.08044053	0.89901490

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.59709850	21.39	0.0001	0.02791173
MDLBM3M3	0.22873590	11.13	0.0001	0.02055650

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 1	PR > | T |
MDLBM3M3	0.22873590	−37.52	0.0001

JOINT HYPOTHESIS: INTERCEPT = 0 AND MDLBM3M3 = 1

F(2,149)	PR > F
2771.11	0.0001

Table V–19
OLS Regression: Actual Market Price on Benchmark 30-Year Model Price

Dependent Variable: Actual market price per $1 stated value (MKT);
Explanatory Variable: Model price per $1 stated value of BM30Y model using the forecasted risk premium from forecast method three, regression of previous implied risk premia, as the appropriate risk premium (MDLBM30Y3).

F VALUE	PR > F	R-SQUARE
308.93	0.0001	0.674626
ROOT MSE/MEAN	ROOT MSE	MKT MEAN
0.069062	0.06208785	0.89901490

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.24257248	6.44	0.0001	0.03768788
MDLBM30Y3	0.85692181	17.58	0.0001	0.04875373

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 1	PR > | T |
MDLBM30Y3	0.85692181	−2.93	0.0039

JOINT HYPOTHESIS: INTERCEPT = 0 AND MDLBM30Y3 = 1

F(2,149)	PR > F
350.59	0.0001

Table V–20
OLS Regression: Actual Market Price on Option-Based Random Walk Interest Rate Model Price

Dependent Variable: Actual market price per $1 stated value (MKT);
Explanatory Variable: Model price per $1 stated value of OBRW model using the forecasted risk premium from forecast method three, regression of previous implied risk premia, as the appropriate risk premium (MDLOBRW3).

F VALUE	PR > F	R-SQUARE
173.35	0.0001	0.537772
ROOT MSE/MEAN	ROOT MSE	MKT MEAN
0.082314	0.07400195	0.89901490

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.23472024	4.62	0.0001	0.05081222
MDLOBRW3	0.93596634	13.17	0.0001	0.07108792

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 1	PR > | T |
MDLOBRW3	0.93596634	−0.90	0.3692

JOINT HYPOTHESIS: INTERCEPT = 0 AND MDLOBRW3 = 1

F(2,149)	PR > F
494.30	0.0001

Table V–21
OLS Regression: Actual Market Price on Option-Based Expectations Hypothesis Interest Rate Model Price

Dependent Variable: Actual market price per $1 stated value (MKT);
Explanatory Variable: Model price per $1 stated value of OBEH model using the forecasted risk premium from forecast method three, regression of previous implied risk premia, as the appropriate risk premium (MDLOBEH3).

F VALUE	PR > F	R-SQUARE
355.04	0.0001	0.704386
ROOT MSE/MEAN	ROOT MSE	MKT MEAN
0.065828	0.05918034	0.89901490

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 0	PR > | T |	STD ERROR OF ESTIMATE
INTERCEPT	0.29825098	9.25	0.0001	0.03224529
MDLOBEH3	0.68455819	18.84	0.0001	0.03633073

VARIABLE	COEFF ESTIMATE	T FOR H_0: COEFF = 1	PR > | T |
MDLOBEH3	0.68455819	−8.68	0.0001

JOINT HYPOTHESIS: INTERCEPT = 0 AND MDLOBEH3 = 1

F(2,149)	PR > F
47.58	0.0001

Table V–22
Mean Square Error (MSE) and Its Components

FORECAST METHOD ONE:
PRIOR QUARTER'S IMPLIED RISK PREMIUM

	BM3M	BM30Y	OBRW	OBEH
BIAS	0.00020525	0.00085272	0.00056044	0.00021473
INEFFICIENCY	0.00098845	0.00027364	0.00032734	0.00063224
RANDOM ERROR	0.00291444	0.00202072	0.00184785	0.00207136
MEAN SQUARE ERROR	0.00410813	0.00314707	0.00273563	0.00291834

FORECAST METHOD TWO:
AVERAGE OF PREVIOUS QUARTERS' IMPLIED RISK PREMIA

	BM3M	BM30Y	OBRW	OBEH
BIAS	0.07905941	0.00089786	0.00144312	0.00003119
INEFFICIENCY	0.00521141	0.00016858	0.00012717	0.00016044
RANDOM ERROR	0.00930413	0.00781567	0.00679045	0.00541203
MEAN SQUARE ERROR	0.09357495	0.00888211	0.00836074	0.00560366

FORECAST METHOD THREE:
REGRESSION OF PREVIOUS IMPLIED RISK PREMIA

	BM3M	BM30Y	OBRW	OBEH
BIAS	0.17717331	0.01768045	0.03582421	0.00045887
INEFFICIENCY	0.06032268	0.00021987	0.00002943	0.00174851
RANDOM ERROR	0.00638497	0.00380384	0.00540375	0.00345592
MEAN SQUARE ERROR	0.24388097	0.02170416	0.04125740	0.00566331

Bibliography

1. Alderson, Michael, Keith Brown and Scott Lummer. "Dutch Auction Rate Preferred Stock," *Financial Management,* **16** (Summer 1987), 68–73.

