

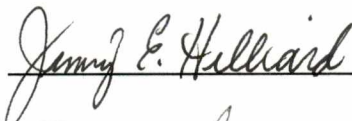
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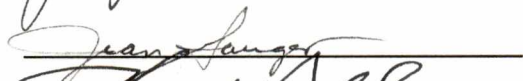
I am submitting herewith a dissertation written by Tim W. Vines entitled "An Empirical Investigation of Treasury Bond Futures Option Portfolios." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Ph.D., with a major in Business Administration.

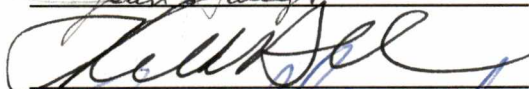


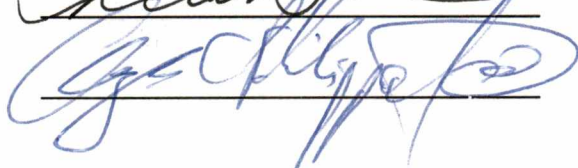
Ron Shrieves, Major Professor

We have read this dissertation
and recommend its acceptance:









Accepted for the Council:



Associate Vice Chancellor
and Dean of the Graduate School

**AN EMPIRICAL INVESTIGATION OF TREASURY
BOND FUTURES OPTION PORTFOLIOS**

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Tim W. Vines
August 1992

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This document would not have been possible without the efforts of my committee chairman, Dr. Ron Shrieves. I would also like to thank the other committee members, Dr. George Philippatos, Dr. Harold Black, Dr. Jean Gauger, and Dr. Jimmy Hilliard; each provided assistance under frequently unusual circumstances. My colleagues at Louisiana State University in Shreveport supplied ample quantities of understanding and support. Jean and Dwight Vines, my parents helped both financially and logistically. Finally, although they would never ask for any mention in a document such as this, my wife, Ginger, and sons, Matt, Aaron, and Patrick should be acknowledged above all others. They paid the highest price.

ABSTRACT

This dissertation examines the return distributions of portfolios containing Treasury securities and the Treasury Bond Futures Option. The two principle areas of investigation are the characteristics of the distributions and the effect on return of a number of portfolio properties. Information is provided about the similarity of covered call and protective put strategies using futures options to the evidence from equity option studies. Both strategies reduce return and dispersion relative to the spot portfolio, while the put portfolios increase positive asymmetry and the call portfolios provide negative asymmetry. As suggested by theory, banks and government bond dealers can benefit from the reduction in interest rate risk each strategy provides. However, the effect on return of the change in the asymmetry of the positions does not follow the predictions of the skewness preference literature. Evidence suggests that investor groups may exist which value these portfolios based on the convexity or concavity of the payoff functions. Other contributions of this study are: 1) verification with actual market price data of the opportunity expanding capabilities of option use; 2) a description of the relative performance of various measures of dispersion and asymmetry; 3) the use of a multivariate model which may be used for tests of a wide variety of studies of the investment behavior of individuals and institutions; and 4) the application of an error components model to account for the complex variation often encountered in studies that pool time series and cross-sectional data.

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CHAPTER 1

INTRODUCTION

The rapid change in the financial markets experienced during the 1980's is likely to continue in the future. Many of the new securities developed over that period possess characteristics which are very similar to those of the option. A number of these new securities have tremendous trading volume, indicating popularity with investors. However, these securities are not universally accepted. The events of October 1987 and the subsequent calls for the termination of option index arbitrage serve to highlight this fact. Securities exchanges and investment houses spend millions annually on the development of new securities, many of which fail to attract significant volume.

In order to determine the benefits of these and future innovative securities, it is important to enhance our understanding of the option. Previous attempts have not been completely successful for a number of reasons. One problem is a reliance on model-generated price data. As option markets mature, the lack of adequate market data is no longer a deterrent. Also, previous studies have relied on investment theory which either depends on overly restrictive assumptions about investor utility, fails to include possibly significant influences, or lacks sufficient empirical support.

This study investigates the motivations for option use. It takes advantage of the availability of actual market price data, and avoids the limitations on investor utility found in prior studies. The model developed here tests the effect of a wide range of portfolio characteristics on the utility of a specific investor group known to use options. In addition, this study determines to what extent the distributional characteristics of recently developed options correspond to the equity option, about which more is known.

Simulated portfolio positions containing Treasury securities and interest rate futures options are used to provide inputs into a multifactor model with variables drawn from the most important findings of related studies. The portfolio strategies examined, namely covered calls and protective puts, use futures options because of evidence which suggests that they are widely used by commercial banks and government bond dealers. The use of the futures option is also motivated by the desire to test conclusions drawn from equity option studies with a different and previously unused set of data. The greater liquidity and higher trading volume of the futures option market provide more reliable data than the alternatives, spot options on Treasury securities or options on interest rate indices.

The literature concerning financial institution use of interest rate options implies two primary motivations: risk reduction and the expansion of investment opportunities. The analysis of portfolio return distributions and use of the multifactor model will allow the determination of the appropriateness of the option strategies for these purposes.

Until the motivations of various classes of investors are tested, statements about the effect of options upon the financial markets will remain largely conjecture. Government agencies will be unable to determine whether new securities should be approved or if existing securities should continue trading. Security exchanges and investment houses will continue to invest capital into possibly unsuccessful financial engineering which may result in the persistent misallocation of funds to inefficient uses.

A. OPTIONS AS INNOVATION

Prior work, mostly theoretical, has indicated that the primary purpose of option trading is to provide investors with the opportunity to create return distributions which were previously unavailable. This premise can be better understood by examining the idea of financial

innovation. Financial innovation is characterized by Silber (1983) as an attempt by economic units to avoid the costs of various constraints in the effort to optimize some objective function. Van Horne (1985) cites two standards against which an innovation should be judged. The first is that the innovation should enhance the operational efficiency of markets by reducing the spread between savers and borrowers. The second is that the innovation causes the markets to move closer to completeness. This can be achieved if the number of desirable outcomes available to investors is increased. Miller (1986) reinforces these standards by citing the reduction of transaction costs and the expansion of the market as indicators of a successful innovation. Finnerty (1988) defines the design, development, and implementation of innovative financial instruments as financial engineering. He explains that if new securities allow the reallocation or reduction of risk, then the yield on securities can be reduced and the innovation has served its purpose.

Figlewski (1987) explains the role of derivative securities (futures and options) in the financial markets. The primary role of these securities depends upon enhanced opportunities for risk management. By making the markets more complete, derivatives provide investors with a better opportunity set. Figlewski also refers to a common argument against derivative assets as successful innovation. The payoff patterns from these securities can be duplicated with dynamic asset strategies.¹ Derivative assets can negate this objection if their transaction costs are lower than that for alternative strategies or if they overcome institutional trading constraints. Ross (1976A) shows that options can, in a state-preference theory framework, be used to achieve market completeness. He also argues that options can be developed less expensively than the primitive securities of Arrow (1964).² Breeden and Litzenberger (1978) take this

¹ See Rubinstein and Leland (1981).

² Also see Copeland and Weston (1983).

process one step further by showing how to create and price the synthetic primitive claims suggested by Arrow. Arditti and John (1980) duplicate and extend the findings of Ross. Leland (1980) examines the utility functions of investors that might benefit from portfolio insurance (the protective put). He concludes that two types of investors would demand the payoffs of purchased options: a) those whose expectations are more optimistic than the market average; and b) those whose risk tolerance increases faster than average, as wealth increases.

B. THE CURRENT STATUS OF RESEARCH

Despite the theoretical articles espousing the idea that options improve market completeness, the empirical evidence to date does not fully support this claim. Several studies provide evidence that the distributions of portfolios containing equity options may be markedly different from non-option portfolios. The authors of these studies argue that they support the conclusion that options are a significant innovation. However, these studies are inconclusive for two reasons. The first is the lack of adequate option market data. Prior studies did not have access to true option prices because of the recent introduction of these securities to the markets. In the absence of these prices, valuation models were used to generate theoretical price data which might not be accurate. The second problem with prior studies is their failure to establish the desirability of option portfolio distributions, and is more difficult to resolve. Of the few studies which address this question, most use models which either contain overly restrictive investor utility assumptions or do not provide adequate information about why a portfolio or asset is preferred to alternatives.

Merton, Scholes, and Gladstein (1978, 1982) (MSG) provide the initial evidence on the distributional characteristics of the covered call and protective put. The most notable findings are that the addition of

equity options to stock portfolios provides asymmetry, or skewness,³ as well as a reduction in dispersion, to the return distribution. Bookstaber and Clarke (1984, 1985) provide similar evidence by simulating the distributions for an entire range of possible equity outcomes rather than the historical outcomes used by MSG.

Although these studies conclude that equity option portfolios provide return distributions which differ from those of the underlying stocks, each suffers from the problems mentioned above. These studies use variants of the Black and Scholes (BS) (1973) pricing model to overcome the lack of reliable market data. There are significant drawbacks to the use of BS for non-equity options.⁴ Furthermore, none of these studies attempt to specifically determine the relationship between return and other portfolio characteristics. There is no determination of whether the distributional characteristics are priced by investors. This linkage is necessary for the determination of why a specific group of investors choose the option portfolios, and whether the option itself is a successful innovation.

The literature discussing option strategies is quite extensive. The positions described in any individual study often depend on an investor's expectation of a particular market movement or the belief that a security is mispriced. These expectations or beliefs may be temporary or not widely held, as suggested by Leland

³ The literature uses the term skewness in a general way. To be correct, the third moment of a probability distribution, or raw skew, is different from the most frequently used empirical measure, relative skewness. The raw skew is calculated as

$$[\sum (r_i - \bar{r})^3] / N$$

Relative skewness is the raw skew divided by the standard deviation raised to the third power. The term skewness will be used to indicate asymmetry in general.

⁴ Although BS prices equity options well, extensions to other securities have been questioned. See Schaefer and Schwartz (1987).

(1980), making it difficult to draw conclusions about the effectiveness of the position. Consider, for example, a group of optimistic investors who purchase portfolio insurance, in effect, to speculate on their expectations. Their motivation, and the price they are willing to pay, may differ from that of any average confidence hedgers. In addition, these "speculators" may differ from period to period in the degree of faith they place in their expectations, and therefore, in their demand for insurance.

This work examines the effect of distributional characteristics on return for some specific types of positions held by financial institutions. In the case of bond dealers and commercial banks, the motivations for the use of two option positions are well understood, and likely to differ from those of speculators. The first of these positions is the covered call, the combination of the purchase of the underlying security with the sale of the call option. The second position, known as the protective put, is the simultaneous purchase of the underlying security and the put option. Evidence suggests that these positions are widely held by commercial banks and bond dealers. Although these positions do have limited speculative applications, each is also associated with motivations that are neither temporary nor narrowly held. The first motivation is the desire to hedge interest rate risk. The second is the enhanced utility associated with asymmetric returns, or skewness.

The Treasury bond futures option (TBFO) provides a mature, liquid market with historical price information in sufficient quantity to identify portfolio characteristics without resort to a theoretical pricing model. This allows the investigation of actual portfolio return distributions for the option strategies discussed above. The remaining question will be the desirability of the resulting distributions. Several studies of this type exist, but the diversity of the methodologies and results makes it difficult to generalize conclusions. In addition, these studies fail to identify a specific group of users and investigate this group's investment objectives. These difficulties provide this study's

motivation.

C. SUMMARY

This paper will develop and test option strategies used by commercial banks and government bond dealers. The first task is to examine the distributions of the return from these strategies. These distributions will be compared to the evidence gathered from equity portfolios to establish the degree to which traditional option theory and empirical findings can be extended to the newer futures option. In addition, differences in the distributions of the covered call, protective put, and spot only strategies will be examined. The next task is to determine the impact of several different characteristics on portfolio return. This should provide the information necessary to determine whether the distributional changes commonly attributed to options are valued by a particular group of investors. These findings will provide valuable evidence needed to evaluate new securities, particularly if and how these securities expand the set of capital market opportunities available to investors. The flexible methodology also may be useful in a number of other areas of capital market research, such as futures hedging and the financial engineering of new securities.

CHAPTER 2

THEORETICAL FOUNDATIONS

The purpose of this chapter is to present a brief review of those elements of financial theory which have a direct bearing on the use of options to enhance market completeness and which have implications for tests of the nature and desirability of option distributions. The first topic will be the importance of innovation to equilibrium in the financial markets. For options, as well as other derivative securities, to play an important part in the financial markets, they should provide at least one of the benefits associated with innovation: increased operational efficiency or expanded investment opportunities. The second topic is a description of options and the specific types of positions held by financial institutions. Finally, this chapter presents the various investment models, and their shortcomings, which either have been used in prior studies of options or will be used herein.

A. FINANCIAL INNOVATION AND MARKET EQUILIBRIUM

The primary foundation of the theory of finance is the basic model of how wealth is accumulated and allocated by individual economic units. Since this model is familiar and available in a number of sources,⁵ only a brief reiteration follows. Utility maximizers face a wealth constrained optimization problem involving consumption in each of a number of different time periods. With perfect and complete markets, an equilibrium exists in which each unit is able to maximize welfare. This equilibrium is Pareto-optimal in the sense that no mutually beneficial trades persist; thus the welfare of society is maximized, all claims on consumption (securities) are priced such that the marginal rates of

⁵ See Fama and Miller (1972) or Hirshleifer (1970).

substitution are equal for every economic unit, and terminal wealth is certain (i.e. riskless). The assumption of market completeness is essential to this result. In a complete market, the value of future consumption is known for each possible state of nature. In addition, a security exists for each state, allowing economic units to trade in each possible outcome. Since all economic units agree on the likelihood of a given outcome and are able to provide for the optimal level of future consumption in that state through security trading, the riskless equilibrium detailed above is achieved. However, in reality, there are an infinite number of different outcomes to any intertemporal trade, eliminating the possibility of complete markets, and the resulting equilibrium. Hirshleifer (1970) extends the above model to show the effect of relaxing the assumption of completeness. The resulting solution is characterized by higher claim prices, ambiguous terminal wealth, and the lack of Pareto-optimality in some states of nature. Thus, if markets are not complete, society's welfare must be lower than if the converse were true. The creation of new securities which allow some economic units to take advantage of previously unavailable mutually beneficial trades is termed a viable or significant innovation. To the extent that a new security is unsuccessful in this respect, because of the costs of developing the security and the possible misallocation of wealth by those trading in the new security, society's welfare may well be lower than before that security was created.

Van Horne (1984) utilizes transaction costs to describe the effect of operational inefficiencies on society's welfare. These costs serve to decrease the return to saving and socially beneficial production opportunities. As the returns to saving decrease, the willingness to save is lessened. To extract these funds for production, interest rates must increase. This increase in costs decreases the net present value of projects, forcing the rejection of some opportunities which were previously acceptable. Thus, holding constant the time preferences of

savers and the intrinsic value of production opportunities, transactional frictions result in an opportunity loss to society.

In the idealized situations described above, the development of the effect of innovative securities becomes almost trivial. In reality, the loss of welfare is impossible to quantify. However, if it can be shown empirically that a certain security provides an ex post distribution of returns which either cannot be obtained with previously available alternatives or can only be obtained at higher cost, it can be surmised that this security qualifies as innovative. The first task of this paper is to perform the tests which can determine not only whether the futures option provides for such a unique distribution, but also whether at least one class of investors values this distribution.

B. THE ROLE OF OPTIONS

An option is a contract which provides its holder with the right to purchase (call) or sell (put) a specific asset at a specific price (strike price) at or over some time period. The value of the option will depend on the value of the underlying asset. Since the right to purchase an asset at a fixed price is more valuable as the value of the asset increases, the value of a call increases with asset price. However, if the asset's price falls, the potential loss on the option is limited to the initial purchase price (premium). The holder of the option is never required to exercise the right to buy or sell. It is this limited liability feature which leads to the expectation that option returns are asymmetric. The value of a put option increases as the asset's price falls. If the asset appreciates, put value declines. This loss is also limited to the premium paid. The change in wealth of the option writer (issuer) will be the opposite of the buyer's. The underlying asset for a futures option is a futures contract. Buyers of a call possess the right to enter into a long (buy) position in the underlying contract at the strike price specified by the option. Holders of the put can exercise the option to obtain a short (sell)

position. Writers are required to take the opposite positions.

The combination of issuing a call and purchasing the underlying asset is known as a covered call. This strategy is illustrated in Figure 1. For declines in the value of the spot asset, losses are partially offset by the premium paid to the option writer. For small declines, the premium outweighs the spot losses although the potential for downside outcomes is unlimited. The negative relationship between spot and call value which exists when the spot asset's price increases results in a limited but fixed upside return. The holder of the covered call is thus insulated from the unlimited losses associated with naked call writing. The combination of limited upside return and unlimited downside potential results in a theoretical distribution of returns which is negatively skewed. In addition, the negative correlation between spot and call for price increases and the premium effect on the downside should reduce risk for this position relative to the spot alone.

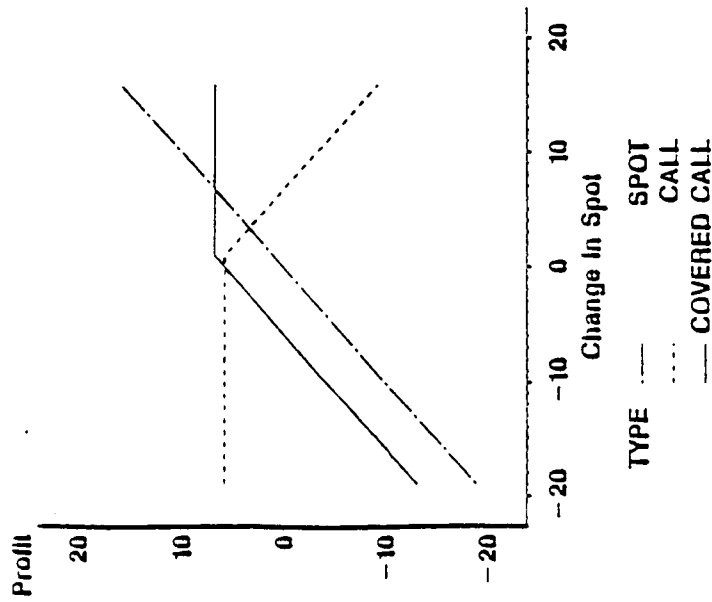
Figure 1 also shows the protective put, a purchased put option combined with the spot asset. The holder of this position is unable to realize the full benefit of increasing asset prices because of the premium payment. However, as asset prices fall, the increase in the put's value in effect sets a floor value for the position. Losses on the spot are offset by gains to the put. Once again the negative relationship between put and spot for spot declines and the premium effect result in lower variance than spot only holdings. Because of the unlimited potential for upside return and the limited downside losses, the return distribution for a protective put should be positively skewed.

