Wartime finance and the term structure of interest rates

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TAYLOR, Julian Howard, 1943-
WARTIME FINANCE AND THE TERM STRUCTURE OF INTEREST RATES.

Iowa State University, Ph.D., 1969
Economics, general

University Microfilms, Inc., Ann Arbor, Michigan
WARTIME FINANCE AND THE
TERM STRUCTURE OF INTEREST RATES

by

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A Dissertation Submitted to the
Graduate Faculty in Partial Fulfillment of
The Requirements for the Degree of
DOCTOR OF PHILOSOPHY

Major Subject: Economics

Approved:

Signature was redacted for privacy.

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Signature was redacted for privacy.

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Signature was redacted for privacy.

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Iowa State University
Of Science and Technology
Ames, Iowa
1969
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REVIEW OF LITERATURE

I

The following dissertation is a theoretical and empirical examination of the relationship between rates of interest over the range of debt maturity. The study examines the current status of what has come to be called "the term structure of interest rates", offers an alternative theoretical solution to the problem, and presents some empirical test results.

While the question of interest rate structure covers all forms of debt which are publicly contracted, this study confines itself to marketable debt. Marketable debt refers to obligations of state, local, and federal governments, and corporate debt which are traded on the open market. The theoretical discussion of the rate structure is designed to include all marketable debt; however, due to the lack of adequate data, the statistical tests are carried out only on marketable debt issued or guaranteed by the United States Government. This is common practice, and as we shall see, is particularly reasonable for the time period of our test data.

II

The term structure of interest rates has for some time been a problem of interest to economists both because of its
intriguing nature and because of its policy implications. We begin the examination of the problem with a review of the major theoretical contributions, and then proceed to offer an addition to current theory.

The basic problem is this: how can essentially riskless securities, identical in every respect except term to maturity, have different yields? Over time the United States federal debt market has exhibited rising, falling, humped, and nearly flat yield curves. The body of term structure inquiry is concerned with discovering what sort of behavior or what forces allow short rates to lie below long rates in one instance and above them in another. What causes intermediate rates occasionally to lie above both short and long rates?\(^2\)

In another vein, what can be done to influence the shape of this yield curve? Such things as inventories and short-term international capital flows are traditionally thought to be sensitive to the short-term rate; housing starts and heavy capital formation are thought to be sensitive to the

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\(^1\)By a riskless security we mean one on which there is no risk of default. This does not rule out any capital gains or losses which the bond holder might experience as a result of simple price changes.

\(^2\)Short, long, and intermediate have no exact maturity connotation. For practical purposes, three month Treasury bills are the shortest debt outstanding, while some government and private bonds run up to and beyond twenty years. The United Kingdom has for years issued perpetual securities.
long-term rates. These rates are clearly matters with which policy makers are concerned. Can the two ends of the market be treated independently? Are they perhaps locked together? What policy tools are most effective in the market? The answers to these questions are not immediately apparent.

In order to keep this task manageable it has been confined almost exclusively to examination of the relationship between rates. Policy prescriptions are left relatively undeveloped, though not excluded.

So far a rather substantial body of literature on interest rate structure has arisen. So much has been written that we can cover only the major contributors in detail, leaving others to passing mention. At the outset we divide the literature into theoretical contributions and statistical tests. In order to establish the problem we shall in this section review only theoretical contributions. Statistical contributions will be reviewed in a later chapter.

For our purposes it is sufficient to group the theoretical contributions into two schools of thought: the "expectations" approach and the "market segmentation" approach. The expectations hypothesis posits that yield differentials arise as a result of expectations about future rates of interest. The segmentation hypothesis contends that investors do not view securities of different maturity as substitutes, and consequently that yield differentials arise because securities
are essentially separate commodities, each with its own supply and demand. The security market is then broken up into maturity segments between which there is imperfect linkage.

Though many previous authors (31) (37) (106) have noted a relationship between short-term rates and long-term rates, the current debate seems to stem from J.R. Hicks, *Value and Capital* (39). Hicks begins by examining the relationship between rates of interest on various maturity loans and concludes that the entire loan structure can be thought of as composed of current and future one-period loans.