2. Ball, Laurence. "Why Does High Inflation Raise Inflation Uncertainty?" *Journal of Monetary Economics,* (June 1992), 371–88.

3. Black, Fischer, Emanual Derman and William Toy. "A One-Factor Model of Interest Rates and its Application to Treasury Bond Options," *Financial Analysts Journal,* **46** (January/February 1990), 33–39.

4. Black, Fischer and Myron Scholes. "The Pricing of Options and Corporate Liabilities," *Journal of Political Economy,* **81** (May/June 1973), 637–59.

5. Brennan, Michael and Eduardo Schwartz. "Savings Bonds, Retractable Bonds and Callable Bonds," *Journal of Financial Economics,* **5** (August 1977), 67–88.

6. Cox, John, Jonathan Ingersoll and Stephen Ross. "An Analysis of Variable Rate Loan Contracts," *Journal of Finance,* **35** (May 1980), 389–403.

7. Cox, John, Jonathan Ingersoll and Stephen Ross. "A Theory of the Term Structure of Interest Rates," *Econometrica,* **53** (March 1985), 385–407.

8. Golob, John. "Does Inflation Uncertainty Increase with Inflation?" *Federal Reserve Bank of Kansas City Economic Review,* (Third Quarter 1994), 28–38.

9. Heath, David, Robert Jarrow and Andrew Morton. "Contingent Claim Valuation with a Random Evolution of Interest Rates," *Review of Futures Markets,* **9** (January 1990), 54–76.

10. Ho, Thomas and Sang-Bin Lee. "Term Structure Movements and Pricing Interest Rate Contingent Claims," *Journal of Finance,* **41** (December 1986), 1011–29.

11. Johnson, Herb. "Options on the Maximum or the Minimum of Several Assets," *Journal of Financial and Quantitative Analysis,* **22** (September 1987), 277–83.

12. Longstaff, Francis. "The Valuation of Options on Yields," *Journal of Financial Economics,* **26** (July 1990), 97–121.

13. Margrabe, William. "The Value of an Option to Exchange one Asset for Another," *Journal of Finance,* **33** (March 1978), 177–86.

14. Merton, Robert. "A Rational Theory of Option Pricing," *Bell Journal of Economics and Management Science,* **4** (Spring 1973), 141–83.

15. Poirier, Dale. "Cubic Splines," *The Econometrics of Structural Change,* North Holland Publishing, 1976, 21–55.

16. Rabinovitch, Ramon. "Pricing Stock and Bond Options when the Default-Free Rate is Stochastic," *Journal of Financial and Quantitative Analysis,* **24** (December 1989), 447–57.

17. Ramaswamy, Krishna and Suresh Sundaresan. "The Valuation of Floating Rate Instruments: Theory and Evidence," *Journal of Financial Economics,* **17** (December 1986), 251–72.

18. Stulz, Rene. "Options on the Minimum or the Maximum of Two Risky Assets: Analysis and Applications," *Journal of Financial Economics,* **10** (July 1982), 161–85.

19. Schervish Mark. "Multivariate Normal Probabilities with Error Bound," *Applied Statistics,* **33** (January 1984), 81–94.

20. Schervish Mark. "Multivariate Normal Probabilities with Error Bound: Corrections," *Applied Statistics,* **34** (January 1985), 103–04.

21. Vasicek, Oldrich. "An Equilibrium Characterization of the Term Structure," *Journal of Financial Economics,* **5** (November 1977), 177–88.

22. Wilson, Richard. "Adjustable Rate Preferred Stocks," *Floating Rate Instruments: Characteristics, Valuation and Portfolio Strategies by Frank Fabozzi,* Probus Publishing, 1986, 53–77.

23. Winger, Bernard, Carl Chen, John Martin, William Petty and Steven Hayden. "Adjustable Rate Preferred Stock," *Financial Management,* **15** (Spring 1986), 48–57.