The expected asymmetry from the covered call and protective put serve as the premise for the existence of option trading. The notion that these positions alter distributional characteristics seem to imply that the option enhances market completeness. Ross (1976A) discusses several aspects of this potential. In Arrow's (1964) state/space approach to uncertainty, the market is complete when there exists a primitive security

Figure 1: Option Strategy Payoffs

This graph shows the payoffs for a covered call strategy (a) and protective put strategy (b) held until maturity. The actual positions used in this study will be liquidated prior to maturity, but the use of the futures option closest to maturity insures that this diagram provides a close approximation to the true nature of the return distribution.

COVERED CALL



PROTECTIVE PUT

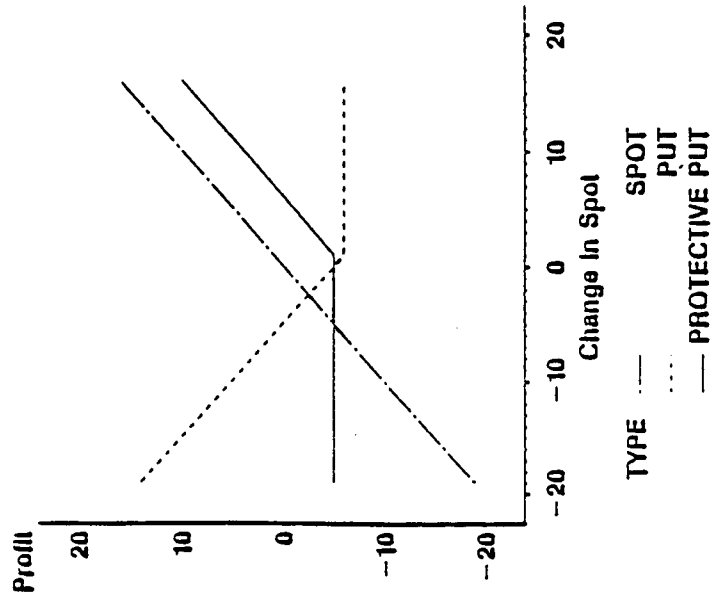


Figure 1

for each state of nature. A primitive security pays unity in one state and nothing in all others. These securities can be placed into portfolios which provide any pattern of returns desired. Ross suggests that, in an incomplete market the creation of contingent claims (options) may be less costly than the creation of new primitive securities. The options needed, however, should be multiple options (options which depend on multiple contingencies). This necessity is eliminated upon the formation of an efficient fund of assets with the characteristic that its returns in each state of nature are different. Ross shows that simple options (depending on only one contingency) written on this "super fund" can span the same space as multiple options on primitive securities.

Breeden and Litzenberger (1978) continue upon the lines initiated by Ross. They suggest the use of options written on aggregate consumption, rather than the asset portfolio of Ross. These authors also show that the prices of primitive securities can be calculated with portfolios of simple consumption options. In effect, this result leads to the conclusion that all asset prices can be determined given the prices of options. Arditti and John (1980) simplify the proof of Ross by eliminating the assumption that the super fund be composed of securities with limited liability. Given any portfolio with distinct returns in each state, another portfolio can be found with only positive, distinct returns.

The importance of these works to the present study is to show that, in theory, options are an important tool for the enhancement of market completeness. The implication is that previously unattainable patterns of returns are possible with options. This theoretical background provides the basis for the wide popularity of options and the frequent introduction of new types of options. Unfortunately, only limited empirical evidence of the achievement of these benefits has been provided. In the next section, the theory used in attempts to establish the linkage between options, market completeness, and investor utility is briefly examined.

C. INVESTMENT THEORY AND OPTIONS

Previous studies of the desirability of option portfolios relied on only one of a number of possible theories of asset selection. Early studies used the mean/variance framework which is too restrictive in its assumptions. Later examinations invoke stochastic dominance (SD) theorems which do not provide adequate rationale to explain which investors will choose options. A later study relies on skewness preference, but does not obtain reliable results. Each of these approaches is described below.

1. Mean/Variance

Early studies of the utility derived from option investing utilize traditional mean/variance theory (MV). The requirements for MV to successfully describe the behavior of investors have been widely investigated. In general, two conditions provide for the validity of the theory.⁶ The first possibility is that investment returns follow a normal distribution, or some other distribution which can be fully distinguished based on only the first two moments. Many studies of equity returns have found that this may not be the case, but that, in general, MV can still provide useful results. The returns on option portfolios are clearly not adequately described by the first two moments. The second possibility is that the investors possess a quadratic utility function. One of the properties of such a function is that only the first two moments of the probability distribution of returns affect utility. Given the expected returns for the protective put and covered call, any study of options based on MV runs the risk of failing to account for the presumed asymmetry of option positions.

Another difficulty with the use of MV for the explanation of option holdings is the common assumption that investors possess homogeneous expectations and the resulting reliance on the market portfolio. Ritchken (1985) claims that each position in derivative securities, or securities that derive value from financial assets, is two-sided. For every investor

⁶ These conditions are restated and referenced in Beedles (1979).

long in the option, there must be an offsetting short position of equal size, resulting in a net weight of zero in the market portfolio. The implication is that spot securities, such as stocks and bonds, are not subject to this requirement, since these securities derive value from real assets. Although it is possible for investors to be either long or short in any spot position, it is not necessary that each long position accompany a short position. Thus, the spot assets have a weight equal to market value in the market portfolio, while derivative assets have zero net weight. Leland (1980) also criticizes models which assume homogeneous expectations for this reason, and discusses conditions under which portfolio insurance would be desired by some investors. This approach is discussed in more detail in Section 4 below.

2. Stochastic Dominance

One way to allow for the asymmetrical nature of option portfolio returns is to utilize an investment and evaluation tool known as stochastic dominance (SD).⁷ The basic premise of this tool is that portfolio efficiency can be determined with only general information concerning the investor's utility function. This is in sharp contrast to evaluation based on the mean and variance of return. SD would work for all risk averse investors, including quadratic utility investors. In addition, SD makes no assumptions about the shape of the return distribution.

The basic process involves the comparison of the cumulative distribution functions of the alternatives. For example, by assuming that investors prefer more to less, the first degree stochastic dominance (FSD) rule can be evoked. An investment F dominates investment G if the cumulative distribution function, $F(x)$, is less than or equal to $G(x)$, with at least one inequality. One of the shortcomings of FSD rules is that they frequently are unable to select between two alternatives. The remedy

⁷ Probably the most comprehensive source of information about SD is Bawa (1975).

employed is to make the requirements for dominance more stringent. For example, if FSD failed to find the dominant pattern of returns, and if the investigator is willing to assume that investors are risk averse, second degree stochastic dominance (SSD) might work. SSD states that F dominates G if the integral of $G(x) - F(x)$ is greater than zero. In other words, the asset with the smaller area under the distribution function would dominate. The final SD rule which corresponds to a useful economic interpretation is third degree stochastic dominance (TSD). The additional assumption needed is that investors possess decreasing absolute risk aversion. Thus F dominates G if the integral of the integral found for SSD is greater than or equal to zero, and the average of F is at least as great as the average of G. This can account for a possible preference for skewness.

While the strength of SD is the wide range of investor preferences which it will accommodate, unfortunately, there are weaknesses which limit its usefulness. One problem is the frequent inability of SD to choose between portfolios. Tehranian (1980) discusses the necessary conditions for ranking with any SD criteria. One condition is that the lower bound for G be less than for F. This condition will be violated if empirical observation of F results in the occurrence of extreme outliers. Another condition is that the mean of F be at least as large as the mean of G. This condition allows for the possibility that an asset with a slightly lower mean, but a much lower variance will not be selected. To achieve a definitive ranking among various stock portfolios, Tehranian found it necessary to go as high as the ninth degree, a condition which, so far, cannot be reconciled with financial theory. The possible failure to eliminate some inefficient portfolios will limit the applicability of any empirical findings. In addition it is not possible to determine precisely why certain portfolios dominate others. To overcome these problems, financial economists need an investment selection and evaluation criterion which overcomes both the narrowness and possible mis-specification of

mean/variance and the generality of SD. An alternative for the case of option portfolios is to include skewness explicitly as an object of choice in the investor's utility function.

3. Skewness Preference

The first attempt to model the possible preference for skewness can be found in Arditti (1967). The author develops utility functions which depend on the first three moments. Levy (1969) criticizes this development, claiming that this dependence on the third moment implies a cubic utility function. The characteristic of such a function is that the investor is risk averse at lower levels of wealth, but prefers risk at higher levels. Kane (1982) shows that a preference for skewness can be consistent with a number of utility functions. Jean (1971) and Arditti and Levy (1975) extend the Markowitz selection model to incorporate the third moment. Finally, Kraus and Litzenberger (1976) develop an equilibrium asset pricing model which allows systematic co-skewness to affect the required return for an asset.

The primary difficulty with skewness preference theory is a lack of consistent empirical support for its predictions. Tests of this theory, which are more fully described in Chapter Four, suffer from the incidence of a high degree of correlation between risk measures, such as beta and variance, and measures of skewness. The theory predicts that both risk and skewness are determinants of asset return, yet the computational similarity of the measures used in the tests may limit simultaneous use. One of the expected contributions of the present study is to use instrumental variables which do not possess this computational similarity. A second difficulty with the theory is an inability to account for the possibility that, during certain periods, there may be investors who pay for concave payoff functions.⁸

The nature of the investment theory needed to explain the holding of option portfolios has not been completely resolved in the literature. The

⁸ Section 4 below discusses the work of Leland (1980).

impact of risk, as measured by dispersion, on security return is well established, but it appears that this measure alone may not be sufficient to explain the use of options. The results from both SD and skewness preference models indicate that some measure of asymmetry, in addition to dispersion measures, may provide valuable information about investor behavior.

4. Generalized Insurance Payoff Functions

Leland (1980) and Brennan and Solanki (1981) discuss the application of traditional insurance theory to the more recently developed concept of portfolio insurance. Leland develops two conditions, either of which imply a preference for the purchase of a protective put. The first condition is that the investor shows risk tolerance which increases with wealth more rapidly than the average market participant. Such an investor is shown to choose a spot portfolio with higher risk than the average portfolio, and to purchase insurance. The seller of the insurance (put writer) would hold a spot position which contains less market risk. Under these circumstances, homogeneous expectations are consistent with a demand for both long and short positions in puts and calls.

The second condition is that the investor hold more optimistic expectations than the average. In order to trade on these beliefs, but still maintain acceptable risk levels, portfolio insurance will be purchased. Leland classifies insurance purchasers as preferring payoff functions that are convex with respect to terminal spot value. Figure 1 showed that the protective put is convex to spot value. There must simultaneously exist a group of investors which prefer concave functions, such as the covered call. This approach is consistent with skewness preference theory for the purchase of puts and calls. The preference for convex payoff functions would have the same effect on return as the demand for positive skewness. However, for option writers, a conflict between insurance theory and skewness preference exists. The possible demand for concave payoff functions suggests a return effect which is the opposite of

the hypothesized aversion to negative skewness. The existence of so many possible influences on the users of option strategies suggests that a multifactor model, in the spirit of the Arbitrage Pricing Theory, (APT), by Ross (1976B), may be useful. The APT can account for a wider range of economic influences than either M/V or skewness preference models alone, while at the same time providing more specific information than SD. The background for this type of model is examined in Section 5 below.

5. Multifactor Models

The basic assumption of the APT is that security returns follow a linear generating function of k factors or indices. The basic form of this function is

$$\tilde{r}_i = E_i + b_{i1}\tilde{y}_1 + \dots + b_{ik}\tilde{y}_k + \tilde{\epsilon}_i \quad (1)$$

where E_i is the expected return on the i^{th} asset, b_{ik} is the sensitivity of asset i 's returns to changes in the k^{th} factor, γ_k , and ϵ_i is a unique or nonsystematic mean zero risk factor for the i^{th} asset. Ross shows how an investor can form arbitrage portfolios with no wealth, no risk, and subsequently, no return. Since there are a large number of possible combinations of existing securities which can be used in the formation of these arbitrage portfolios, the return on each security is shown to depend on that security's sensitivity to the k factors. This relationship can be expressed as

$$E_i = \lambda_0 + \lambda_1 b_{i1} + \lambda_2 b_{i2} + \dots + \lambda_k b_{ik} \quad (2)$$

The λ_k are risk premia corresponding to the γ_k in Equation (1).

Roll and Ross (1980), cite two major differences between the APT and the CAPM. The first is that APT allows multiple generating factors, eliminating the restriction of the single factor in CAPM. modest utility assumptions needed to achieve the no-arbitrage equilibrium of APT. The APT also holds for multiperiod analysis and does not rely on an efficient market portfolio. Thus, there is no assumption concerning the distribution

of asset returns, the investors' utility function is not restricted, and there is no necessity for the market portfolio. By eliminating the need to measure the entire universe of assets, researchers can draw conclusions about the relative value of a specific group of assets.

Tests of the APT generally use the following procedure:

1. Collect a time series of asset returns.
2. Compute the variance/covariance matrix of the returns.
3. Use a maximum likelihood factor analysis routine to identify the number of factors and their weights for the set of returns.
4. Use factor weights to explain the cross-sectional variation of the returns and to measure the size and significance of the risk premia.

Factor analysis is a statistical procedure which determines the set of factors and weights which minimize the covariance of the nonsystematic risk term in equation (1) for the set of returns. Elton and Gruber (1987) present a basic explanation of this procedure. The researcher selects a hypothesized number of factors and performs the analysis. The number of factors is then increased and the procedure repeated. This continues until the probability of an additional factor explaining a significant level of covariance falls beneath a subjectively acceptable level. Unfortunately, the signs of the generated weights have no meaning, there is no identification of the factors themselves, scaling of the weights and factors is arbitrary, and the order of the factors may be inconsistent between repetitions.

Even before the APT, studies of debt securities relied upon multifactor models. An early study which sets this precedent is Fisher (1959). Numerous authors continued this approach. Gultekin and Rogalski (1985) test the APT on Treasury securities and find mixed support for the predictions of the theory. However, the results do indicate that multifactor models explain Treasury returns better than single index models.

5. Summary

Theory suggests that options exist to expand market opportunities for investor utility maximization. The asset selection techniques used in prior option research have resulted in very little empirical support for the notion that asymmetry is an important component of this expansion. MV theory is unable to account for the impact of asymmetry on investor utility. SD does not allow the researcher to perform a rigorous analysis of the relationship among the possible determinants of investor utility. The skewness preference theory, in addition to providing inconclusive evidence, fails to account for the zero net derivative security demand. In contrast, the untested application of insurance theory to option demand suggests motivations that do allow for the zero market weight of derivatives. Multifactor models similar to the APT and those used for debt securities may provide an alternative that is able to overcome the lack of conclusive evidence which characterizes existing option studies.

CHAPTER 3

FINANCIAL INSTITUTIONS AND OPTIONS

The purpose of this chapter is to present the findings of the literature relating to the use of options by banks and government bond dealers. This information is necessary to develop the principal strategies that employ the Treasury Bond Futures Option (TBFO). These strategies coincide with the investment objectives underlying the testable hypotheses. Before this discussion it is necessary to provide a brief description of the securities which will comprise the tested option positions, medium and long term Treasury debt and the TBFO.

A. THE MARKETS

The U.S. Treasury security market is the largest, most liquid and most widely held single issuer debt market in the world. In 1989, over half of the \$2,700 billion of Treasury securities outstanding were either notes or bonds, coupon-bearing securities with an original maturity greater than one year, with ten years the maximum maturity for notes. The coupon is paid in two installments each year, half on the 15th of the maturity month, the remainder six months later.

Domestic financial institutions are the largest holders of Treasury securities.⁹ In 1988, financial institutions held 34% of the outstanding Treasury debt. Nonfinancial holders include individuals (25%), governments (20%), and foreigners (16%). Of the financial institutions, depository institutions held 13% of all treasuries, pension funds (9%), insurance companies (6%), and mutual funds (6%). Treasuries made up 10% of total bank assets, 21% for insurance companies, 28% for pension funds, and 25% for mutual funds.

⁹ This information is from Wann (1989), p. 36.

Facilitating transactions in this over-the-counter market is a small group of dealers. The Federal Reserve monitors the performance of about 50 primary dealers.¹⁰ Primary dealers gain access to the Fed's trading screen and can temporarily borrow securities from the Fed to settle trades, in addition to other benefits. Such dealers must maintain a volume of at least 1% of the total market (\$40 billion per day in 1988), make continuous two-way quotes and are required to meet capital requirements. Although some of these primary dealers are independent, most are owned by large, full-service securities firms or commercial bank holding companies. As a group, secondary dealers handle less than 10% of the total market. Profits for dealers come from the spread earned on trades as well as coupon receipts and capital gains from the security inventory.

The value of the TBFO depends upon conditions in the underlying market for the T-bond futures contract (TBF). Since its introduction by the Chicago Board of Trade in 1977, the TBF has grown to become the most heavily traded of all futures contracts. In fact, the daily volume in this market routinely exceeds the volume of the underlying cash market. In effect, there is no specific bond on which the contract trades. Prices are based on an assumed 20 year, 8% coupon bond. Any bond with 15 years until maturity or first call can be used to satisfy delivery. The face value of each contract is \$100,000. Maturities for the contract are March, June, September, and December.

The dominant user of the TBF appears to be the dealers of U.S. Government securities.¹¹ They reportedly use this contract to hedge the value of their inventory and for speculative or arbitrage positioning

¹⁰ An extraordinary example of this relationship between the Fed and the dealers occurred in the August of 1991, when Salomon Brothers admitted violation of several of the regulations under which dealers operate. Ultimately the Fed responded by revoking Salomon's ability to bid on customers' behalf.

¹¹ See Schwarz, Hill, and Schneeweis (1986).

based on their intimate knowledge of cash market prices. Wann (1989) reports that 69% of the average daily spot position of these dealers (\$26 billion) was offset by futures in 1987. At the end of that year, the CBOT had about \$34 billion face value in outstanding contracts, or open interest. This indicates that the dealers accounted for about one half of the trading volume in the TBF market.

The TBFO was first offered in 1982. Buyers of a call possess the right to enter into a long (buy) position in the \$100,000 underlying futures contract at the strike price specified by the option. Holders of the put can exercise the option to obtain a short (sell) position. Writers are required to take the opposite positions. All positions are immediately marked to market at the current futures price. Maturities coincide with the underlying TBF, although trading in the TBFO ceases in the month prior to maturity.

Historically, institutional investors have been infrequent users of equity options. The general perception of options as speculative securities, uncertainty about the legality of option use by the certain types of institutions, and the lack of knowledge concerning option strategies seem to be the most important reasons. According to Jarrow and Rudd (1983), the objectives to be gained from option use are expanded risk management opportunities not available with other securities and the ability to participate in market movements without changing the underlying cash portfolio. The investment strategies that are most frequently used with equity options are the protective put and the covered call.