Having assumed all interest payments are held and paid together with the face value of a bond at maturity, certainty about future short-term rates of interest, no transactions costs, and perfect mobility of funds between markets he writes:

"Looking at it in this way, the rate of interest for loans of two weeks running from our first Monday, is compounded out of the 'spot' rate of interest for loans of one week and the 'forward' rate of interest, also for one week loans, but for loans to be executed in the second week. If no interest is paid until the conclusion of the whole transaction then the same capital sum must be arrived at by accumulating for two weeks at the two-weeks rate of interest, or alternatively by accumulating for one week at the one-week rate, and then accumulating for a second week at the 'forward' rate. The two transactions are ultimately identical." (39, p. 145)

To place this relationship in algebraic terms we introduce Meiselman's notation (57). This notation will be used
extensively in the remainder of the chapter.

\[ R = \text{actual rate of interest} \]
\[ r = \text{expected rate} \]
\[ r_n = \text{expected } n \text{ year rate } (n = 1, 2, \ldots,) \]
\[ r_{n \mid t} = \text{expected } n \text{ year rate with expectation formed at time } t. \]
\[ t+1r_{n \mid t} = \text{expected } n \text{ year rate with expectation formed at time } t; \text{ the rate is expected to prevail in time } t+1, (i = 1, 2, \ldots). \]

For example:

\[ 1970^{r_2}_{1968} = \text{the two year rate of interest expected in } 1968 \text{ to prevail in } 1970. \]

Clearly, \( t^r_{n \mid t} = t^R_n \) that is, the \( n \) year rate currently expected to prevail over the next \( n \) years is identical to the current \( n \) year market rate.

Defining analogously \( t^P_n \) as the price on an \( n \) year security at time \( t \), the total return on a bond maturing in \( n \) years is \( t^P_n(1+tR_n)^n \). Suppose an investor is considering a two year investment. The return on a two year security will be \( t^P_2(1+tR_2)^2 \). Alternatively, the investor may invest sequentially in two one-year securities. He would then be investing in one security at a known rate, \( t^P_1(1+tR_1) \), and the second at an expected rate, \( (1+t+1r_{1 \mid t}) \). The total return would then be \( t^P_1(1+tR_1)(1+t+1r_{1 \mid t}) \). Clearly he will choose the most profitable path. In Hicks' world of certainty
is known so that arbitrage will keep the holding periods equal; thus, \( tP_2(1+tR_2)^2 = tP_1(1+tR_1)(1+t+1R_1) \). Now for simplicity, assume the same amount of funds will go to either market so that \( tP_1 = tP_2 \), and hence \( (1+tR_2)^2 = (1+tR_1)(1+t+1R_1) \). The same reasoning applies to an investor considering 3 years, 4 years, etc. In general, the long-term rate is found to be the geometric mean of expected future short-term rates, that is;

\[
(1+tR_n) = \left[\left(1+tR_{1_t}\right)(1+t+1R_{1_t})(1+t+2R_{1_t})\cdots(1+t+n-1R_{1_t})\right]^{1/n}.
\]

If short rates are expected to rise, the current long rate will exceed the current short rate, and this is termed an ascending yield curve. The converse is also true.

Hicks however adds a final twist to the discussion by introducing Keynesian "backwardation". It is argued that borrowers typically wish to ensure the availability of adequate funds for long periods of time as this assures smooth operation, but that lenders have no such desire. If anything, lenders ordinarily prefer to lend for short periods of time in order to maintain liquidity; thus there develops a "constitutional" weakness which leads Hicks to conclude:

"The forward short rate will thus exceed the expected short rate by a risk-premium which corresponds exactly to the 'normal backwardation' of the commodities markets. If short rates are not expected to change in the future, the forward rate will exceed the current short rate by the extent of this premium; if short rates are expected to
rise, the excess will be greater than this normal level; it is only if short rates are expected to fall that the forward rate can be below the current rate." (39, p. 147)

These issues then become the two fundamental ones about which term structure theory revolves: Is it actually the case that the long-term rate can be no more than the mean of the expected future short-term rates, or can there be other influences? And, secondly, is there actually a constitutional weakness in the market which gives rise to liquidity premia in the longer maturities? For the most part these questions are empirical ones, but they are at the core of the problem and emerge again and again.

In the Hicksian theory and in the theories that follow, the reader's attention will be particularly directed toward the role of the investment period or "horizon". The fundamental issues mentioned above are intimately connected with the horizon, and it is the contention of this writer that the horizon must be considered as part of an investor's decision process. This contention will be supported in Chapter II, so we pay particular attention to the role of horizon in the coming literature review.