Although detailed statistics are not available, evidence suggests that in contrast to the equity option market described in the preceding paragraph, the market for futures options is heavily used by institutional investors. Goodman (1983) reports that over half of the options on debt instruments are used by broker/dealer firms for their own accounts. Other significant users include thrift institutions and banks. Reifer (1988) also indicates that money center banks are heavy users of the TBFO.

B. WHY FINANCIAL INSTITUTIONS HEDGE

The theory of financial risk centers around the idea that, under reasonable circumstances, investors are only compensated for their exposure to market, or systematic risk. Diversifiable, or total firm risk becomes less important. It is not necessary for an individual firm to take measures to reduce total risk since the shareholders are able to form portfolios to diversify for themselves. In such an environment, a firm's participation in hedging activities would, at best, not increase firm value. In addition, some financial theory indicates that, under certain conditions, firm owners may have a desire to increase total risk. Galai and Maslous (1976) argue that the levered firm's stock is equivalent to a call option on firm value. To enhance stock value the risk of the assets can be increased to the benefit of the shareholders and the detriment of the creditors. Merton (1977) applies this equity/option relationship to financial institutions and deposit insurance. In the absence of risk based insurance premiums, the bank owners have the equivalent of a put option on firm assets, and the accompanying incentive to increase firm risk.

These ideas call into question any attempt by firms to decrease risk, and therefore, the hedging motive of banks and dealers. In fact the implication is clear that under certain situations, firm risk should be increased. Perhaps due to the observation that firm risk reduction persists, researchers have sought theoretical explanations which are consistent with this behavior. Two promising explanations have been put forth in the literature. The first explanation depends upon the agency relationship which exists between the firm owners and managers. The second relies on the presence of costs associated with financial distress.

1. Agency Theory

The general premise of agency theory is that utility maximizing agents act in their own best interest at the expense of the principal. One agent/principal relationship exists between the owners of the firm and the managers. Owners are assumed to be diversifiers who are unconcerned with

total risk. Managers, however, derive much of their wealth from their investment of human capital in the firm. In practice, it is more difficult for the manager to diversify than for the owners. Thus, depending upon the compensation scheme, the ability of the owners to monitor the manager, and the degree of owner control over firm decisions, the manager may be able to reduce firm risk, and his own, at the expense of the owners. Lambert and Larcker (1985) provide an efficient summary of this literature. In fact, these authors even suggest that the manager has a direct incentive to offset his risk aversion by making the consequences of downside risk less severe and those of upside risk more pronounced. In other words, not only may managers have an incentive to hedge, they may prefer asymmetric risks, lending support to both motivations for option use cited herein. Several studies have found evidence of the tendency of managers to eliminate diversifiable risk.

Amihud and Lev (1981) examine the case of conglomerate mergers. Previous studies imply this activity may provide no benefit for the owners of acquiring firms. The authors find that manager controlled firms engage in greater merger activity than owner controlled firms. Amihud, Kamin, and Ronen (1983) investigate systematic risk and income smoothing by owner controlled versus manager controlled firms. Again the evidence supports the claim that manager controlled firms attempt to reduce diversifiable risk. Saunders, Strock, and Travlos (1990) examine commercial banks in the presence of deregulation, which increases total risk. Manager controlled firms had less total risk prior to deregulation, and the difference increased in the post-deregulation environment. Each of these studies indicate that firm hedging may be expected despite the owners' ability to provide for their own diversification.

2. Financial Distress

The second explanation of hedging behavior relies on the idea that risk reduction activities may actually increase firm value for owners. The risk premia associated with discount rates are widely believed to be

determined predominantly by systematic risk. However, Jensen and Meckling (1976), as well as Myers (1977), show that the possibility of bankruptcy may induce owners to invest suboptimally. Titman (1984) uses this idea to show that financial distress may induce owners to prefer a reduction in total firm risk. Financial difficulties serve to disrupt firm operations, reducing sales, drying up sources of funds and affecting firm decisions about future investment projects. Firm value may be enhanced by reducing the probability of these difficulties, and the accompanying reduction in firm cashflow. Thus, even though the required rate of return may not be affected by hedging, the firm's cashflow can be enhanced, and firm value increased.

C. HEDGING APPLICATIONS

The most frequently cited bank uses of TBFO's are altering the characteristics of Treasury portfolios and managing balance sheet risk, or asset/liability management (ALM). There are alternatives to the option in achieving the goals associated with both of these uses, most notably the TBF. There are two advantages of the option contract over the futures. First, the TBFO provides the investor with the ability to participate in unanticipated favorable changes in interest rates, while the futures contract reduces both upside and downside risk. Second, the lack of margin requirements for option purchases eliminates the daily mark-to-market cashflows associated with futures. The primary disadvantages of the option seems to be the high initial cost of the premium, (futures are "free"), and a perceived lack of hedging efficiency relative to the futures contract.¹²

1. Asset/Liability Management

The use of options for ALM is discouraged, perhaps unintentionally, by the regulatory approach to accounting for options. Koppenhaver (1987)

¹² See the survey by Block and Gallagher (1988). It should be pointed out that no empirical evidence concerning the relative hedging or risk reduction capabilities of the option and futures exists.

reports that the intent of the regulators is to prohibit the use of derivatives for speculative purposes. Fee income earned as a result of option trading must be deferred until the option matures or is exercised. Written option positions are valued at the lower of cost or market, while the price for purchased options must be immediately expensed. Also, contract losses cannot be deferred. This immediate expensing of losses is designed to act as a deterrent to only speculative trading, but may limit legitimate hedging activity. Financial institutions typically account for security positions on an amortized cost basis, i.e. there is no market valuation made and losses are deferred. In the case of a purchased put, an increase in interest rates will result in an economic loss on the spot security and a gain on the option. However, the accounting treatment only recognizes the gain, resulting in higher net income. Rate declines result in a deferred gain on the spot, but the immediate expense of the option loss. In addition, for each case, the put premium is expensed with the net result of an earnings change. For a written call (covered), increasing (decreasing) rates result in deferred losses (gains) on the spot but immediate gains (losses) on the call. Thus, for the most common option hedges, accounting earnings volatility is increased in each case, a result which is inconsistent with the goals of asset/liability management. This situation occurs even though the bank may have correctly hedged and actually lowered balance sheet risk. To date, accounting and regulatory practices fail to accommodate the balance sheet risk reduction potential of options.

2. Treasury Security Portfolio Management

Treasury management, on the other hand, is likely to benefit from the use of TBFO's. Bank holdings of Treasuries can be classified into two types: investment portfolio and dealer. The investment portfolio (IP) consists of secondary market securities. These securities are managed separately from the loan portfolio. Logan (1988) lists several constraints on the management of this portfolio. One purpose of the IP is to provide

liquidity. If there is an unexpected increase in liability withdrawals or in the takedown of loan commitments, the securities in the IP must be readily converted to meet this requirement. Another use involves ALM. The IP is easiest place to alter the overall sensitivity of the balance sheet. The maturity of this portfolio can be shortened or lengthened more readily than other assets or liabilities. Thus, the interest rate risk position of the IP depends on the condition of other balance sheet items. The relatively high default risk of the loan portfolio requires low default risk in the IP for diversification. This low default risk also allows banks to offset to some degree the risk-based capital guidelines recently enacted. Valenza (1989) reports a recent survey of banks concerning the priority of the objectives for this portfolio. The banks rank interest rate risk as the most important consideration. Liquidity was the second most important consideration, followed by return. These objectives give Treasuries an advantage over other securities, and make them a principal component of the IP. Weberman (1988) and Vogelstein (1990) both report recent increases in Treasury holdings for banks.

Turning to the dealer holdings, Kwast (1989) reports that these activities of commercial banks usually earn a greater return than other activities. In addition to providing an important service for bank customers, dealer activities provide ready access to the market for the bank itself and provide increasingly important fee income. Because of the need to respond to customer demand, both bank and nonbank dealers often find themselves forced to take positions which are contrary to current market movements. When the dealers' customers desire to sell, the dealer must buy. This severely exposes the dealer to market movements. According to Lodge (1985), the dealer operations are the center of most option hedging activity. Koppenhaver (1987) indicates that this is probably due to the liberal treatment of dealer operations by bank regulators. This leniency is facilitated by the requirement that dealer securities be placed in separate trading accounts, distinct from securities held for

other reasons, such as the IP.

In essence, bond dealers and banks use TBFO's to assist in the management of an asset which is encumbered with so many constraints that more traditional techniques may not be available. The first motivation seems to be a desire to protect the Treasuries from changes in interest rates. If adding TBFO's to these portfolios offsets changes in rates by decreasing the price change, this hedging motivation is satisfied. It should also be repeated that this goal can be achieved in a number of alternative ways. The second motivation concerns the asymmetry of the portfolio returns. By completely eliminating the effect of rate changes, the bank or dealer would be forfeiting the increases in value associated with rate declines. Thus, if the TBFO allows the institution to experience security gains for decreasing rates, while decreasing losses during adverse movements, the asymmetry motivation is satisfied.

D. HEDGING STRATEGIES

As noted earlier, the most frequent equity option positions found in practice were the covered call and the protective put. Although no detailed survey of the type of futures option position held by banks and dealers exists, the covered call and protective put are also prominent in the practitioner-oriented literature concerning TBFO's. The covered call combines the writing (issuing) of a call option with a long position in the underlying (spot) asset. Larger spot increases would be offset by larger option losses. Chance (1989) cites this strategy as popular because it has lower risk than either the spot or option alone. Thus the covered call should be attractive to financial institutions for its risk reduction characteristics. Lodge (1985) cites the covered call as a way to "remove" Treasuries which have suffered value declines. Rather than being forced to recognize the loss associated with the sale of the depreciated securities, the bank can offset further losses by writing call options. Dealers and banks may also be attracted to the fee income generated by the premium

received for the option, if it provides adequate compensation for the expected negative skewness.

The protective put combines a long position in the spot asset with the purchase of put options. The exercise price can be compared to the deductible found in insurance contracts. The lowest possible return is the strike price floor less the premium paid. This reduction in downside risk corresponds to the hedging motivation. However, the ability to participate in spot increases satisfies the asymmetry motive and demand for convexity as well. The banks and dealers could protect their inventories from increases in rates, while benefitting from asset appreciation in periods of falling rates.

Government bond dealers and commercial banks are frequent users of the TBFO. Reportedly, their primary motivations are the desire to reduce the risk associated with Treasury positions or to provide for asymmetrical returns. However, no studies of the distributions provided by TBFO's have been performed. Although some evidence exists that equity options provide risk reduction and skewness, this evidence is marred by the problems originally discussed in Chapter 2 and further explained in Chapter 4 below. Evidence on the distribution of equity option positions, and the limitations of this evidence are also presented in the next chapter.

CHAPTER 4

EMPIRICAL EVIDENCE ON OPTION PORTFOLIOS

This chapter examines the distributional characteristics of option portfolios and efforts to determine the attractiveness of these characteristics to investors. Though the presence of skewness is one of the most consistent findings of studies of option position distributions, no consensus concerning the desirability of this aspect has been reached.

A. DISTRIBUTIONAL CHARACTERISTICS

Prior empirical studies provide support for the expected distributions described in Chapter 2. Merton, Scholes, and Gladstein (1978, 1982) examined the return distributions of covered calls, protective puts, and other equity option positions. In the first study, MSG form positions using the stocks for which options were listed in December 1975. Assuming equal investment in each security, no taxes or transaction costs, and the reinvestment of dividends, MSG found that the spot portfolio was highly correlated with the market and provided slightly positive skewness. Since exchange traded options were not available until 1973, MSG use a dividend adjusted variant of the option pricing model developed by Black and Scholes (1973) to calculate premiums for the period 1963-1975. Since this model is for European options with no dividends, there is concern over the accuracy of the derived premiums. MSG state that holding the option positions to maturity, thus eliminating the possibility of early exercise, and thereby lowering option buyer return, will offset the low prices (and higher returns) provided by the model.

The option positions chosen were the fully covered written call and a strategy which involves the purchase of calls and investment in commercial paper. The fully covered strategy is to write calls on the

number of shares held. This strategy is varied by strike price, one position in the money, one at the money, and two out of the money.¹³ All option maturities were six months from the beginning of each hedge period. The options/paper strategy combines purchased call options with purchased, low risk, short term securities. The rationale is that the low risk bond investment will offset the high risk of the options. Ten per cent of each portfolio is allocated into options, with the options chosen based on the ratio of strike to asset price.

The results for the covered call indicate that the option/spot positions provided consistently lower returns than the stocks alone when stock prices were up, but also lower losses for decreases in stock price. The deeper out of the money the position was at inception, the higher the average return. All covered calls displayed lower variance than the spot, with the in the money portfolio the lowest. As expected, each strategy provided for negative skewness, which got smaller for out of the money positions. In summary, the covered call on portfolios of stocks resulted in lower returns, lower variance and negative skewness. The option/paper strategy resulted in less extreme losses, lower returns, and greater positive skewness. The variance was generally reduced except in the case of the deep out of the money position.

In 1982, MSG turned their attention to put option positions. They examine uncovered put writing and the protective put. The study uses the same stock samples as the 1978 paper, but the period is extended for an additional 1.5 years. They use a put pricing model which requires a numerical solution. One of the principal theoretical differences in puts and calls is the increased occurrence of early exercise for the put.¹⁴

¹³ Option positions are often described by their "moneyness". For a call to be in the money, the strike price must be lower than the spot price. At the money positions have strike equal to spot, and out of the money positions are characterized by strike greater than spot. For the put the definitions of in and out are reversed.

¹⁴ See Jarrow and Rudd (1983), chapter 5, for the rationale behind early exercise of the put.

For this reason, the strategy of holding the position until maturity will understate profits. To account for this difficulty, MSG use the pricing model to develop an early exercise criterion. When asset price falls beneath the critical stock price, early exercise is assumed. For the put writer, this necessitates a reserve of cash set aside (in commercial paper) to provide for the required purchase of the security. All writing positions (again varied by strike/spot price ratio) provided decreased returns and lower variance. In fact, these positions closely resemble the covered call except that the puts provided low but positive skewness, rather than the calls' negative skewness. When early exercise is not allowed, the skewness of the written put positions is negative. Higher exercise prices resulted in greater risk and greater skewness. The protective put resulted in slightly lower returns than the stocks but provided for lower risk and much higher positive skewness.

As the first empirical observations of option/equity portfolios, MSG provide important evidence about the distribution altering characteristics of "innovative" securities. Although the patterns of returns are greatly expanded, it is not clear that large numbers of investors benefit from this effect. One difficulty is that the results presented depend on the assumed premium levels. MSG repeatedly warn the reader that actual premiums may vary substantially in some cases. The results, especially for the level of return, are also limited to the underlying return distributions provided during the study period.

Bookstaber and Clarke (1984, 1985) attempt to show the effect of options over a wider range of spot asset outcomes. They also provide a sensitivity analysis to adjust for the possible mispricing of Black-Scholes. These authors develop an algorithm which provides spot/option returns that are not dependent on idiosyncratic market conditions. The algorithm assumes that stock returns are generated by a single index market model. Random market returns can then be generated from a number of probability distributions. This allows for a generation

of option/spot returns over all possible return levels. These simulations provide results consistent with MSG. Covered calls decrease return and risk relative to the underlying stock position. In addition, the calls provided for negative skewness. The interesting insight allowed by tracing the entire return distribution is that the reduction in risk occurs because of the elimination of returns that would be higher than expected. In contrast to this result, it is found that protective puts decrease return and risk, but create positive skewness. Thus, both option strategies lower return and risk, but the protective put eliminates downside variance. The other important result from Bookstaber and Clarke (1984) is the sensitivity analysis provided for option premiums. Because of the possible model mispricing, premiums are purposely altered and the simulations replicated. The return-altering characteristics of options were not affected, indicating the robustness of the results.

B. MV EVIDENCE

Both MSG and Bookstaber and Clark avoid the issue of which investors might prefer the portfolio strategies studied. Later studies attempt to identify the benefit to be gained from these positions. The first of these rely heavily on the traditional MV framework. Mueller (1981) studies the covered call. He compares a stock only strategy to two stock/option portfolios, one out of the money at inception, the other in the money. From the possible combinations, Mueller uses the Markowitz selection algorithm to divide the three portfolios into groups which possess the same expected return. The in the money call portfolio consistently provides lower risk, leading the author to conclude that covered calls result in the elimination of risk without the corresponding reduction in return. Ritchken (1985) provides a similar study. He derives efficient frontiers for a variety of stock and option positions. The familiar result of less risk without less return is duplicated. In addition, portfolios containing options always enter the efficient set. Ritchken interprets

this result as an inefficiency in the market for options. Since options are derivative securities, which possess a zero net supply, their weight in the market portfolio should be zero. However, these results imply that the written position dominates the purchased option, implying that the assumed B/S prices are incorrect. The author calculates the prices which drive the calls to the theoretical zero weight and finds them to be lower than the Black/Scholes prices.

Studies of the desirability of portfolio insurance (protective put) also contain MV inconsistencies. Rendleman and McEnally (1987) cite this strategy as "one of the most successful investment management innovations of our time, having attracted over \$50 billion dollars of portfolio assets..".¹⁵ The intent is to set a floor on portfolio return, even if the floor is some positive return. The cost is invariably described as the foregone returns when the underlying portfolio performs well. The method of evaluating portfolio insurance used by Rendleman and McEnally is to compare the strategy to a strategy which maximizes the expected logarithmic utility of return. The cost of portfolio insurance is taken to be the difference between the protective put return and the return on the "optimal" portfolio. The authors compute random stock returns and corresponding holding period returns for insurance strategies with three different floor values. Option prices were derived from the Black-Scholes valuation model. As expected the insured portfolio provided consistently lower returns than the optimal strategy. The difference becomes smaller for lower floors and for greater stock volatility. The insured portfolios outperformed the optimal only about 40% of the time. The higher the floor, the more frequently the investor had to settle for this minimum return. The insured portfolios provide a narrower dispersion of returns. An

¹⁵ Although exact figures are difficult to find, there is evidence that many portfolio insurance customers decreased usage after the October 1987 stock market difficulties. Prior to the 19th, Leland, O'Brien, and Rubinstein (LOR), the firm which invented portfolio insurance, had over \$60 billion in fund assets. This value fell to about \$30 billion in the following months. See Kupfer (1988).

unusual result is obtained when the authors alter the coefficient of risk aversion for the assumed utility function. For the less risk averse investors, the cost of insurance is very high in terms of foregone returns, yet the optimal portfolio for these investors does contain purchased puts. Investors with greater risk aversion can earn closer to the optimal return with insurance, but their optimal portfolios contain written, rather than purchased, puts. The authors conclude that portfolio insurance strategies are suboptimal for both types of investors, but more aggressive investors should hold portfolios with some insurance component. This analysis is consistent with the work of Leland (1980), who provides a theoretical examination of the utility functions of investors who might benefit from portfolio insurance. His conclusions are that investors with risk tolerance that increases faster than average or with above average market expectations might benefit from portfolio insurance.

Garcia and Gould (1987) also examine portfolio insurance. They compare the foregone return for different floor levels to the return on the S&P 500. They conclude that lower floors provide less risk and higher costs. Clarke and Arnott (1987) use the algorithm described by Bookstaber and Clarke (1984) to measure the cost of portfolio insurance. Once again the insurance strategy lowers return, but lower floors provide lower costs and greater variance. These authors also report skewness statistics which indicate that higher floors increase the positive skewness more than lower floors. Zhu and Kavee (1988) provide similar findings to the above studies. Insurance strategies provide for lower returns and risk than a buy and hold stock strategy. Greater market volatility results in lower returns for both the spot and insured positions, but the risk of the protective put increases less.

Bookstaber and Clarke (1984) use their findings about the effect of options on the skewness of equity portfolios to question the use of MV analysis for these portfolios. The empirical studies described above seem to reinforce this opinion. The two general conclusions which can be drawn

are that the covered call can reduce risk without the theoretical decline in return and that portfolio insurance seems to bear a high cost in foregone returns. The first result clearly does not seem to be reconcilable with MV. Such a position would be taken by investors until the demand to write calls would drive prices down, eliminating the utility enhancement. The conclusion that protective puts are too expensive is questionable in light of the observed popularity of the strategy among investors.

These studies of portfolio insurance, as well as those for covered calls, have in common an evaluation based on return and risk, with risk consistently measured in terms of dispersion about an expected or average value of return. The general results that the short call strategy enhances performance by reducing variance without reducing return and that the protective put exposes the investor to large decreases in return both neglect the explicit interaction of the asymmetric nature of option portfolio distributions with the mean and variance. To give due credit, several of the authors mention this inconsistency, and the entire analysis of insurance strategies was predicated upon the diminished downside outcomes, but none of the studies attempted any correction for the skewness of portfolio returns. To explain the use of options, investigators must look beyond the first two moments of the return distribution. We now turn our attention to studies which do this by eliminating the restriction that investor utility is depends on only the first two moments.

C. SD EVIDENCE

The assumption needed for TSD has been shown by Arditti (1967) and others to imply a preference for positive skewness. For this reason, and the observed skewness of option portfolios, Booth, Tehranian, and Trennepohl (1985) use SD, as well as other methods, to identify efficient option portfolios. Four portfolio strategies are investigated; stock only,

purchased calls, a combination of purchased calls and treasury bills, and the covered call. Stock prices were gathered for the period 1963 to 1978. Black-Scholes call premiums were calculated assuming a six month holding period. The size of the efficient sets for MV and SD were similar but the content of the portfolios was different. Only 39% of the option portfolios selected with MV were also selected with SD. In contrast, 61% of the stock portfolios were identified by each method.

The authors also report distributional measures for each type of portfolio which provide some indication of the effect of diversification. As the number of securities is increased, the mean and positive skewness of the option only portfolio slightly decreased, while variance was halved. The stock only portfolio showed no decrease in mean, a slight decrease in variance, and a large increase in positive skewness. The option/bill strategy provided outcomes similar to the stock only, except that skewness decreased. Finally, the study showed little change in mean and variance but a large decrease in negative skewness as the number of securities was increased in the covered call portfolio. The efficient sets contained portfolios with options for each criteria. These results indicate that the covered call is not as dominant as the earlier MV results indicate. The possibility of skewness as a criterion for performance seems to offset the advantage to the covered call suggested by earlier studies.

Trennepohl, Booth, and Tehranian (1988) perform similar analysis on the protective put, put writing, stock, and covered call. It is determined that SD provides the ability to discriminate between alternatives with different levels of skewness which provides for a more reasonable delineation of the efficient set of portfolios. In contrast to the MV results reported above, portfolio insurance is not a suboptimal strategy due to its high cost. The increases in positive skewness which result from the combination of stocks and puts offsets the decline in return. In addition each strategy is significantly represented in the

efficient set, with only naked put writing faring poorly.

These results serve to highlight the importance of the third moment to the problem of investment selection. However, for financial economists to develop a stronger theory of investor utility, it is important that the relationships among the criteria of choice be more strongly identified. While SD shows the importance of skewness, we are unable to derive such a strong relationship from its results. The mechanics of SD also result in the frequent failure to distinguish among alternatives. In Booth, Tehranian, and Trennepohl (1985) a mean/semivariance and a mean/skewness criterion result in smaller efficient sets than either SD or MV. This indicates the ability to discriminate more finely than SD. In the following section, the results provided from the analysis of skewness preference are reviewed.

D. SKEWNESS PREFERENCE EVIDENCE

Arditti (1967) uses regression to test the impact of several variables on the returns of a wide variety of stocks. In addition to variance and skewness, the author looks at the market correlation coefficient, industry variables, the debt ratio and the dividend payout ratio. Regressions with skewness and variance indicate that both variables are significant and correctly signed. Increased risk results in higher returns. Positive skewness reduces return. Several other studies provide similar results. Arditti (1971) finds the predicted relationship between skewness and return for mutual funds. McEnally (1974) finds that the relatively low returns generated by high risk (beta) common stocks may be attributable to positive skewness. High beta stocks have consistently higher positive skewness. Beedles and Simkowitz (1978) duplicate these results. In fact, the only published evidence which directly contradicts the findings of relevance for skewness is that of Francis (1975).

Jean (1971) and Arditti and Levy (1975) develop skewness models in a portfolio context. Krause and Litzenberger (1976) derive and test an

equilibrium model which they felt overcame the empirical difficulties of the Sharpe (1964) and Lintner (1965) two moment models.¹⁶ The Krause and Litzenberger model can be expressed as

$$E[R_i] - R_f = b_1\beta_i + b_2\gamma_i \quad (3)$$

where the beta is the systematic risk of the i^{th} asset with the market and the gamma is the systematic skewness with the market. These authors calculate gamma as

$$\frac{[\sum (x_{Mt} - \bar{x}_M)^2 \times (x_{kt} - \bar{x}_k)]}{\sum (x_{Mt} - \bar{x}_M)^3} \quad (4)$$

The predictions of this model are supported. The intercept is not significantly different than zero and the beta and gamma are significant and correctly signed. The predicted sign of gamma depends on the underlying market skewness. In periods where the "market" experiences returns below the mean, an asset with a positive coskewness should also tend to provide lower than average returns. Both the market and the asset would be negatively skewed, and, if the theory accurately predicts reality, investors would require a higher return. If the market is positively skewed, portfolios with positive co-skewness should have lower returns. Friend and Westerfield (1980) retest this model, varying the sample, market index, and grouping procedure. The results concerning gamma were supported, but problems with beta and the intercept were discovered which coincided with difficulties in the Sharpe/Lintner model. Junkus (1991) tests this model with financial and agricultural futures contracts and finds no significant systematic skewness effect.

The results in each of the studies of this equilibrium model were obtained in the presence of a high degree of correlation between the risk measure and skewness measure. As can be seen in footnote 3, the

¹⁶ Miller and Scholes (1972) examine the empirical evidence concerning the Sharpe/Lintner model. It is interesting to note that one of the culprits for poor results is skewness in the sample of returns used.

computation of these measures is very similar. Each contains expressions of deviations from the mean raised to either the second or third power. In addition, the definition of relative skewness requires the use of the standard deviation. Beedles and Simkowitz (1980) discuss these and other measures. The raw skew is criticized because of its sensitivity to the size and starting point of the estimation interval. In addition, the authors cite the nonnormality of the raw skew's distribution which may make hypothesis testing difficult. Fogler and Radcliffe (1974) and Hawawini (1980) find evidence of the estimation sensitivity and recommend the use of the relative skewness measure. However, Beedles and Simkowitz note that this measure is also sample sensitive, and suggest an index of asymmetry as an alternative measure. These authors estimate this index as

$$\hat{S} = (v_1 - v_2) / (v_1 + v_2) \quad (5)$$

where v_1 is the number of observations falling more than two mean absolute deviations (MAD) above the median, and v_2 is the number falling more than two MADs below the median. Their findings indicate that the use of this measure provides the same conclusions about return asymmetry as the relative skew. However, no article has found conclusive evidence concerning the best estimate of asymmetry. Beedles and Simkowitz also use the mean absolute deviation as an alternative to variance, citing its relative insensitivity to the extreme observations noted in asymmetric distributions.

Only two papers test skewness models on option portfolios. The first is Wingender (1985). The portfolio distributions described by MSG for covered calls and protective puts are replicated and used to determine the cost of both raw and relative skewness. If the previous conclusions are correct, increases in positive skewness should lower return for portfolios with the same variance. The regressions used both variance and skewness as independent variables in explaining portfolio return. The sign of the skewness coefficient is consistently significant and correctly signed.

However for the case of covered calls, the regressions provide the incorrect sign for the variance coefficient. The author suggests that this indicates either multicollinearity or model mis-specification. Unfortunately, the author also finds that the cost of skewness seems to vary depending on how the skewness was generated. To further explore this phenomenon, the author arranges the portfolios into ten different variance classes. Within each class, regressions are run which depend on return being a function of only skewness. The negative impact of skewness on return becomes more pronounced with this effort, but the covered call still provides puzzling results. The cost of skewness generated with calls seems to be less expensive than that generated by puts. The risk groupings used in this study could be the cause of this effect. The covered call strategy consistently generates portfolios with lower variance than the protective put, thus the low risk classes tend to be predominantly covered calls while the high risk classes contain more protective puts and stock only portfolios. As noted earlier, although the variance of covered calls and protective puts might be similar when compared to equity returns, they are the result of the elimination of different types of uncertainty. The covered call removes upside risk, while the protective put eliminates the downside. By failing to include alternatives to raw and relative skewness as measures of asymmetry, or variance as a measure of risk, Wingender is unable to completely support the predictions of skewness preference. An additional explanation for the inconsistent skewness "prices" found in Wingender is the possibility that the trading activities of convexity/concavity preference groups, as described in Leland (1980), offset the effect of those that are averse to negative skewness. Thus, the extra return associated with negative skewness may be eliminated by premiums for concave payoffs, while the lower returns accompanying positive skewness might be magnified by premiums for convex payoffs.

The second test of skewness preference in option portfolios is

Cotner (1991) who uses call options on S&P 100 index to investigate systematic coskewness. The author finds significant support for both covariance and coskewness as important factors in the pricing of equity index models.

Although the studies of skewness preference models are fraught with methodological problems which prohibit its unconditional acceptance, they do provide some evidence that skewness may be important in asset selection. It should be reiterated here that none of the evidence to date relays any information about the effect of skewness on debt option portfolios. This suggests a final alternative for the present study; to use a multivariate model similar to those found in the literature investigating debt securities. The following section presents a brief review of the evidence from models of this nature.

E. MULTIVARIATE MODELS

Although frequently used in the study of debt securities, multifactor models, other than Kraus and Litzenberger described above, have not been applied to option portfolios. Fisher (1959) used a multivariate model to explain effect of default risk and marketability on the risk premiums on corporate bonds. Numerous studies mimic this approach. For brevity, only one will be discussed here. Boardman and McEnally (1981) improve on the methodology of Fisher by controlling for default risk and including other bond characteristics, such as call and sinking fund provisions, payment priority, and industry classifications. The authors conclude that the industry variable provides the most important influence on bond price, although other variables did have effect. The only one relevant to the study of Treasury portfolios is the call provision, which decreased price.

This type of model seems to see continued use today because of a general lack of support for the ability of asset pricing models which rely on systematic risk measures to explain bond returns. This lack of support

is discussed and verified in Gultekin and Rogalski (1985). They cite the Boquist, Racette, and Schlarbaum (1975) finding that the beta for Treasuries is nonstationary. This is due to the relationship between beta and duration, a measure of the bond's interest rate risk which varies with maturity. Friend, Westerfield, and Granito (1978) test CAPM on corporate bonds and find that residual variance is at least as important in explaining return as beta. The advent of the APT provided an alternative to the CAPM for explaining bond returns.

Several tests of the APT have resulted in consistent results. Roll and Ross (1980) found that three or four factors were relevant for equities, different groups of stocks provided identical intercepts, and that the addition of a security's own variance to the risk premia estimating equation did not improve the explanatory power when compared to the factor weights alone. Chen (1981) provides similar results. These studies used relatively small numbers of securities for the groups tested. Dhrymes, Friend and Gultekin (1984) find that as group size increases, so does the number of factors. These authors also find inconclusive results concerning the intercept. Chen, Roll and Ross (1983), hypothesize a specific set of factors and investigate the ability to explain the covariance of securities. Inflation, a maturity spread factor, a default risk factor, and production growth seem to explain much of the covariance.

Gultekin and Rogalski (1985) test the APT with Treasury bond data from the CRSP tapes. They form constant maturity portfolios to correct for the nonstationarity of risk factors noted above. Continuously compounded monthly raw returns and excess returns were each used for the test. The type of return did not alter the results. The results of the factor analysis indicate that at least two factors are relevant for Treasuries. The authors also test various forms of the CAPM with this data. Although their findings indicate that the multivariate approach performs better than the single index approach, neither is completely satisfactory.

CHAPTER 5

ISSUES AND HYPOTHESES

Much of the literature concerning options is designed to introduce potential users to the perceived benefits of this type of security. Unfortunately, many of the conclusions drawn in this work are not fully substantiated. Although theory supports the use of options on the grounds that they provide return outcomes that are otherwise unavailable, empirical evidence is not complete. The only distributional evidence which exists for option portfolios concerns equity options. All of this evidence depends on model generated option prices, and half relies on simulated equity returns. This evidence suggests, in accordance with theory, that option portfolios, particularly the covered call and protective put, do provide asymmetrical returns. The covered call should have lower variance than the spot and should produce negative skewness. The protective put also lowers variance, but provides for positive skewness. No empirical analysis of the distributions provided with the TBFO exists, although much of the practitioner literature concerning this newer security implies that the asymmetry found in the stock option studies extends to the futures option.

The evidence concerning the desirability of distributions produced by the covered call and protective put is even less convincing. MV analysis is clearly not adequate, primarily because of its failure to account for asymmetry. The result of this failure is that researchers draw conclusions about option portfolios which are in direct conflict with the principles of market efficiency and rational investor behavior. SD, although it overcomes the restrictive assumptions associated with mean/variance, does not allow investors to determine which security characteristics cause one alternative to dominate another. The skewness

preference models lead to conflicting results about the relationships among security attributes. The failure to obtain the correct sign for the variance term and the different return effects of positive and negative skewness do not lend support to these models. A methodology left untried is a multivariate model like those used in the study of debt securities. This allows the investigator to choose attributes suggested by the theoretical models in the effort to identify the significant characteristics of option portfolios.

This study is designed to examine whether options represent a significant financial innovation. This question raises two major issues concerning the use of option strategies. The first issue is whether the findings concerning the distributional characteristics of equity options can safely be extended to other types of options, in this case the TBFO. The second issue is the nature of investor utility. Do users of the TBFO pay for the characteristics associated with option strategies. Even if the TBFO provides the expected distributional characteristics, it must be determined whether investors price these characteristics in the market.

A. DISTRIBUTIONAL CHARACTERISTICS

Theory and empirical evidence from equity options suggest that both the covered call and protective put reduce risk and provide skewness. The covered call is expected to provide negative skewness, while the protective put should result in positive skewness. The extent to which the TBFO, when combined with bond positions, provides these results is an empirical question. A related topic is the extent to which various measures of risk (variance, MAD, and duration) and asymmetry (raw skew, relative skew, co-skewness and the skewness index) provide similar indications of the shape of resulting distributions. This research will address this issue by forming portfolios designed to possess a wide range of distributional characteristics. Comparisons of the return distributions indicate to what degree the TBFO conforms to expectations.

B. UTILITY HYPOTHESES

This set of hypotheses addresses the effect of distributional and other portfolio characteristics on the level of portfolio return. Traditional investment theory suggests that increasing levels of risk must be accompanied by increasing return. If the conclusions of skewness preference analysis are valid, the occurrence of negative skewness should be accompanied by an increase in return. Positive skewness should be accompanied by decreases in return. The work by Leland (1980) suggests alternative rationale for option holding, allowing the examination of the skewness preference hypothesis in a new light. The possibility that the investor chooses to write calls because of the concavity of the payoff function directly conflicts with the theoretical effect of negative skewness on return. The effect of risk and skewness have to be determined before it can be concluded that the covered call and the protective put satisfy the hedging and asymmetry motivations of financial institutions. To provide linkage to the usage of a multivariate model for this purpose, other characteristics will be included in the tests. The first characteristic is the call provision found in Treasury bonds. Multivariate models of bond return suggest that investors require higher return to accept the uncertainty associated with this provision. The call provision is also of interest because of possible effects on the return distribution. A callable bond may be viewed as a portfolio containing a debt security and a call option sold to the borrower. In addition, tests of APT suggest that macroeconomic variables affect security returns. Chen, Roll, and Ross (1983) find that industrial production, inflation, and two yield spread variables explain return differences among common stocks. For the case of Treasury portfolios, the maturity spread (long Treasury rate minus short Treasury rate) is the most likely candidate to provide the necessary linkage of this study to prior multivariate work.

The tests described in the next chapter also are designed to avoid the methodological difficulties encountered in prior studies of the

hypotheses detailed above, specifically the suspected multicollinearity between variance and skewness. The computation and utilization of alternate risk and asymmetry measures as independent variables in the model should result in discovery of a combination of distributional measures which avoids or reduces any of the suspected multicollinearity.

CHAPTER 6

DATA, METHODOLOGY, AND DESCRIPTIVE STATISTICS

In this chapter the preliminary characteristics of the spot securities and the data sources are described. The procedures used for the formation of the three types of option positions used by banks and dealers, as well as the selection and calculation of the values of the independent variables is then detailed. In addition, the statistical methodology is described, along with the expected results.