Lutz (51) is the second major contributor to the expectations hypothesis. He starts from nearly the same premises as Hicks but examines the case in somewhat more detail. Lutz, like Hicks, assumes there is no investment cost, no default
risk, and perfect mobility of funds on either side of the market, but adds the notable improvement of removing the assumption of perfect foresight. This allows investors to hold differing expectations about future short-term rates.

Lutz also differs from Hicks on the issue of liquidity premia. Suppose there is an investor who holds a bond which matures in the same length of time for which he thinks his funds are available. If the investor changes maturity he trades a certain return for an uncertain one, therefore a positive premium will be required to draw him into another maturity. "It is not legitimate, therefore, to conclude (with Hicks) that the effect of the risk factor, as such, must necessarily be to make long rates higher than shorter ones." (51, p. 512) Lutz essentially concludes that risk factors (or "liquidity premia") can exist in either end of the market, but the observation is made in passing and not formalized.

The major contribution of Lutz is the removal of the assumption of perfect foresight on the part of investors. Assuming there are only two markets available, a long and a short, the investor will enter that which he expects to yield the greatest return for a particular time. The question to resolve is which market offers the greatest return? Lutz writes of the investor:

"He will discount the price at which he
expects to sell the bond at the time when he wants to disinvest (this price is dependent on what he anticipates the long rate will be at that date) and all the interest payments up to that time, back to the present moment, using as the discount factor for each year the short rate which he expects to prevail in that year." (51, p. 513)

This procedure gives the investor a "subjective" price for the bond which he compares with the current market price. If the investor's subjective price is above the market price then the bond is undervalued by the market and the maximum profit can be obtained by investing in a long-term security. If his subjective price is below the market price, the bond is overvalued and the investor gets the maximum return by investing sequentially in short-term securities. This process allows the investor to decide which market yields the greatest return for the particular time he intends to invest. The horizon is assumed to be fixed by non-market factors and plays no part in the investment decision. The presumption is that all investors undertake this sort of calculation so that each is placing his funds on the basis of what he expects future short-term rates to be. The change from Hicks' approach is that investors, while certain of expectations, hold diverse ones. The yield curve will then reflect these diverse expectations in a rising, falling, or level pattern. The exact method by which the yield curve is established is as follows.

The discounting procedure introduces two sets of expectations into the analysis; that of the individual investor
and that of the "market". The current long rate expresses the market's expectation of future short-term rates, and as we have seen, the individual investor has his own set of expectations which may or may not agree with the market. Lutz further argues that the individual's expectation of future long-term rates need not be consistent with his expectation of future short-term rates.

"In the present case, however, an investor's personal expectations about the future course of short rates do not necessarily commit him as to his expectations about the long rate, since the latter depends, not on what he thinks about the future short rates, but what the 'market', i.e. other people, think about them. The individual investor therefore, may quite reasonably form an opinion about the future long rate which is inconsistent with his opinion about future short rates. From this it follows that an investor, if he discounts, as above, the bond price expected at the end of his entire investment period plus the interest payments up to that time, and obtains a 'subjective' bond value which is below (or above) the current bond price, will not necessarily go into the short market (or the long market) now." (51, p. 514)

It is then argued that the possibility of inconsistent expectations gives rise to two alternative investment patterns. The investor may expect that at some intermediate date the yield to maturity on his bond may rise above or fall below the average of short rates. If this is the case he may discount, as before, that high or low price back to the present. If that discounted price is above the current bond price the investor may enter the long market first with the intention of shifting to the short market later. If the
discounted price is below the market price the investor would enter the short market now with the intention of shifting to the long market later.

These cases of expectation could clearly be complicated by introducing a subjective bond price which moves either above or below the expected future short rates in several places. The result is that any pattern of rates can be explained.

Suppose that we begin from an equilibrium position in which all rates are equal. Now let expectations change so that most investors expect future short-term rates to rise. Different people will clearly have different expectations about the amount of rise. Investors whose subjective bond price is below the market price will enter the short market (now) while those whose subjective evaluations are above current prices will enter the long market. On the assumption that most investors expect rates to rise, there will be a general shift of funds into the short market and out of the long market, driving the short rate down and driving the long rate up. The tendency for long rates to rise will be stopped by the equality of supply and demand for funds in each market, and the entrance to the short market of all investors with a subjective price below the market price (51, p. 516).