A. DATA

The period to be examined in this study is 1983 to 1990, a recent time frame which has not been subjected to tests of the option portfolio strategies. In addition, this period is characterized by an almost trendless series of Treasury returns (see Figure 2). Even the events of October 1987 did not generate returns different from the remainder of the study period. Data for the spot securities come from the 1990 Government Bond Files of the Center for Research in Security Prices (CRSP), which contain returns and other security characteristics for all Treasury issues. Bonds and notes that contain at least one monthly return over the test period and that contain no unusual tax provisions were selected. This resulted in a sample of 16,737 usable monthly bond return observations. Of these returns, 2,140 were from bonds with call provisions, 3,211 were noncallable notes, and the remaining 11,386 were noncallable bonds. Information collected from CRSP for each observation includes the unadjusted return, amount outstanding, price, and duration. Each observation month contains between 140 and 560 bonds, 19-23 of which contain call provisions. The range of durations in each month has an interval sufficiently wide to suggest substantial dispersion of interest

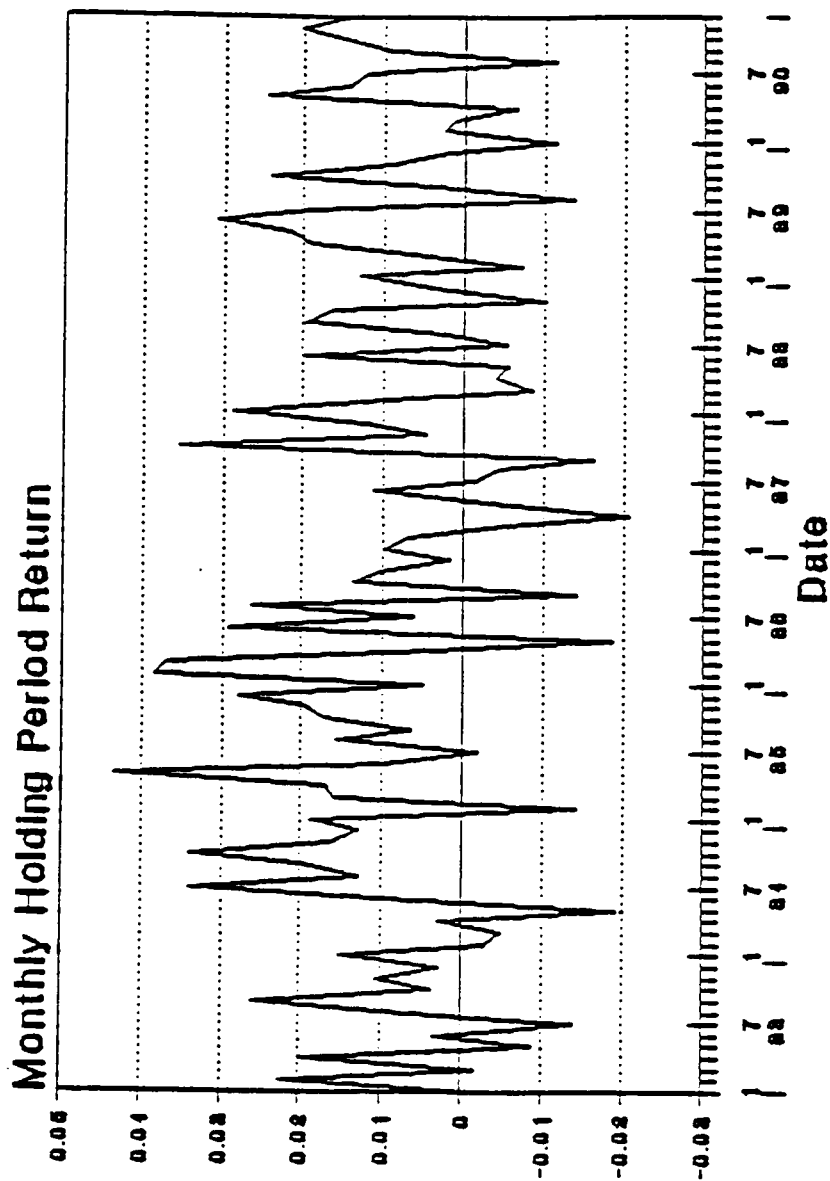


Figure 2: Study Period Treasury Market Returns

rate risk. Although more sophisticated measures of interest rate risk exist, the data for duration¹⁷ are easily obtainable from the CRSP tapes, and there is a large body of evidence which supports the use of duration as an interest rate risk measure.

1. Formation of Spot Portfolios

These bonds will be divided into 42 portfolios for each of the 96 months, as shown in Panel A of Figure 3. Six portfolios will contain only callable securities, to allow for a test of the effect of the call provision on portfolio return. The non-callable bonds available in each month are first ranked according to duration, then placed into one of six groups based on this ranking. The first group contains the bonds with the lowest duration, the second group has bonds with slightly higher duration, and so forth. This monthly segmentation into duration groups insures a wide range of interest rate sensitivity in the portfolios, and allows for a test of any interaction between the original level of risk and the effect of the option strategies. To eliminate the possibility of systematic differences in the portfolios within each duration group, securities are randomly assigned to one of six portfolios, resulting in a total of 36 noncallable portfolios. This randomization is achieved by creating an additional variable, the scaled product of the duration and return of each security. The bonds and notes were then ranked according to this meaningless variable within each duration group, and assigned portfolio numbers systematically. This likely eliminates the possibility of the first portfolio containing the lowest duration securities from that group. It also increases the probability that the six portfolios in each

¹⁷ The duration measure used for the CRSP Bond Files is calculated as

$$\frac{\sum t_j P_{tj}}{\sum P_{tj}} - t_0$$

where P_{tj} are the present values at time $t = 0$ of j cashflows promised at subsequent times $t_1, t_2, \dots, t_n$. This calculation provides a duration measured in days.

Panel A: Original Spot Portfolios

Bond Type		Number of Portfolios
Short Duration/No Call	Group 1	6
	Group 2	6
	Group 3	6
	Group 4	6
	Group 5	6
Long Duration/No Call	Group 6	6
Callable	Group 7	6
Total		42

Panel B: Option Strategies

	All	Call/In	Call/Out	Put/In	Put/Out	Spot
Callable	6	1	1	1	1	2
Non- Callable	36	6	6	6	6	12
Total	42	7	7	7	7	14

Figure 3: Segmentation of Portfolios

group are similar. The return of each security will be weighted by its publicly held market value to obtain portfolio return,

$$r_b = \sum (m_i / M) r_i \quad (6)$$

where r_b is the portfolio return, m_i is the market value of the i^{th} bond, M is the total market value of all bonds in the portfolio, and r_i is the return on the i^{th} bond. Investment in the portfolio is assumed to be \$100,000 to correspond to the denomination of the option contract.

2. Segmentation By Option Strategy

Two thirds (28) of these 42 spot portfolios will then be employed in the option strategies. See Figure 3, Panel B, for a summary of the resulting portfolios by position. Of the six callable portfolios, two will be randomly selected for utilization in the covered call strategy and two into protective puts. Twelve covered calls and twelve protective puts, two of each from every duration group, will be created from the noncallable portfolios.

Following the convention established by MSG, half of the protective puts and covered calls will be in the money, half out of the money. The futures contract which best follows changes in spot prices should be that nearest to maturity. Thus, options on this contract will be selected based on the ratio of strike to futures price; one in the money and one out of the money. The futures option chosen is that which will be closest to maturity, but still trading, at the end of the observation month.¹⁸ Price data for each option is obtained from the Wall Street Journal, and verified with price data from the New York Times.

¹⁸ For example, at the beginning of May 1983, the nearby option is on the June futures contract. However, this option will no longer be trading at the end of May, requiring selection of the September futures option. This procedure also eliminates the occurrence of early exercise. Overdahl (1988) finds that only one-tenth of a percent of TBFO's are exercised with more than one week to maturity.

B. METHODOLOGY

The tests described in this section are designed to provide information about the two issues raised in Chapter 5. The first issue concerns the nature of the return distribution generated by using the TBFO to alter the spot portfolio. This will indicate whether the futures option provides results similar to the equity option. The second issue concerns the effect of various portfolio characteristics on portfolio return.

1. Calculation of Variable Values

For each portfolio, cashflows at the beginning of the month are assumed to include outflows for the spot securities, and an inflow from the writing of a call or an outflow for the purchase of a put. At the end of the month, the bonds are sold and options liquidated. The bond return includes coupon payments. For protective put positions, the option is sold at month end; for the covered call the option is purchased. Thus the total option portfolio return is calculated as

$$r_p = \frac{[r_B (100000) + (P r_o)]}{(100000 + P)} \quad (7)$$

where r_p is position return, P is the option premium (negative for call writing), r_o is the option return, and other variables are as in Equation 5, page 43.

Variance, duration¹⁹, and mean absolute deviation will serve as measures of risk. The third moment, relative skewness, and the index of asymmetry described in Beedles and Simkowitz (1980) will serve as measures of the higher order impact. Each of these variables are calculated by using the return observations from the previous 24 months, exclusive. Thus, the first value for each of the six measures is for January 1985, but is calculated based on the observations for January 1983 through December 1984. In addition, two measures of co-skewness are

¹⁹ Garman (1985) shows the calculation of duration for call and put options on futures contracts.

calculated for each portfolio and month. The first uses the value weighted returns of all Treasuries outstanding that month as the "market". The second market proxy will be the weighted average return of the forty-two portfolios. The previous 24 monthly observations are used to determine the mean needed for calculation of values for co-skewness (Equation 4, page 42).

The yield spread is included to provide linkage to the multivariate model of Chen, Roll and Ross (1983). It is calculated each month as the promised yield on the TB with the greatest time until maturity minus the shortest maturity TB yield. In addition, a base interest rate series is included to account for macroeconomic effects. Four different series were used. The values for these series are calculated as the equivalent monthly return²⁰ on the Treasury Bill closest to maturity, the Treasury Bill closest to one month until maturity, the 30 day dealer-placed commercial paper quote from the New York Times, and the Federal Funds quote, also from the Times. This variable should account for any variation in bond returns associated with changes in market conditions between periods.

2. Distributions

Summary statistics of the return, risk measures, and skewness measures for the 42 portfolios are provided in Table 1. For each calculated average, two tests of significance were performed, the T test and the signed rank test. Both test the hypothesis that mean levels are different from zero. The T test assumes normality, while the signed rank test is nonparametric in nature. In all cases, as predicted by theory, the addition of futures options to the T-bond portfolios resulted in decreased

²⁰ Treasury bill data quotes are calculated on the "bankers discount" basis. To adjust to the true yield the following formula is used:

$$IR = \frac{365 \times Disc}{360 - (Disc \times days)}$$

where IR represents investment return, Disc is the discount yield, and days is the number of days to maturity. This annual yield figure, as well as the annual figures for the federal funds and dealer paper quotes are then converted to a monthly basis.

Table 1: Summary Portfolio Statistics (1985 - 1990)¹

Spot Covered Call Protective Put

Panel A: All Portfolios (1008 observations, 14 portfolios)

Return	.00899	.00674	.007654
Variance	.00042	.000304	.000275
Duration	1581	1615	1550
MAD	.01383	.012217	.011646
Raw Skew	.000002	-.0000039	.0000064
Relative Skew	.074811	-.70493	.948835
Skew Index	.10294	-.6832	.709028
Coskew (spot)	1.207417	3.891843	-3.29546 ²
Coskew (Port.)	3.159974	.828513 ³	-.98849 ³

¹ p levels for all t and signed rank tests < .05 unless noted

² signed rank test not significant (p > .05)

³ t test not significant (p > .05)

Table 1: (Summary Statistics continued)¹

Spot Covered Call Protective Put

Panel B: Noncallable Portfolios (864 observations, 12 portfolios)

Return	.008761	.006213	.0071
Variance	.000306	.00028	.000221
Duration	1316	1345	1289
MAD	.011544	.011689	.010615
Raw Skew	.000001	-.0000048	.0000045
Relative Skew	.063613	-.80732	.935331
Skew Index	.083603	-.69475	.69865
Coskew (spot)	1.042824	3.806599 ²	-3.35364 ²
Coskew (Port.)	2.51022	.208089 ^{2,3}	-1.54369

¹ p levels for all t and signed rank tests < .05 unless noted

² signed rank test not significant (p level > .05)

³ t test not significant (p level > .05)

Table 1: (Summary Statistics Continued)¹

Spot Covered Call Protective Put

Panel C: Callable Portfolios (144 Observations, 2 Portfolios)

Return	.010411	.0099	.010974
Variance	.001168	.000445	.000596
Duration	3175	3239	3115
MAD	.0276	.015384	.017828
Raw Skew	.0000073	.0000013 ³	.000018
Relative Skew	.141998	-.09057 ³	1.029859
Skew Index	.218981	-.61389	.771296
Coskew (spot)	2.194975	4.403304	-2.94638 ³
Coskew (Port.)	7.0584	-.61389	2.342708

¹ p levels for all t and signed rank tests < .05 unless noted

² signed rank test not significant (p > .05)

³ t test not significant (p > .05)

return, with the covered call providing a lower average value (.00674) than the protective put (.007654). In addition, the protective put provides for lower average dispersion than the covered call for the variance measure (.000275 to .000304) and the MAD (.011646 to .012217). Both option strategies have less dispersion than the spot only positions. The results for asymmetry also provide general support for the predictions of theory. The covered call strategy turns the slightly positive raw skew of the spot portfolios (.0000021) into -.0000039. The protective put triples the spot's positive skewness (.0000064). The averages for the relative skew and the skew index support this asymmetry effect.

The information from the two coskewness measures for the option positions is disappointing. The coskewness values indicate that the spot only positions have asymmetry which move with both indices (1.207 and 3.159). In addition, this group of portfolios exhibits more right skewness than either index.²¹ This is reasonable because the spot portfolios exhibit greater dispersion than the indices. The values for the covered calls and protective puts do not have the sign predicted by Kraus and Litzenberger (1976), although this question is difficult to address in light of the small positive or zero skewness of the indices. As can be seen in Equation 4, page 42, deviations of the index about the mean will have a greater impact on the coskewness measure than will deviations in the portfolio. With a large number of the index observations indicating near zero deviations from the mean of the market or the portfolio return, some observations may be unduly influencing the coskewness values.²² In

²¹The mean value of the spot index is .008692, The variance is .000213. The raw skew is .00000013, much smaller than the portfolios studied. The t value for the null hypothesis that skewness is equal to zero is 1.5277, which is significant at 10%. The signed rank p level is .1351. For the portfolio index, the mean, variance, and skewness are .007872, .00001, and .00000038, respectively. The t value is zero.

²² The distributional characteristics for the indices did not change materially upon elimination of the callable bonds, which were suspected to be a possible cause of any outliers. The mean, variance, and raw skew for the spot index became .00874, .000213, and .000000013 after the deletion. For the portfolio index summary measures became .007797, .000063, and

addition, the significance tests of the option portfolio coskewness averages indicate a higher probability of error than most other variables in Table 1. The great possibility of measurement error in the raw skewness of the indices indicates the coskewness measures are spurious.

Turning to those portfolios which contain only noncallable T-bonds, similar results are obtained. Both option strategies lower return and variance, with the put providing higher returns and less dispersion than the covered call. However, when dispersion is measured with MAD, the covered call shows slightly higher levels of risk (.011689) than the spot (.011544). The findings for skewness are consistent with theory and the results for the entire sample, slightly positive skewness for the spot, enhanced positive skewness with the addition of puts, and negative skewness from the covered call. The difficulty with the coskewness measures persists and the reliability of the estimates falls appreciably.

The portion of the sample consisting of callable bonds provides a greater range of inconsistencies. In effect, a callable bond is already an option portfolio. The purchaser of a callable bond holds a combination of a noncallable bond and a short call on that bond written to the Treasury Department. Theory suggests that this covered call should provide negative skewness. The raw skewness coefficient for the spot only callable portfolio is positive (.0000073), but greater than that of the noncallable spot portfolios (.0000012). The raw skew for the covered call is also positive (.0000013) but lower than for the callable spot portfolios. This finding is similar to Booth, Tehranian, and Trennepohl (1985), who report that as additional written calls are added to a covered call portfolio, the negative skewness declines. The experience in the present study is that positive skewness, as measured by the raw skew, persists. The other skewness measures typically bear the same sign as the raw skew with larger absolute values, but do not for the covered call. This indicates that the

.00000023. More importantly, upon elimination of the callables bonds, the extreme observations reported by PROC UNIVARIATE in SAS did not change.

positive raw skew measure might be the result of the small sample of callable bonds used for this study. Both the relative skew (-.09057) and the index (-.61389) indicate negative skewness for the covered call. In addition, the coskewness measures with all 42 portfolios does show the expected sign for both puts and calls.

In general, Table 1 indicates that using callable bonds with any of the strategies provides greater dispersion and return than noncallable portfolios. This result may be a duration effect, as all callable bonds possess greater duration than the highest non-callable duration group. Also, this type of bond seems to provide a range of skewness which is slightly higher than for the corresponding noncallable strategies. In addition, it would appear that the nature of the distributional effects of the TBFO is similar to the evidence gathered with the equity option. Each option strategy provides the expected decrease in dispersion and the appropriate direction of skewness. In general, the coskewness variables, because of measurement problems, do not give a clear indication of this effect. Low levels of significance, and inconsistent and opposite signs lead to an inability to draw conclusions. The comparisons made with ANOVA and the Kruskal-Wallis test described in Chapter 7 below should provide useful information about the coskewness measures as well as any differences among the three strategies for the other distributional measures. Chapter 8 investigates the pricing of these characteristics with multiple regression models.

CHAPTER 7

EMPIRICAL RESULTS: DISTRIBUTIONS

This chapter provides empirical information about the first major issue addressed in this study, the nature of the distributional change provided by the use of TBFO's. In Part A, the rationale behind the tests is presented. Part B discusses the results pertaining to this issue. These results are then used to evaluate the differences in the distributions of the spot securities, the covered calls, and the protective puts. The second issue, the economic impact of the portfolio characteristics on return is addressed in Chapter 8.

A. KRUSKAL-WALLIS AND ANOVA

The purpose of the tests described in this section is to determine the differential distributional aspects of the three different portfolio strategies. Each type of test has strengths and weaknesses for this purpose. The first test will be the Kruskal-Wallis rank test (Neter, Wasserman, and Kutner, 1985). The second is the F test for analysis of variance. Each tests for different mean values among various treatments. The primary difference is the assumption of the nature of the distributions for the test variable. ANOVA assumes the normal distribution, while the distribution-free Kruskal-Wallis test only assumes similar distributions among the treatment groups. Neter, Wasserman, and Kutner state that the F test (ANOVA) is robust against departures from normality, but the added safety of the Kruskal-Wallis test suggests that its use is appropriate for this study. The distributions of the eight distributional variables appear to at least approach nonnormality. Additionally, the Tukey test of differences among pairs of means is applied. This is a multiple comparison method which determines which of

the treatment means cause F test rejections.

The basic procedure for the Kruskal-Wallis is to pool the three samples (spot, covered call, and protective put), rank the observations for the test variables (variance, MAD, raw skew, relative skew, and the skew index), and determine the mean ranks for each strategy. In this case, the pooling will occur along two different classification variables, the duration group and the moneyness. This allows differences to be identified from rather homogeneous subsets of the data. For the moneyness classification, the spot only positions are temporarily eliminated. (Spot positions cannot be segmented by moneyness). The test statistic is calculated within each classification as

$$\frac{\sum n_i (\bar{R}_i - \bar{R})^2}{\left[\frac{n_T (n_T + 1)}{12} \right]}$$

where the numerator represents the sum of the squared differences between classification mean and grand or overall mean, and the denominator is the variance of the ranks. This statistic is distributed as χ^2 with $k - 1$ degrees of freedom, with k number of treatments. Large values of this statistic indicate that a group is very different from the pooled sample and lead to rejection of the null hypothesis that all treatment means are equal.

The second test of the distributions is the F test from ANOVA. This test also detects differences in the means of various treatments. The application here is the multi-factor ANOVA model described in Neter, Wasserman, and Kutner (1985). This model will be applied sequentially, first to the dispersion measures²³, then to the asymmetry measures. Each of these seven variables, covering 72 months and 42 portfolios, will serve as the dependent variable in a multivariate ANOVA model. The form for this

²³ Because of the experimental design, ANOVA was not performed on the dispersion variable duration. The segmentation of portfolios by this variable makes such analysis unnecessary.

model will be

$$Y_{ij} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + e_{ij} \quad (9)$$

where the Y_{ij} is the level of the examined variable, subject to two distinct treatments, the α_i representing the strategy, the β_j representing first the duration group, then the moneyness of the option. The μ represents the average level for all treatments combined, and the e are assumed to be mean zero, independent error terms. In addition, the procedure can examine the interaction of portfolio characteristics. The $\alpha\beta$ term represents either the strategy/duration or the strategy/moneyness effect. The j first ranges from group 1 (low duration) through group 6 (high duration) for the first application, then from 1 (in the money) to 2 (out of the money). Although the portfolios containing callable bonds were not intentionally ranked by duration, each had a duration higher than the portfolios in group 6.

Although examination of the summary statistics for variance and skewness indicates that there may be distributional differences between the spot, covered call, and protective put, the use of the ANOVA technique will determine the significance of any differences. In addition, the Tukey procedure performs simultaneous pairwise comparisons of every treatment level mean to every other treatment mean under a single alpha level to determine which treatment level differences is the cause of a significant F value. Results of these tests are located in the following section.

B. PORTFOLIO CHARACTERISTICS AND DISTRIBUTIONAL EFFECTS

1. Kruskal-Wallis

Table 2 provides the results of the nonparametric Kruskal-Wallis test for differences among the spot, covered call, and protective put strategies. The outcomes for the dependent variable variance indicate that the differences in dispersion among the strategies are highly significant for all duration groups. The critical value of χ^2 for the duration group

Table 2: Kruskal Wallis Tests (1985 - 1990)

Chi-square Tests by Duration Group and Moneyness ¹							
(N = 3024 except for moneyness groupings where N = 2016)							
	Var.	MAD	Raw Skew	Rel. Skew	Skew Index	Coskew (S)	Coskew (P)
Grp 1 (low)	296	294	382	344	334	3	25
Grp 2	245	204	330	311	337	5	26
Grp 3	37	27	283	275	290	4	23
Grp 4	101	189	240	296	204	8	24
Grp 5	195	276	110	181	212	8	22
Grp 6 (high)	239	257	136	213	307	3	23
Grp 7 (Call)	174	212	125	209	293	5	23
In money	39	19	420	479	756	1	29
Out money	.3	2	632	599	718	.1	105

¹ Critical value for all Grp tests is 10.5966, for money 7.87944.

tests (rows titled GRP) is 10.5966 ($k - 1$ is 2, value is for lowest alpha on table: .005). For the moneyness tests (rows titled money) the degrees of freedom are reduced to 1 and the critical value to 7.87944 because of the elimination of the spot portfolios from the sample. Only the out-of-the-money group variance was not significantly different across strategies. The value of .3 indicates that the variance between the strategies is not different when the comparison is restricted to out-of-the-money portfolios. This could be due to the expected differential impact of moneyness on the dispersion of protective puts and covered calls found by Merton, Scholes, and Gladstein (1978, 1982). In-the-money covered calls are expected to lower variance relative to out-of-the-money covered calls. In-the-money put portfolios should provide higher dispersion than those out-of-the-money. Since the sample statistics indicate that the put portfolios provide lower dispersion than the call portfolios, the out of the money portfolios should have the closest dispersions. The differences in ranks are highly significant for each of the duration groupings as well as for the in-the-money portfolios.

The results for MAD are in the second column. Once again, the conclusion is that the distributions are different for the strategies. Only the out-of-the-money portfolios are not distinguishable by MAD. This inability to detect any significant dispersion differences for out-of-the-money portfolios does not extend to the tests of the three asymmetry measures. Each asymmetry test indicates that the different strategies provide different levels of skewness. For the absolute measures, this provides strong support for the theoretical distributions of protective puts and covered calls and the empirics from Table 1. The last two columns detail the χ^2 results for the two coskewness measures. None of the tests for the coskewness with the Treasury "market" provide significant results. This could indicate that the true values of this coskewness measure are not distinguishable from zero, especially in light of the different signs for puts and calls found in Table 1. The coskewness with the "market" of

42 portfolios however is always significant. Unfortunately, the Kruskal-Wallis test does not lead to any conclusion as to the relative magnitudes of the measures. The next section details the results of the ANOVA procedure which can provide this information.

2. ANOVA

The tables below display the values of the F tests for differences in each of the factor level means for the seven distributional measures. Table 3 concerns the independent variable variance. Panel A indicates that the overall F value for the duration group model (301.95) is highly significant. At least one of the factor groupings (strategy or duration) provides for a significantly different variance than the overall mean. Both the strategy and duration are important to the level of portfolio variance. The overall F for the moneyness model (17.68 in Panel B) is significant, but group differences are caused by the strategies, not the exercise price of the option. The Tukey comparisons by strategy support the conclusions of other studies and those drawn from the sample means and nonparametric tests described in the previous section. Specifically, it can be determined that each strategy results in different levels of variance as compared to each other strategy.²⁴ The spot only variance is the highest, followed by the covered call then the protective put. The nonparametric tests of the previous section indicate this failure is probably due to the out-of-the-money portfolios. The duration means indicate that, at least for the higher levels, variance is higher when the portfolio is composed of bonds with relatively high durations. Only the three high risk portfolios had mean variance which was different than all other groups. The segmentation by moneyness indicates that there is no difference between the in-the-money and out-of-the-money positions.

Table 5 displays the statistical findings for mean values of MAD.

²⁴ The traditional result of the Tukey test is to find groups of treatments that are different from other groups. For simplicity, the "Yes" and "No" entries in Tables 4 - 10 indicate whether a treatment is different from all other treatments.

Table 3: F Test for Variance (1985-1990)

	F	P Level
Panel A: Duration Model (N =3024)		
Model	301.95	.0001
Strategy	156.46	.0001
Duration Group	602.46	.0001
Interaction	175.95	.0001
Panel B: Moneyness Model (N=2016)		
Model	17.68	.0001
Strategy	6.58	.0104
Moneyness	.57	.4521
Interaction	45.9	.0001

Table 4: Tests of Group Differences for Variance (1985-1990)

Factor	Mean	Different ¹ (.05 alpha)
Panel A: Pairwise Tukey Test for Different Means by Strategy		
Spot	.000429	Yes
Covered Call	.000304	Yes
Protective Put	.000275	Yes
Panel B: Pairwise Tukey Test for Different Means by Duration		
Duration Group 1 (Low)	.000202	No
Duration Group 2	.000170	No
Duration Group 3	.000155	No
Duration Group 4	.000174	No
Duration Group 5	.000270	Yes
Duration Group 6 (High)	.000645	Yes
Duration Group 7 (Callable)	.000737	Yes
Panel C: Pairwise Tukey Test for Different Means by Moneyness		
In-the-money	.000285	No
Out-of-the-money	.000294	No

¹ Yes indicates this group different from all other groups

Table 5: F Test for MAD (1985-1990)

	F	P Level
Panel A: Duration Model (N=3024)		
Model	372.22	.0001
Strategy	87.11	.0001
Duration Group	717.84	.0001
Interaction	246.93	.0001
Panel B: Moneyiness Model (N=2016)		
Model	6.4	.0003
Strategy	5.77	.0164
Moneyiness	2.02	.1549
Interaction	11.41	.0007

Table 6: Tests of Group Differences for MAD (1985-1990)

Factor	Mean	Different ¹ (.05 alpha)
Panel A: Pairwise Tukey Test for Different Means by Strategy		
Spot	.0138379	Yes
Covered Call	.012217	Yes
Protective Put	.011645	Yes
Panel B: Pairwise Tukey Test for Different Means by Duration		
Duration Group 1 (Low)	.008908	No
Duration Group 2	.008781	No
Duration Group 3	.008933	No
Duration Group 4	.009818	Yes
Duration Group 5	.012264	Yes
Duration Group 6 (High)	.018992	Yes
Duration Group 7 (Callable)	.020271	Yes
Panel C: Pairwise Tukey Test for Different Means by Moneyness		
In-the-money	.01221	No
Out-of-the-money	.011762	No

¹ Yes indicates this group different from all other groups

Once again, the overall F values indicate that there are differences among the different strategies and among the duration classifications. In addition, the nature of the differences seems to be almost identical to those detected for variance. This suggests the ability of MAD to serve as a useful proxy for variance as a risk measure.

Tables 7-12 report the F values for the absolute asymmetry measures. Raw skewness provides consistently significant F values for all factors in both ANOVA models. The different risk levels, strategies, and money positions do impact the level of the raw skew. Like the dispersion results above, duration only provides for different mean skewness at higher levels. When skewness is measured by the relative skew (Table 9), the moneyiness F value falls to 5.37 which is still significant at the .025 level. Using the skew index as the asymmetry measure (Table 11) causes the F value for moneyiness to fall to 0, obviously not significant. Each other factor effect is significant for each of the three asymmetry measures. The Tukey means by duration for the raw and relative skewness measures continue to illustrate that only at higher risk levels is the asymmetry different among groups. This does not follow for the skewness index. Panel D, Table 12 indicates that no duration group provides a mean which is significantly different from all other groups.

Tables 13-16 concern the two coskewness measures. Indications are that strategy does make a difference in coskewness when the spot portfolios are used as the "market". This directly contradicts the χ^2 results reported in Table 2. Because of this contradiction and the significance problems noted in Table 1, it is likely that the distribution of this variable fits the assumptions of the Kruskal-Wallis test more closely than ANOVA. The differences in coskewness are not detectable when segmentation by duration groups or by moneyiness is performed. Table 15 provides results which agree with Table 2 more closely. Both the duration and moneyiness models indicate differences in coskewness among the three strategies, although the significance is not always at the lowest levels.

Table 7: F Test for Raw Skewness (1985-1990)

	F	P Level
Panel A: Duration Model (N=3024)		
Model	92.24	.0001
Strategy	413.44	.0001
Duration Group	136.5	.0001
Interaction	16.59	.0001
Panel B: Moneyiness Model (N=2016)		
Model	179.76	.0001
Strategy	503.37	.0001
Moneyiness	23.68	.0001
Interaction	12.21	.0005

Table 8: Tests of Group Differences for Raw Skewness (1985-1990)

Factor	Mean	Different ¹ (.05 alpha)
Panel A: Pairwise Tukey Test for Different Means by Strategy		
Spot	.00000206	Yes
Covered Call	-.00000393	Yes
Protective Put	.00000642	Yes
Panel B: Pairwise Tukey Test for Different Means by Duration		
Duration Group 1 (Low)	-.0000024	No
Duration Group 2	-.0000021	No
Duration Group 3	-.0000014	No
Duration Group 4	-.0000004	No
Duration Group 5	.0000013	Yes
Duration Group 6 (High)	.0000068	Yes
Duration Group 7 (Callable)	.0000088	Yes
Panel C: Pairwise Tukey Tests for Different Means by Moneyness		
In-the-money	.00000012	Yes
Out-of-the-money	.00000237	Yes

¹ Yes indicates this group different from all other groups

Table 9: F Test for Relative Skewness (1985-1990)

	F	P Level
Panel A: Duration Model (N=3024)		
Model	212.32	.0001
Strategy	1801.72	.0001
Duration Group	42.56	.0001
Interaction	32.3	.0001
Panel B: Moneyiness Model (N=2016)		
Model	728.7	.0001
Strategy	2148.92	.0001
Moneyiness	5.37	.0206
Interaction	31.81	.0001

Table 10: Tests of Group Differences for Relative Skewness
(1985-1990)

Factor	Mean	Different ¹ (.05 alpha)
Panel A: Pairwise Tukey Test for Different Means by Strategy		
Spot	.07481	Yes
Covered Call	-.70493	Yes
Protective Put	.94884	Yes
Panel B: Pairwise Tukey Test for Different Means by Duration		
Duration Group 1 (Low)	-.05897	No
Duration Group 2	-.11664	No
Duration Group 3	-.05024	No
Duration Group 4	.07066	No
Duration Group 5	.21501	Yes
Duration Group 6 (High)	.32344	Yes
Duration Group 7 (Callable)	.36043	Yes
Panel C: Pairwise Tukey Test for Different Means by Moneyness		
In-the-money	.16328	Yes
Out-of-the-money	.08063	Yes

¹ Yes indicates this group different from all other groups.

Table 11: F Test for Skew Index (1985-1990)

	F	P Level
Panel A: Duration Model (N=3024)		
Model	311.2	.0001
Strategy	2798.86	.0001
Duration Group	19.77	.0001
Interaction	42.3	.0001
Panel B: Moneyiness Model (N=2016)		
Model	1929.07	.0001
Strategy	5777.84	.0001
Moneyiness	0	.9842
Interaction	9.37	.0022

Table 12: Tests of Group Differences for Skew Index (1985-1990)

Factor	Mean	Different ¹ (.05 alpha)
Panel A: Pairwise Tukey Test for Different Means by Strategy		
Spot	.10294	Yes
Covered Call	-.6832	Yes
Protective Put	.70903	Yes
Panel B: Pairwise Tukey Test for Different Means by Duration		
Duration Group 1 (Low)	.08619	No
Duration Group 2	-.03843	No
Duration Group 3	.01227	No
Duration Group 4	-.00401	No
Duration Group 5	-.06134	No
Duration Group 6 (High)	.18032	No
Duration Group 7 (Callable)	.12546	No
Panel C: Pairwise Tukey Test for Different Means by Moneyness		
In-the-money	.0131	No
Out-of-the-money	.01273	No

¹ Yes indicates this group different from all other groups

Table 13: F Test for Coskewness (with Spot)

	F	P Level
Panel A: Duration Model (N=3024)		
Model	5.36	.0001
Strategy	50.67	.0001
Duration Group	.89	.4995
Interaction	.04	1.0000
Panel B: Moneyiness Model (N=2016)		
Model	22.64	.0001
Strategy	67.61	.0001
Moneyiness	0	.9501
Interaction	.3	.5841

Table 14: Tests of Group Differences for Coskewness (Spot)
(1985-1990)

Factor	Mean	Different ¹ (.05 alpha)
Panel A: Tukey Test for Different Means by Strategy		
Spot	1.2074	Yes
Covered Call	3.8918	Yes
Protective Put	-3.2955	Yes
Panel B: Tukey Test for Different Means by Duration		
Duration Group 1 (Low)	-.526	No
Duration Group 2	-.061	No
Duration Group 3	.227	No
Duration Group 4	.768	No
Duration Group 5	1.151	No
Duration Group 6 (High)	1.433	No
Duration Group 7 (Callable)	1.217	No
Panel C: Tukey Test for Different Means by Moneyness		
In-the-money	.2709	No
Out-of-the-money	.3255	No

¹ Yes indicates this group different from all other groups

Table 15: F Test for Coskewness (42 port.)

	F	P Level
Panel A: Duration Model (N=3024)		
Model	4.55	.0001
Strategy	14.68	.0001
Duration Group	10.2	.0001
Interaction	.03	1.000
Panel B: Moneyiness Model (N=2016)		
Model	5.58	.0008
Strategy	5.26	.0219
Moneyiness	.51	.4742
Interaction	10.95	.001

Table 16: Tests of Group Differences for Coskewness (42 port.)
(1985-1990)

Factor	Mean	Different ¹ (.05 alpha)
Panel A: Tukey Test for Different Means by Strategy		
Spot	3.16	Yes
Covered Call	.8285	Yes
Protective Put	-.9885	Yes
Panel B: Tukey Test for Different Means by Duration		
Duration Group 1 (Low)	-1.835	No
Duration Group 2	-1.153	No
Duration Group 3	-.668	No
Duration Group 4	.217	No
Duration Group 5	1.234	No
Duration Group 6 (High)	4.554	No
Duration Group 7 (Callable)	4.651	No
Panel C: Tukey Test for Different Means by Moneyness		
In-the-money	.2035	No
Out-of-the-money	-.3635	No

¹ Yes indicates this group different from all other groups

Duration group and moneyness again fail to provide means which are totally distinguishable.

C. SUMMARY OF DISTRIBUTIONAL FINDINGS

With several noted inconsistencies, the tests in this section provide useful information about the distributional characteristics of the three positions. The use of futures options with either a covered call or a protective put strategy does significantly change the distribution of Treasury portfolios. Both strategies lower variance and provide the expected types of absolute asymmetry. Covered calls are skewed to the left and protective puts are right skewed. These differences persist for each of the three asymmetry measures, with the raw skew providing the most distinctive measure. The least promising measure appears to be the skew index. As noted in Chapter 4, the calculation of the index for this study follows that used in Beedles and Simkowitz (1980). The findings in that paper were obtained with equity securities. In addition, a value was considered extreme if beyond two MAD's from the center. That sample of equities likely possessed more extreme values than are found in this sample of Treasuries. Perhaps the use of a smaller number of deviations, such as 1.5 or 1, would give the index more power in detecting skewness in low risk securities. The performance of the coskewness measures does not seem to follow theory. If the average values calculated for the coskewness variables are accurate measures of the portfolio skewness effect, the absolute asymmetry measures must be inaccurate. The alternative is that the coskewness outcomes are due solely to measurement error, and the absolute variables give a better indication of the distribution shape. Given the stronger showing of the absolute measures, it must be concluded that the coskewness measures are of less value for this sample. This opinion is strengthened by the mathematical dependence of the coskewness measures on the raw skew. In addition, the distributions of the two market proxies used in the calculation of coskewness do not indicate asymmetry.

The tests above also provide information about one other issue, the relationship between asymmetry and dispersion measures. The summary statistics (Table 1) and the strategy-duration interaction terms from ANOVA indicate that the asymmetry of both covered calls and protective puts is different for portfolios in each duration group. This difference is that greater duration put portfolios are more likely to have more positive skewness than low duration put portfolios. The call strategy provides for less negative skewness in the high risk portfolios. This result coincides with the findings of McEnally (1974) and Beedles and Simkowitz (1978) that were described in Chapter 4. Additional information about this duration/skewness relationship, commonalities among the other variables, as well as results of the "pricing" tests can be found in the following chapter.

CHAPTER 8

EMPIRICAL RESULTS: PRICING

Although the information in the previous chapter indicates that the distributions of the futures option are similar to those of the equity option, no conclusion about the motivation of option users should be drawn. As noted above, only if investors pay to achieve the differences in the distributions of various options and the corresponding spot securities, should these differences be used as validation for the existence of derivative securities. The regressions described in this chapter were designed to address this issue. The first section provides the details of the regression model. The next section investigates the similarity of the various dispersion and asymmetry measures through correlation statistics. This analysis is important because of the findings of possible multicollinearity in previous studies of skewness preference. The final section provides the regression results.