The process of readjustment can conveniently be summarized by Figure 1.1 from Lutz (51). It is assumed that the
Figure 1.1. Interest rate equilibrium of Lutz

total volume of funds available for investment is the fixed amount ON. $D_L$ and $D_S$ are demand curves for long and short funds respectively, where $D_S$ is drawn with N as the origin and $D_L$ is drawn with O as the origin. Initially CB is the rate pattern which leads to OL invested in longs and NL in shorts. When the expectation of a rise in rates is introduced, CA emerges as the array of differing subjective expected future long-term rates. The new expectation will draw additional funds out of the long market into the short market. This movement will drive rates down in the short market and
drive rates up in the long market. The shifting will con-
tinue until, as noted, all who have a subjective bond price
below the current price are in the short market and the supply
and demand for funds in each market are equal. We observe on
the diagram that shifting ceases when OM funds are in the long
market and MN are in the short market. At this point there is
no further tendency for funds to move between markets and the
equilibrium rate-spread is FE since OE is the long rate and
OF is the short rate.

The same sort of analysis would obtain if rates were
expected to fall. In this case the line OA which arrays sub-
jective bond rates would fall below CB so that funds would
flow out of the short market into the long market. The
equilibrium rate-spread thus obtained would be with short
rates above long rates. Obviously, the only case consistent
with a level yield curve is when investors expect no change
in future rates.

In many ways this analysis is similar to that of Hicks,
and the two taken together form the cornerstone of the ex-
pectations theory.

Lutz, however, is not without his critics. Luckett (49)
has pointed out some internal inconsistencies in the Lutz
model and has criticized the expectations approach on other
grounds as well.

Luckett first points out that Lutz has introduced two
demand curves for funds, yet simultaneously assumes perfect mobility on the part of both lenders and borrowers.

"The ability of lenders to place their funds in either market is perfect; there is frictionless movement in either direction. But curiously, we find the exact opposite extreme on the borrowing side of the market. Here we find that people seeking funds are committed to either the long-term market or the short-term market. They cannot exercise that option which Lutz has previously assumed to exist, of borrowing for short periods and regularly renewing as an alternative to borrowing long." (49, p. 137)

More important to the theory are Luckett's comments on the investor's capacity to form inconsistent expectations about future long and short rates.

"But surely the behavior of this single investor will then warp the rate pattern so that it no longer reflects the 'market's' expectations about the future course of interest rates. And is not the market made up, after all, of individual investors? If they form independent expectations about the course of long-term rates — expectations, that is, which are inconsistent with what they anticipate will occur in the short-term market — then the rate pattern is based on what everyone thinks everyone else thinks; long rates have no relevancy to short rates." (49, p. 139)

Despite the theoretical problems which are involved, Lutz's approach is a significant extension of and improvement on Hicks' approach.

Luckett's final, and perhaps major, criticism is leveled not at Lutz per se but at the general approach of which Lutz is typical (49, p. 140). Luckett points out that there are two methods by which an investor can arrive at his
"subjective" bond price. He can independently form expectations about long term rates or he can discount an expected sale price by using expected one year rates to the bond's maturity (49, p. 140). The first approach leads to the theoretical problems we have been discussing, the second requires the investor to estimate future short rates n years into the future. This second alternative, Luckett contends, is clearly not reasonable.

"We are thus treated to the spectacle of an individual standing on the eve of World War II, atomic bombs, the cold war, the postwar inflation, the Employment Act of 1946, et hoc genus omne, trying to decide what short-term interest rates will be fifteen to twenty years in the future. It will not do to rebut that we know these things only by hindsight. That is the whole point. The future is pregnant with so many possibilities that there is no basis in knowledge on which to form a prediction of short-term interest rates a generation hence, and no rational person could venture such a prediction." (49, p. 141)

This is a well-taken criticism and is one which can be applied to virtually all expectations models. Note particularly that this is a criticism of the arbitrarily long horizon. The model allows no change in horizon resulting from market forces. As we shall see it is this provision and the liquidity premium question which give rise to variations on the basic Hicks-Lutz model.

Malkiel (53) (54) (55) has taken one of the better theoretical expectations approaches. Malkiel argues that bonds, for the most part, are traded by professionals on the basis
of price, not yield (55, p. 51). The consideration of bond price movements, then, is of paramount concern. This factor, along with an expected normal range of rates and expectations proper, are the three factors upon which his theory is built (55, p. 50).

The beginning statement of Malkiel's theory is a set of five theorems concerning the mathematics of bond price movements. For our purposes only the first two are relevant; the remaining three add detail but not substance. Assuming that all bonds carry the same coupon, and that the yield curve is flat, he proves:

Theorem 1: Bond prices move inversely to bond yields.

Theorem 2: For a given change in yield from the nominal yield, changes in bond prices are greater, the longer the term to maturity. (55, p. 54)

At this point the second factor, an expected normal range of rates, is introduced. Malkiel posits that investors expect rates to remain within the historically established bounds of (say) 2 per cent to 5 per cent. A horizon over which investors plan alternative strategies is also introduced, and assumed to be one year. Like Lutz, Malkiel arbitrarily fixes the horizon and allows it no substantive role in the decision process. It is nevertheless this shorter horizon which presumably eliminates the problem of guessing at short rates n years in the future.
Paraphrasing liberally from Malkiel, we follow his example. Suppose the yield curve were level at 4\% per cent. Investors have no expectations about whether rates will rise or fall, but clearly must be concerned about what could happen. While rates are expected to stay in the 2 per cent to 5 per cent historical range a rate fall from 4\% to 2 per cent in one year seems unlikely. The probable lower bound is (say) 3\% per cent, but the upper bound is 5 per cent as rates could be expected to rise to 5 per cent within the year quite easily. Investors are then certain that rates will lie between 3\% and 5 per cent over the year.

This situation leaves more to hope than to fear, even in the absence of explicit expectations about rate changes. The worst that could happen would be a rise in rates (to 5 per cent) subjecting investors to capital losses. The best that could happen would be a fall in rates (to 3\% per cent) giving investors capital gains. Since no explicit expectation about the direction of rate change is allowed, investors are assumed to regard the alternative events of a rate rise and rate fall as equally likely. In this example the lower bound is farther from the current rate than the upper bound which, regarding rise and fall as equally likely, produces a mathematical expectation of gain which is larger than the mathematical expectation of loss. This being the case, investors will move to the long-term end of the market where
(by Theorem 2) price changes will be greatest. This move­ment drives the long rate down and drives the short rate up until equilibrium is reached with a descending yield curve.

The same sort of reasoning holds if rates are near the lower bound of the historical range. Rates at (say) 2½ leave more to fear than to hope as the maximum price decline is greater than the maximum rise. This condition makes the mathematical expectation of loss greater than the mathematical expectation of gain so that investors are drawn to the short­est maturities to protect against price declines. This shifting drives short rates down and long rates up until equilibrium is again reached, but with an ascending yield structure

The yield structures have been explained with the only expectation being that of a normal range of rates. Malkiel then introduces the third factor; expectations proper. The investor may, for example, attach 0.75 probability to a rate rise and 0.25 to a rate fall. Assuming that all possible out­comes can be represented by a Von Neumann-Morgenstern utility index, each event is weighted by its probability and that act with the highest utility index is chosen. While, as we have seen, it is the position of current rates vis à vis the nor-

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1Malkiel points out that he uses the extreme changes only as an example. As long as the situation leaves more to hope than fear, or vice versa, the results will be the same, in the absence of direct expectation, as if any other arbi­trary points had been used.
mal range that determines whether the yield curve rises or falls, it is the probability attached to the event of rate rise or rate fall which determines the curve's slope (55, p. 65). That is, the position of rates currently still dictates where the largest expected gain (smallest loss) will occur, but these gains and losses are weighted by the probability assigned to each. If the "market" attaches a particular probability to (say) a rate fall when rates are near the upper bound, the curve descends more sharply than in the state with no expectations. The converse involves the same reasoning.¹

This model is a significant improvement over Hicks-Lutz as it apparently removes the problem of guessing at future short rates. As Luckett writes, "To put the matter as succinctly as possible, the Hicks-Lutz theory assumes long-term forecasts of short-term rates, whereas the Malkiel theory assumes short-term forecasts of long-term rates." (47, p. 323)

Malkiel arbitrarily introduces a one year horizon with which the entire market is assumed to operate. But at the same time he refers to his rate changes and investor's expectations as "within the year" (55, p. 61). We are not really sure what the horizon is, yet the entire market pre-

¹Presumably the "market" is some sort of an average of individual expectations. Malkiel makes no explicit statement about this.
Bumably acts on this horizon. We shall have more to say about the horizon problem in the next chapter.