A. THE MULTIVARIATE MODEL

The return on the portfolios in this study is hypothesized to be affected by the level of risk, the degree of asymmetry, whether or not the Treasury securities are callable, the basic return to savings in the economy, and a yield spread variable used to account for the possibility of varying risk preferences over time. The form of this regression will be

$$r_{it} = \beta_0 + \beta_1(d_{it}) + \beta_2(s_{it}) + \beta_3(c_{it}) + \beta_4(y_t) + \beta_5(br_t) + (e_{it}) \quad (10)$$

where r_{it} is the return on the i^{th} portfolio in the t^{th} time period, the beta are regression coefficients, d represents the measure of risk or dispersion, s is the measure of asymmetry or coskewness, c is a call provision dummy, y is the yield spread variable, and br is the variable

representing the base return.²⁵

The inclusion of the risk factor follows traditional economic theory. Risk will be represented by one of several variables. The first is the estimate of variance from 24 prior observations of the portfolio. mean absolute deviation (MAD) from the estimation period. Finally, the portfolio duration is a contemporaneous measure of interest rate risk. The sign of the dispersion variable should be positive.

According to skewness preference theory, the sign of the absolute asymmetry measure should be negative. This expectation follows from the skewness preference literature which suggests that an investor would prefer to have deviations above the mean rather than below. If an investment provides for upside outcomes more frequently than downside, its distribution is positively skewed. According to the literature, to gain this skewness, the investor is willing to sacrifice return. The raw skew, relative skew, and skewness index from the 24 month estimation period is used. The sign of the coskewness measure should be the opposite of the skewness of the indices. As noted earlier, both indices display only slightly positive skewness for the study period. If this value is truly different than zero, it leads to the expectation that the coskewness variable will be negatively signed.

The inclusion of the portfolios with call provisions serves two purposes. The first is to link the multifactor model here with previous studies of debt securities. The previous literature suggests that investors demand a premium for the risk that they may be forced to sell the security at some predetermined price. In this light, the sign of the call coefficient should be positive. The second interesting aspect of callable securities is that they are, in effect, an option portfolio. The investor buys a bond and implicitly writes a call option to the issuer. As

²⁵The return on the Treasury bill with maturity closest to one month is the only base return variable for which results are presented in Chapter 8. The other return variables mentioned earlier in this chapter did not materially affect any regression results.

noted in Chapter 4, Section C, this implicit option portfolio diversification may make skewness less negative, hence return lower.

The maturity yield spread variable is the only macroeconomic variable available from the CRSP tapes which Chen, Roll, and Ross (1983) found to be related to the factor loadings in their test of the APT. The inclusion of this variable is intended to account for any change in risk premiums associated with changes in market conditions. For example, a change from a positive spread to a negative spread indicates a relative rise in short rates and an implied decrease in the premium associated with interest rate risk. A large (small) spread would indicate high (low) risk premiums. The sign of this coefficient should be positive, to account for the higher prices associated with a lower risk premium. The base interest variable should possess a positive sign. As returns in the economy increase, the returns of the option portfolios should also go up. Inclusion of this variable also results in the interpretation of the regression coefficients as return premia.

The conclusion that the three strategies provide markedly different distributions partially supports the idea that an important benefit of options is the provision of otherwise unavailable investment opportunities by altering existing spot distributions. However, the addition of options changes both the dispersion and the symmetry of the spot. It remains to be seen if either of the changes is valued by investors.

B. CORRELATION ANALYSIS OF PROXY VARIABLES

The use of so many alternate measures of risk and asymmetry in this study is prompted by the finding of possible multicollinearity in the regressions performed by Wingender (1985) and others. If this finding is due simply to the computational similarity between variance and skewness, the use of MAD, duration, and the skew index may avoid this problem. To this end, several measures of dispersion and asymmetry were developed for use in this study. To provide information about the similarity of the

calculated values for these measures within this sample, Pearson correlation coefficients and Spearman rank order coefficients were calculated. These results are presented in Tables 17-19. The use of the additional measure (Spearman) is prompted by the possible non-normality of several of the variable distributions. As seen in Table 17, the three dispersion measures possess significant and positive relationships. Variance and MAD have the strongest measures (.955, .985). These measures seem to be similar and adequate proxies for dispersion. The strongest asymmetry relationships presented in Table 18 are among the absolute measures. Each coefficient is significant and positive for both the Pearson and Spearman measures. The coefficients for the coskewness measures are not as strong. Most values for the spot coskewness measure are significant, but close to zero. Only the Spearman values for the option portfolio coskewness are significant, and these are also close to zero. This further lowers the confidence to be placed in these measures as indications of the asymmetry of debt option return asymmetry. Except for the coskewness measures, Table 18 indicates that the three measures of dispersion and the three measures of asymmetry appear to be viable proxies.

Table 19 provides the initial evidence about the relationships of the asymmetry measures with the dispersion variables. At least for this sample, the variance/raw skew coefficients appear low enough (.331, .158) to avoid the multicollinearity suggested by computational similarity and previous studies (Friend and Westerfield 1980, Wingender 1985). The values with MAD and duration are similar. In addition, the strength of the relative skew and the index as proxies for the raw skew is shown. Both have near zero coefficients with all dispersion variables. Although most of the coskewness correlations are significant, the absolute values are all small. The general conclusions from these results are that the use of alternate dispersion and asymmetry measures should result in regression coefficients which are relatively free of the multicollinearity problem.

Table 17: Correlation Coefficients for Dispersion Measures (1985-1990)
(N=3024)

	Variance	MAD
Panel A: Pearson Coefficients		
MAD	.955*	-
Duration	.584*	.617*
Panel B: Spearman Coefficients		
MAD	.985*	-
Duration	.552*	.553*

* chance of error less than .05, other values not significant

Table 18: Correlation Coefficients for Asymmetry Measures (1985-1990)
(N=3024)

	Raw Skew	Rel. Skew	Skew Index	Coskew (s)
Panel A: Pearson/Spearman Coefficients				
Raw Skew	-	.607*/.885*	.480*/.748*	-.059*/.048*
Rel. Skew	-	-	.733*/.804*	-.125*/.030
Skew Index	-	-	-	-.132*/.052*
Coskew (p)	.028/.210*	.012/.190*	-.012/.134*	.031/.439*

*Chance of error less than .05, other values not significant.

Table 19: Pearson/Spearman Correlation Coefficients for Dispersion and Asymmetry Measures (1985-1990) N=3024

	Variance	MAD	Duration
Raw Skew	.331*/.158*	.265*/.140*	.398*/.222*
Relative Skew	.045*/.039*	.016/.018	.173*/.114*
Skew Index	.068*/-.012	.038*/-.008	.057*/.016
Coskew (S)	.021/.192*	.024/.192*	.042*/.241*
Coskew (P)	.122*/.297*	.113*/.288*	.145*/.390*

*Chance of error less than .05, other values not significant.

The apparent relationship between asymmetry and duration detected by the ANOVA results does not appear in Table 19. The correlation coefficients between the relative skew and duration are only .173/.114. The skewness index/duration coefficients are .057/.016.

C. EFFECT OF PORTFOLIO CHARACTERISTICS ON RETURN

This section presents the regression results obtained with the model described in Part A of this chapter. Some of these results suggest that the model may need modification. In order to determine as accurately as possible the effect of the dispersion and asymmetry variables on return, these modifications are described and the new results analyzed in later sections.

1. Regressions With Base Return Series

Table 20 (raw skew), 21 (relative skew), 22 (skew index), 23 (coskewness-spot), and 24 (coskewness-portfolios) report the results of the multiple regressions designed to address the issue of the effect of portfolio distributions on the utility of commercial banks and bond dealers. Each table contains one column for each of the three dispersion measures. The F is highly significant for each regression, indicating that some of the regression coefficients are nonzero. However, the R^2 are low for all regressions, occasionally rising above the 4% level. This indicates that some significant influence may not be appropriately accounted for by the set of variables used. Such an influence would affect the intercept, which is consistently negative and significant. A further result concerning the intercept is the presence of collinearity between it and the base return variable in all regressions. The collinearity diagnostics provided by the statistical package used for these regressions, (SAS), include a principal component analysis which investigates the structure of the independent variable matrix. This procedure detects commonalities among the independent variables, calculates the condition number for each commonality, and measures the

Table 20: Regression Coefficients and T Values (1985-1990)

Asymmetry Variable: Raw Skew

Values in cells are parameter estimates (T values in parentheses below) Columns identify dispersion variable. N = 3024			
Variable	Variance ($R^2 = .03$) (F = 19.06)	MAD ($R^2 = .03$) (F = 18.29)	Duration ($R^2 = .03$) (F = 19.98)
Intercept	-.0119 (-5.36)	-.0125 (-5.453)	-.011 (-5.072)
Dispersion	5.2473 (4.842)	.2306 (4.421)	.000002 (5.271)
Asymmetry	-52.726 (-1.55)	-39.227 (-1.167)	-74.578 (-2.14)
Yield Spread	29.319 (3.384)	31.01 (3.587)	35.392 (4.104)
Call	.001 (1.00)	.0013 (1.257)	.0003 (.246)
Base Return	3.1304 (8.527)	3.004 (8.275)	2.7005 (7.57)

One tailed critical t is 1.645, two tailed 1.96 (alpha = .05)

Table 21: Regression Coefficients and T Values (1985-1990)

Asymmetry Variable: Relative Skew

Values in cells are parameter estimates (T values in parentheses below) Columns identify dispersion measure. N = 3024			
Variable	Variance ($R^2 = .03$) (F = 18.76)	MAD ($R^2 = .029$) (F = 18.26)	Duration ($R^2 = .03$) (F = 19.05)
Intercept	-.0124 (-5.517)	-.013 (-5.623)	-.011 (-5.18)
Dispersion	4.940 (4.633)	.2258 (4.359)	.000002 (4.779)
Asymmetry	.0003 (.993)	.0004 (1.097)	.00007 (.213)
Yield Spread	29.947 (3.452)	31.507 (3.641)	35.161 (4.07)
Call	.0007 (.625)	.0009 (.89)	.00005 (.043)
Base Return	3.212 (8.727)	3.091 (8.51)	2.805 (7.883)

One tailed critical t is 1.645, two tailed 1.96 (alpha = .05)

Table 22: Regression Coefficients and T Values (1985-1990)

Asymmetry Variable: Skew Index

Values in cells are parameter estimates (T values in parentheses below) Columns identify dispersion measure. N = 3024			
Variable	Variance ($R^2 = .03$) (F = 18.66)	MAD ($R^2 = .029$) (F = 18.17)	Duration ($R^2 = .03$) (F = 19.16)
Intercept	-.012 (-5.452)	-.013 (-5.553)	-.011 (-5.201)
Dispersion	4.867 (4.558)	.2218 (4.286)	.00002 (4.82)
Asymmetry	.0003 (.704)	.0004 (.874)	.0004 (.791)
Yield Spread	29.828 (3.438)	31.39 (3.627)	35.368 (4.095)
Call	.0008 (.729)	.001 (1.003)	.00004 (.032)
Base Return	3.178 (8.679)	3.056 (8.459)	2.805 (7.919)

One tailed critical t is 1.645, two tailed 1.96 (alpha = .05)

Table 23: Regression Coefficients and T Values (1985-1990)

Asymmetry Variable: Coskewness (Spot)

Values in cells are parameter estimates (T values in parentheses below) Columns identify dispersion measure. N = 3024			
Variable	Variance ($R^2 = .03$) (F = 19.27)	MAD ($R^2 = .03$) (F = 18.71)	Duration ($R^2 = .031$) (F = 19.65)
Intercept	-.0121 (-5.456)	-.013 (-5.542)	-.011 (-5.187)
Dispersion	4.882 (4.582)	.2211 (4.275)	.000002 (4.779)
Asymmetry	.00004 (1.857)	.0004 (1.846)	.00003 (1.724)
Yield Spread	29.552 (3.412)	31.069 (3.596)	35.056 (4.065)
Call	.0008 (.726)	.0011 (1.02)	.00007 (.063)
Base Return	3.178 (8.685)	3.052 (8.455)	2.802 (7.917)

One tailed critical t is 1.645, two tailed 1.96 (alpha = .05)

Table 24: Regression Coefficients and T Values (1985-1990)

Asymmetry Variable: Coskewness (portfolios)

Values in cells are parameter estimates (T values in parentheses below) Columns identify dispersion measure. N = 3024			
Variable	Variance ($R^2 = .045$) ($F = 28.17$)	MAD ($R^2 = .044$) ($F = 27.82$)	Duration ($R^2 = .045$) ($F = 28.37$)
Intercept	-.012 (-5.274)	-.012 (-5.348)	-.011 (-5.048)
Dispersion	4.189 (3.941)	.1918 (3.772)	.000001 (4.059)
Asymmetry	.0001 (6.828)	.0001 (6.901)	.0001 (6.726)
Yield Spread	30.088 (3.499)	31.368 (3.657)	34.795 (4.062)
Call	.0006 (.547)	.0008 (.778)	.00001 (.010)
Base Return	3.112 (8.56)	3.006 (8.387)	2.789 (7.934)

One tailed critical t is 1.645, two tailed 1.96 (alpha = .05)

proportion of the variance of each dependent variable explained by the commonality. The condition number is the ratio of the maximum to the minimum principal component. Belsley, Kuh, and Welsch (1980) report that a condition number of 5 to 10 indicates weak dependencies, while values of 30 to 100 indicate strong relationships. Several of the regressions provide condition numbers between 10 and 20. In each case, the intercept and the base return variable have more than 90% of variance traced to the same component. This is probably due to the relatively low variance of the base return series over the test period. When the intercept is eliminated from the regressions, none of the condition numbers is above 4.5. Results of these regressions are reported in section 2 below.

When the base return series is included, each of the dispersion coefficients are correctly signed and significant at alpha levels of .0005. The results for the absolute asymmetry measures are not this strong. The critical value for the one-tailed t test ($\alpha = .05$) is 1.645. Only the raw skew (Table 20, third column) meets this level (-2.138). The raw skew is significant at 10% and 15% with variance and MAD, respectively. The relative skew is significant at 15% with MAD, and at 20% with variance. Each of the raw skew coefficients is correctly signed, but the relative and index measures are consistently positive. In addition, the condition numbers and proportional variance statistics do not include any values which suggest the linkage between skewness and dispersion reported in previous studies. Surprisingly, the coskewness measures performed quite well when compared to the absolute measures. The coskewness (portfolios) is always significant at .005. The coskewness (spot) meets the .05 confidence level. However, the signs of these variables are always opposite of the theoretical expectation, given that each "market" was positively skewed. The possibility that the coskewness measures may be spurious has been noted. These results are probably the consequence of this mismeasurement.

Both macroeconomic variables are significant at high levels. In

addition, each is positively signed. This supports the view of the spread variable as an indication of increased risk aversion in the market. One would expect some relationship between the spread variable and the base return variable. As the base return series increases, the spread variable should tend to get smaller. This is never the case. The condition numbers for the components which explain most of the variance of the spread explain less than 3% of the base return. This indicates that the base return is either not a good measure of conditions in the economy, or that the relationship with the intercept swamps other effects. This issue is addressed in Section 2.

The call dummy is never highly significant. In three of the fifteen regressions, more than 40% of the call dummy's variance is explained by the component which also explains the raw skew (40%-50%), but the condition number is never above 4. Once again some relation to base returns might be expected. Firms are more likely to call debt when rates fall, but the Treasury's response to such a change is uncertain. Neither the proportion of variance nor the condition numbers indicate such a relationship.

In general, this set of regressions provides evidence which supports the notion that holders of option portfolios pay to get the reduction in variance associated with the two strategies. The evidence concerning absolute asymmetry is very weak. The low significance levels for the tests of this effect do not indicate a strong willingness by banks and security dealers to pay for positive skewness. The coskewness results contradict theory, which makes the idea that asymmetry is important to return more doubtful. In addition, the low significance for the call provision variable differs from results associated with corporate bonds. This seems indicate that the Treasury is less likely to use the call provision because of different motivation than the private sector. The interest rate series and the yield spread were both found to have the hypothesized effect.

When collinearity exists between two dependent variables the most likely damage is due to inflated variances, making tests of the regression coefficients less significant. However, it is not certain which variances are overestimated because of the problem. In the case presented above, any problems of this nature are due to the relationship between the base return series and the intercept. One possible solution is to eliminate the intercept from the model. The results of these regressions are presented below.

2. Regression Results Excluding Base Return

Table 25 contains the results when raw skewness is the asymmetry measure, Table 26 for relative skew, Table 27 for the skew index, and Tables 28 and 29 for coskewness. Several changes resulted from the removal of the intercept. The primary impact of restricting the intercept to zero is expected to be a decrease in the variance of the remaining parameter estimates. This change will occur for two reasons. The expected mathematical impact is due to the increase in the degrees of freedom resulting from the elimination of one estimate. The other impact, more difficult to quantify, can be traced to the elimination of the collinearity found with the original model. These effects caused several changes in both the levels and significance of the original parameter estimates.

The first change is that the value of the base return parameter estimate decreased appreciably. The removal of the consistently negative intercept should provide this result, especially in light of the knowledge that the intercept and return variable were related. The sign of the dispersion variables was unchanged, but the level of significance did decrease from the .0005 level to at most .05. This change is apparently not due to the normal reduction in variance and probably resulted from removal of collinearity. Duration seems the least affected of the three. The conclusion that banks and dealers value the risk reduction effects of the option strategies remains unchanged.

Table 25: Regression Coefficients (No Intercept) and T Values
(1985-1990): Asymmetry Variable: Raw Skew

Values in cells are parameter estimates (T values in parentheses below) Columns identify dispersion variable. N = 3024			
Variable	Variance ($R^2 = .175$)* (F = 128.04)	MAD ($R^2 = .1737$)* (F = 126.90)	Duration ($R^2 = .177$)* (F = .129.85)
Dispersion	3.405 (3.284)	.1187 (2.464)	.000002 (4.274)
Asymmetry	-61.492 (-1.802)	-49.857 (-1.478)	-83.183 (-2.378)
Yield Spread	6.339 (.838)	8.081 (1.065)	11.209 (1.553)
Call	.002 (1.606)	.0021 (2.027)	.0008 (.682)
Base Return	1.2227 (13.536)	1.1259 (9.755)	.9871 (8.573)

* R^2 calculated with no intercept in SAS defined as multiple correlation coefficient, but excludes influence of inflated error.

One tailed critical t is 1.645, two tailed 1.96 (alpha = .05)

Table 26: Regression Coefficients (No Intercept) and T Values
(1985-1990): Asymmetry Variable: Relative Skew

Values in cells are parameter estimates (T values in parentheses below) Columns identify dispersion measure. N = 3024			
Variable	Variance ($R^2 = .174$)* (F = 127.29)	MAD ($R^2 = .173$)* (F = 126.41)	Duration ($R^2 = .176$)* (F = 128.48)
Dispersion	2.976 (2.946)	.1069 (2.250)	.000001 (3.693)
Asymmetry	.0001 (.372)	.0001 (1.704)	-.00006 (-.178)
Yield Spread	6.184 (.817)	7.728 (1.018)	10.292 (1.427)
Call	.0013 (1.27)	.0018 (1.704)	.00005 (.472)
Base Return	1.242 (13.852)	1.151 (10.088)	1.054 (9.424)

* R^2 calculated with no intercept in SAS defined as multiple correlation coefficient, but excludes influence of inflated error.