Luckett (47) draws together Malkiel and Hicks-Lutz by demonstrating that the two theories are actually mathematically the same. Following Luckett, we have seen that the Hicks-Lutz expectations model leads to,

$$(1 + tR_n)^n = (1 + tR_{n-1}) (1 + tR_{n-2}) \cdots (1 + tR_1)^n.$$  

If we ignore liquidity premia, institutional constraints, etc., then an unbiased estimate of the relevant future short rate is:

$$1 + tR_{n+1} = \frac{(1 + tR_{n+1})^{n+1}}{(1 + tR_n)^n}$$

Since investors are assumed to try to maximize the return over any period of time, arbitrage will keep holding periods equal. That is, arbitrage will insure that covering a ten year period by ten one-year bonds, two five-year bonds, five two-year bonds, etc., or any combination thereof will yield the same expected return. Luckett then argues that Hicks-Lutz and Malkiel have in common the feature of equal holding period yields resulting from maximizing behavior on the part of the investor (47, p. 323).

Defining $t-1^H_{n+1}$ as the expected holding period yield during $t-1$ on the $n+1$ maturity, Luckett assumes that the market acts so that,

$$t-1^H_n = t-1^H_{n+1} \quad (n = 1, 2, \ldots). \quad \text{Equation 1}$$
defined to be the price of the $n+1$ maturity at $t-1$ and $p_n$ as the price which must be expected to prevail next year so that Equation 1 holds.

"Then (2) $t-1^{n+1} = \frac{t^{P_n} - t-1^{P_{n+1}}}{t-1^{P_{n+1}}}$ making the standard Hicksian assumption that all interest payments are made at maturity. The existence of the expected price $t^{P_n}$ taken together with the known terminal value of the bond, $t-1^{P_{n+1}}(1 + t-1^{R_{n+1}})^{n+1}$, is sufficient to define an expected long-term rate of interest such that (3)

$$(1 + r_{n_{t-1}})^n = \frac{t-1^{P_{n+1}}(1 + t-1^{R_{n+1}})^{n+1}}{t^{P_n}}.$$ (47, p. 323)

Luckett argues that this is a fair statement of Malkiel's hypothesis since there is the implication of a one period horizon, and identical holding period yields.

"It is equally true, however, that equation (3) implies a forecast of a series of forward short-term rates for each year into the future. This is so because as we have seen, the assumption of equal holding period yields implies an expected structure of rates at $t$. And any structure of rates, whether realized or expected, can be looked at in the usual Hicks-Lutz fashion to determine a series of expected short-term rates for each year in the future. Thus we may write:

$$(4) \quad 1 + t^{R_{n_{t-1}}} = \frac{(1 + t^{R_{n+1}}t_{t-1})^{n+1}}{(1 + t^{R_{n_{t-1}}})^n}.$$ (47, p. 324)

Luckett then proceeds to demonstrate that statements 3 and 4 are mathematically equivalent. The point, of course,
is that forming expectations about a whole structure of rates is the same as forming expectations about a series of future short-term rates because these short rates are implied in any complete rate structure; you cannot have one without the other. The presumed advantage over the Hicks-Lutz model gained by introducing a short horizon is revealed to be no gain at all. We still have investors operating on the basis of a long series of expected future short-term rates, and the horizon is still arbitrary.

This review gives the flavor of expectations hypotheses. The participants are assumed to be free of institutional barriers and have no maturity preferences; funds are imagined perfectly mobile, and, most important, investors are imagined capable of predicting short rates into the indefinite future. For the most part, any horizons introduced are arbitrary and do not enter into the decision process.

Despite these apparent drawbacks, statistical tests of the expectations hypothesis provide rather strong support. As is the case with most controversy, however, the results are subject to criticism and are, to some extent, open to interpretation. Since there is a substantial body of purely statistical tests of hypotheses presented herein, we defer discussion of them to a later chapter.

III

We turn now to an alternative approach to the term struc-
ture problem, the "market segmentation" hypothesis.\textsuperscript{1} The major proponents of this hypothesis are Culbertson (23) and to a lesser extent Modigliani and Sutch (60) (61) and Michaelson (58) (59). In general this approach has been considered only residually; institutional considerations if allowed at all, have been relegated to explaining liquidity premia, or have been unsupported by statistical tests. To my knowledge Culbertson is the only author who has started from a purely segmentation point of view and tried to reason from that point to an explanation of observed rate structure. As we will see, even his approach is not theoretically formal.