One tailed critical t is 1.645, two tailed 1.96 (alpha = .05)

Table 27: Regression Coefficients (No Intercept) and T Values
(1985-1990): Asymmetry Variable: Skew Index

Values in cells are parameter estimates (T values in parentheses below) Columns identify dispersion measure. N = 3024			
Variable	Variance ($R^2 = .174$)* (F = 127.34)	MAD ($R^2 = .173$)* (F = 126.49)	Duration ($R^2 = .176$)* (F = 128.57)
Dispersion	2.939 (2.904)	.1056 (2.221)	.000001 (3.679)
Asymmetry	.0003 (.593)	.0003 (.709)	.0003 (.626)
Yield Spread	6.413 (.847)	7.963 (1.049)	10.439 (1.447)
Call	.0014 (1.305)	.002 (1.737)	.0005 (.460)
Base Return	1.242 (13.848)	1.152 (10.095)	1.056 (9.466)

* R^2 calculated with no intercept in SAS defined as multiple correlation coefficient, but excludes influence of inflated error.

One tailed critical t is 1.645, two tailed 1.96 (alpha = .05)

Table 28: Regression Coefficients (No Intercept) and T Values
(1985-1990): Asymmetry Variable: Coskewness (Spot)

Values in cells are parameter estimates (T values in parentheses below) Columns identify dispersion measure. N = 3024			
Variable	Variance ($R^2 = .175$)* (F = 128.04)	MAD ($R^2 = .174$)* (F = 127.16)	Duration ($R^2 = .176$)* (F = 129.18)
Dispersion	2.948 (2.92)	.1050 (2.211)	.000001 (3.636)
Asymmetry	.00004 (1.804)	.00004 (1.807)	.00003 (1.700)
Yield Spread	6.17 (.816)	7.751 (1.022)	10.254 (1.422)
Call	.0014 (1.302)	.0018 (1.748)	.0005 (.488)
Base Return	1.242 (13.855)	1.153 (10.112)	1.059 (9.500)

* R^2 calculated with no intercept in SAS defined as multiple correlation coefficient, but excludes influence of inflated error.

One tailed critical t is 1.645, two tailed 1.96 (alpha = .05)

Table 29: Regression Coefficients (No Intercept) and T Values
(1985-1990): Asymmetry Variable: Coskewness (portfolios)

Values in cells are parameter estimates (T values in parentheses below) Columns identify dispersion measure. N = 3024			
Variable	Variance ($R^2 = .187$)* (F = 138.977)	MAD ($R^2 = .186$)* (F = 138.38)	Duration ($R^2 = .189$)* (F = 139.78)
Dispersion	2.317 (2.302)	.0799 (1.668)	.000001 (2.925)
Asymmetry	.0001 (6.958)	.0001 (7.045)	.0001 (6.826)
Yield Spread	7.668 (1.021)	9.049 (1.202)	10.823 (1.512)
Call	.0012 (1.099)	.0015 (1.472)	.0005 (.423)
Base Return	1.252 (14.075)	1.187 (10.467)	1.104 (9.956)

* R^2 calculated with no intercept in SAS defined as multiple correlation coefficient, but excludes influence of inflated error.

One tailed critical t is 1.645, two tailed 1.96 (alpha = .05)

The coefficients of the raw skew measure remain negatively signed and have increased slightly in significance. Confidence levels increase from .15-.05 to .1-.01 level. Most t values for the relative skew and the index dropped to levels which do not even marginally reject the null. These changes in the findings of the economic relevance of asymmetry provide stronger support for the skewness preference motivation attributed to banks and bond dealers in this paper. It is also interesting to note that this support comes from a test which is not encumbered with the strict assumptions concerning the shape of investor utility function needed for the pure skewness preference models. In addition, there is no indication of any multicollinearity involving the dispersion and asymmetry measures. This lack of collinearity, coupled with the poor performance of the relative skewness and skew index, indicate that the raw skew is an adequate measure of asymmetry for securities with low levels of initial dispersion, like the Treasury portfolios herein. The rationale for the use of the two proxies, sample sensitivity and difficulty in hypothesis testing, are not a concern for this sample. The need for proxies may well be more important for higher risk securities.

The theoretically inconsistent coskewness results do not seem to be affected by the removal of the intercept. Sign, level, and significance remain largely unchanged. In contrast, the results for the other variables in the model also displayed differences. The yield spread, highly significant in the presence of the intercept, becomes marginally significant in most of the second set of regressions. The call provision actually improves in significance for several cases, retaining its positive sign. One further potential cause of difficulty in these results may be due to the nature of the sample. These tests combine time series and cross-sectional observations. Interpretation of the regression coefficients depend on certain assumptions, such as stationarity over time. In the absence of this condition, the coefficients must be interpreted as averages over the study period. Pooling also may result in

a complex error term to account for possible nonstationarity of any omitted regressors. The inclusion of two strictly time series variables, the base return series and the yield spread may partially offset any time series influences of this nature. However, the number of insignificant coefficients reported in the two multiple regression sections may still be the result of pooling difficulties. A shift in parameters over time could have resulted in inefficient estimators. The use of an error components model which assumes an error term consisting of a cross-sectional portion, a time series portion, and a mixed portion, might result in fewer instances of insignificance.

3. Error Components Results

To account for the possible inefficiency of parameter estimates due to the pooling of time series and cross-sectional data, the hypotheses of this study were also tested with the error components model.²⁶ These results for the three absolute dispersion and asymmetry measures are presented in Tables 30-32. The information from these tables shows that the error terms in previous regressions did contain a time series component. Only two of the regressions in Table 30 show any cross-sectional effect, but this variance is quite small. Over time, however, there were shifts that likely lowered the efficiency of the parameter estimates. The least affected variables are those for dispersion. Correctly signed and positive, they provide very strong support for the hedging motivation of dealers and banks. The new tests also cast considerable doubt on the asymmetry conclusions drawn above. Although the raw skew estimates retain the hypothesized sign, the one-tailed t values decline appreciably. With variance as the dispersion measure, significance in raw skew drops from 5 to 10 per cent. The decline is from 1% to 10% when duration is used. The relative skew maintains a 90% level. The other

²⁶ This model is a supplemental routine in SAS (Version 5) known as PROC TSCSREG. Using this procedure and specifying the option FULLER, calculates unbiased variance component estimates suggested by Fuller and Battese (1974).

Table 30: Error Components Regression Results: (1985-1990)

Asymmetry Variable: Raw Skew

Panel A: Parameter Estimates (T values in parentheses below) (columns identify dispersion variable) N = 3024			
	Variance	MAD	Duration
Dispersion	4.46572 (3.9778)	.2108 (3.7442)	.0000017 (5.1588)
Asymmetry	-48.836 (-1.4452)	-46.003 (-1.3514)	-55.429 (-1.6734)
Yield Spread	3.50643 (.19173)	3.17632 (.1724)	10.071 (.5533)
Call	.00135 (1.214)	.00151 (1.288)	.000374 (.3586)
Base Return	1.192 (5.57)	.9768 (4.2053)	.9381 (4.1983)
Panel B: Variance Component Estimates			
Cross- section	0.00000984	0.00000162	0.0
Time Series	0.00004201	0.00004248	0.00004266
Error	0.00027494	0.00027439	0.00027588

One tailed critical t is 1.645, two tailed 1.96 (alpha = .05)

Table 31: Error Components Regression Results: (1985-1990)

Asymmetry Variable: Relative Skew

Panel A: Parameter Estimates (T values in parentheses below) (columns identify dispersion variable) N = 3024			
	Variance	MAD	Duration
Dispersion	4.0531 (4.0279)	.1924 (3.9875)	.0000015 (4.6537)
Asymmetry	.000669 (2.0574)	.000709 (2.1749)	.000429 (1.3086)
Yield Spread	3.38667 (.1854)	3.0561 (.1656)	9.4854 (.51891)
Call	.00093 (.9428)	.00108 (1.113)	.000186 (.1794)
Base Return	1.2037 (5.654)	1.0049 (4.4519)	.9924 (4.4531)
Panel B: Variance Component Estimates			
Cross- section	0.0	0.0	0.0
Time Series	0.00004271	0.00004306	0.00004325
Error	0.0002765	0.0002757	0.00027684

One tailed critical t is 1.645, two tailed 1.96 (alpha = .05)

Table 32: Error Components Regression Results: (1985-1990)

Asymmetry Variable: Skew Index

Panel A: Parameter Estimates (T values in parentheses below) (columns identify dispersion variable) N = 3024			
	Variance	MAD	Duration
Dispersion	3.9126 (3.8822)	.1855 (3.8489)	.0000015 (4.8144)
Asymmetry	.000706 (1.673)	.00077 (1.833)	.000722 (1.7139)
Yield Spread	4.18327 (.22752)	3.91165 (.21178)	9.8014 (.53611)
Call	.00113 (1.1493)	.00128 (1.3267)	.000176 (.1699)
Base Return	1.2061 (5.6554)	1.01435 (4.4907)	.9813 (4.4051)
Panel B: Variance Component Estimates			
Cross- section	0.0	0.0	0.0
Time Series	0.00004287	0.00004314	0.00004328
Error	0.00027649	0.00027565	0.00027684

One tailed critical t is 1.645, two tailed 1.96 (alpha = .05)

asymmetry variables show a greater change. Significance of the incorrectly signed relative and skew index coefficients increases in each case. The correction of the time series component drops the estimates for the call provision and the yield spread variable effectively to zero. The base return remains correctly signed and highly significant.

These changes seem to weaken support for the skewness preference motive addressed in this study. The results for raw skew are consistent with most prior findings, not extremely strong, but consistent enough to maintain the interest of the academic community. The relative skew and the index provide a quite different outlook. Even though, as noted before, each has difficulties when applied to a low risk sample such as Treasuries, they provide evidence which contradicts the hypothesized asymmetry motivation of banks and dealers. A possible explanation for the weak performance of the skewness measures is the alternative explanation for option trading suggested by Leland (1980). He suggested the presence of investor groups which are willing to pay premiums for purchased (written) options based on optimistic (pessimistic) expectations. The premiums paid for both positive and negative skewness would cause the model parameter estimates to differ among the investor groups. An informal test of this possibility would be to test the multivariate model on the samples of calls and puts separately. This is done in Tables 33 and 34. Values for the skew index are omitted. Future users of this measure should consider the inherent variation in the sample before setting the limits for extreme variables.

The segmentation of the sample resulted in an increase in the absolute size and significance of the coefficients for raw skew in protective put portfolios. This is consistent with both the skewness preference hypothesis and the preference for convexity suggested by Leland. For covered calls the asymmetry measure drops to zero in two of the three cases, suggesting that the effect of an aversion to negative skewness by some market participants is counteracted by the preference

Table 33: Error Components Regression Results by Strategy: (1985-1990) Asymmetry Variable: Raw Skew

Panel A: Parameter Estimates (Protective Puts Only) (T values in parentheses below) (columns identify dispersion variable) N=1008			
	Variance	MAD	Duration
Dispersion	9.2745 (2.3089)	.1897 (1.3823)	.0000019 (3.6127)
Asymmetry	-259.276 (-2.7157)	-139.365 (-1.9765)	-142.214 (-2.4786)
Yield Spread	-10.5101 (-.4566)	-9.999 (-.4286)	-4.10328 (-.17999)
Call	.00385 (2.211)	.00433 (2.5106)	.00229 (1.4022)
Base Return	1.3067 (4.7322)	1.2114 (3.6543)	1.073 (3.7754)

One tailed critical t is 1.645, two tailed 1.96 (alpha = .05)

Table 33: (continued)

Panel B: Parameter Estimates (Covered Calls Only) (T values in parentheses below) (columns identify dispersion variable) N=1008			
	Variance	MAD	Duration
Dispersion	11.0287 (3.2894)	.5856 (3.6764)	.0000014 (2.7561)
Asymmetry	-39.2281 (-.6006)	-39.7382 (-.59332)	-104.235 (-1.8053)
Yield Spread	17.25 (.69173)	12.19 (.4853)	38.7639 (1.6515)
Call	.0019 (.7739)	.0014 (.4892)	.00161 (1.0021)
Base Return	.49155 (1.5898)	-.1344 (-.34287)	.4179 (1.3921)

One tailed critical t is 1.645, two tailed 1.96 (alpha = .05)

Table 34: Error Components Regression Results by Strategy: (1985-1990) Asymmetry Variable: Relative Skew

Panel A: Parameter Estimates (Protective Puts Only) (T values in parentheses below) (columns identify dispersion variable) N=1008			
	Variance	MAD	Duration
Dispersion	.71655 (.3352)	.0296 (.3035)	.0000014 (2.8788)
Asymmetry	-.000031 (-.0438)	-.000019 (-.0275)	-.000222 (-.3157)
Yield Spread	-12.145 (-.5228)	-12.238 (-.5229)	-13.066 (-.5776)
Call	.00355 (2.295)	.0036 (2.3996)	.00127 (.8023)
Base Return	1.4693 (5.2453)	1.439 (4.5942)	1.2039 (4.1268)

One tailed critical t is 1.645, two tailed 1.96 (alpha = .05)

Table 34: (continued)

Panel B: Parameter Estimates (Covered Calls Only) (T values in parentheses below) (columns identify dispersion variable) N=1008			
	Variance	MAD	Duration
Dispersion	11.6595 (3.7301)	.6142 (4.1939)	.0000096 (1.8061)
Asymmetry	.000089 (.1331)	.000295 (.4315)	.000226 (.3341)
Yield Spread	17.216 (.6858)	12.551 (.4994)	44.1027 (1.8723)
Call	.0015 (.628)	.000861 (.3083)	.00168 (1.0428)
Base Return	.5057 (1.5597)	-.1237 (-.1237)	.602 (1.8477)

One tailed critical t is 1.645, two tailed 1.96 (alpha = .05)

for concavity developed by Leland (1980). Only the duration model provides the significant, correctly signed coefficient. By comparison, all relative coefficients drop to zero for both the covered call and protective puts.

D. SUMMARY

This chapter presented results which expand the findings concerning the use of option portfolios. As predicted by theory, commercial banks and government bond dealers can lower the interest rate risk associated with inventories of Treasury bonds by using futures options. In addition, although ultimately unnecessary as a solution to collinearity, the use of risk and skewness proxies also provides useful information. MAD, duration, and variance seem to be equally capable of measuring risk in Treasury securities. Because of the default free status, Treasuries can be thought of as assets which possess little, if any, diversifiable risk. This fact, combined with the poor results of the CAPM for all debt securities, suggest that total risk measures represent the appropriate risk proxies for Treasuries. Duration, as a contemporaneous measure of interest rate risk, performed as well as more traditional measures. The skewness measures did not fare as well. Both the raw and relative skews have been criticized for being sample sensitive. The repetitive calculation methods used in this study, in effect, replicate works which have studied asymmetry over time. The raw skew provides relatively strong, consistent results that do not suggest this sensitivity. The skewness index and relative skew seem less valuable along these lines. As noted earlier, perhaps stricter standards for extreme values in the calculation of the skew index may be appropriate for low risk securities like Treasuries. The stronger performance of the raw skew measure indicates that, at least for low risk securities, transformation into relative skewness may be unnecessary.

The evidence in this chapter does not provide total support for the notion that banks and dealers value positive skewness. It would appear

more likely that there may be segments of the Treasury futures option market, dominated by the institutions described in Chapters 3 and 4, which value concavity. A more complete test of Leland's proposal would require more intimate knowledge of the trading activity of a specific group of investors holding pessimistic expectations.

CHAPTER 9

SUMMARY AND IMPLICATIONS

Although theory suggests that option positions are innovative on the ground that they enhance market completeness, published empirical support for this conclusion is inadequate. Despite the lack of evidence, the literature on options repeatedly uses this theoretical result as justification for option positions. This problem becomes more acute for positions which do not involve equity options, the only type of option which does have some observational support for market enhancement. No other study analyzes the distributional characteristics of nonequity options. This study tests the distributional characteristics of one type of nonequity option, the TBFO. Because of the success of the TBFO contract, it is expected that this security does provide distributional changes not available with Treasury only positions.

The characteristic of option positions most frequently cited as causing the popularity is asymmetry, but the positions examined here indicate that risk reduction is also important. It is found that dispersion is substantially reduced through portfolio strategies that use puts and calls. Similar to equity option results, covered calls do provide negative skewness, and protective puts result in positive skewness. In addition to the direct findings concerning the TBFO, it is hoped that this study will encourage the extension of distributional studies to other types of new securities which possess option-like characteristics. The tests of the distributional characteristics also provide information about the use of proxies for risk and asymmetry. MAD, duration, and variance each performed well as risk measures for Treasuries. The raw and relative skewness statistics did not vary across estimation intervals, although the relative measure provides inconclusive pricing results. This finding seems

to strengthen the choice of the raw skew as the appropriate asymmetry measure for Treasury data. The findings of this study also suggest that the inherent dispersion of the securities studied should be considered before the skewness index is used to measure asymmetry.

The second area of inquiry concerns the capability of the TBFO to satisfy the investment objectives of users. To make determinations of this nature requires the specification of a particular set of investors, banks and government bond dealers in this case. The two primary motivations for these option investors are a reduction of exposure to interest rate risk, and the provision of asymmetry or positive skewness. A multivariate model which accounts for these motivations, as well as for the presence of call provisions and changes in market conditions, is estimated. This multivariate model is designed to overcome problems, both theoretical and empirical, associated with the use of other models. Prior research using mean/variance models has been able to determine the effect of options on the dispersion of the return distribution, but they are unable to account for skewness. The tests of models which do allow for skewness suffer from multicollinearity among risk and asymmetry measures. If option positions do provide skewness and risk reduction, the multivariate model described here can determine the effect on position return, serving as a proxy for investor utility.

The dispersion results were very strong. Banks and dealers must be rewarded for increases in risk, and are willing to pay for decreases. The results for asymmetry are not as strong. Only the raw skew supports the asymmetry motivation of the institutional positions studied here. The results are stronger for the protective put than the covered call. This effect would be consistent with the segmented expectations approach used by Leland (1980), although no formal test has been performed. The changes in the skewness of the distribution may be only an unpriced side effect of option portfolio formation. This possibility suggests that option positions should be compared to other strategies designed to reduce

interest rate risk, such as futures contracts.

Also, information is provided that concerns the use of the equilibrium skewness model of Kraus and Litzenberger. The results indicate that the coskewness measure is not consistent with theory when used for Treasury positions. These findings are likely due to measurement error involved when calculating the systematic skewness variables. This effect is similar to the experience of single index covariance models used with bonds.

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