The segmentation hypothesis argues that the major influence in the term structure comes from an independent supply and demand for each debt maturity, where these maturities are weak substitutes at best. Culbertson writes:

\textquote{Rates on short-term and long-term U.S. government securities, which are tied to rates on related private debt, characteristically move simultaneously in the same direction in the short run (over periods of weeks and months), with short-term rates changing over the wider range. The general coincidence of movement in rates reflects basically the simultaneous impact in various credit markets of changes in general credit conditions resulting from changes in business conditions and monetary policy, and substitutability between short-term and long-term debt on the part of both

\textsuperscript{1}This is occasionally refered to as the "institutional" hypothesis.
borrowers and lenders. However, this substitutability is limited in extent, and when the maturity structure of debt supplied to the economy undergoes a substantial short-run change, either because of Treasury debt management operations or actions of private borrowers, this is reflected in the rate structure. Yields on short-term debt average lower than those on long-term debt because of the advantage of the superior liquidity of such debt to the holder and the liquidity disadvantage of issuing such debt to private borrowers. The amount of the liquidity premiums reflected in the term structure can vary with changes in the maturity structure of outstanding debt and with other factors affecting marginal preferences for liquidity in investment assets. Behavior based upon interest rate expectations is important mainly as a factor determining very short-run movements in long-term rates. Such behavior is based mainly on near-term expectations, and is ordinarily of little importance in determining average rate levels, and relationships over considerable periods of time." (23, pp. 488-489)

This quotation is a fair summary of Culbertson's position which he further supports by examining, "Four major factors underlying the market's relative valuation of short-term and long-term debt..." (23, p. 489). These are: liquidity, speculation, supply changes in the face of rigid demand, and differences in costs.

Concerning liquidity, Culbertson argues that it is essentially the ability to convert quickly to cash at a reasonably certain price. Since no investor has perfect foresight and few are willing to act as if they had, each must have some concern about liquidity to handle unforeseen contingencies.

"Particular future cash needs differ in (1)
the degree to which their timing is certain ranging from definite liabilities to pay given taxes on a certain day to completely uncertain contingencies, and in (2) the nearness or remoteness of the time at which they will arise or are most likely to arise." (23, p. 492)

Each of these obligations must be matched by the appropriate liquidity. This leads to the general borrowing rule of matching the debt to the length of time for which the funds are needed or the type of asset to be purchased with the funds (23, p. 494). Given these considerations there is little room for speculation. The rate differences arising out of liquidity premia, which are not the entire difference between rates, should then be responsive to supply changes in the outstanding debt.

Turning to speculation based on interest rate expectations, Culbertson argues that a great many factors must be taken into account for each investor. Assets from which to choose, time periods for comparison, scale of operation, the market in which to operate, the investor's frame of reference, etc., are all factors relevant to expectations determination. These factors are sufficiently unique and unstable for each investor so that, "...the net effect of speculative activity is not usually something that is clear and definite, but is rather the net result of individual patterns of operation that are diverse and in many cases inconsistent." (23, p. 496)

It is thus argued that speculation is of little impor-
tance overall and any influence which it does exert is limited to very short-run considerations. This is so because near-term expectations are the only ones well enough formed to act upon, and because short-term speculation gives greater returns as a result of short period price fluctuations (23, p. 497). Culbertson also points out that so many profitable opportunities have been passed over that it is difficult to see how speculators could stay in business. Most investment, Culbertson argues, is non-speculative; an investor selects a portfolio according to his maturity needs and based upon past earnings, and holds it through short-run shifts, whatever they may be (23, p. 499).

The third of the four factors to be considered is that of supply. Up to this point a reasonably strong case has been made that an investor's maturity holdings are generally not a matter of indifference — that funds are not perfectly mobile, and that liquidity needs do exist. It then follows from this that the term structure will be affected by supply changes in the outstanding debt. There are, of course, changes in the demand for debts of different maturity, but such factors as legal restrictions on institutional holdings, diversification desires, geographical immobility of funds, etc., serve to maintain some rigidity of demand, and thus enhance the supply effects.

The fourth factor, relative costs, is generally regarded as not significant and is, therefore, ignored.
IV

This brief review gives us some familiarity with the term structure problem. We have purposely not covered each detail, nor covered all of the contributors. The contributors which we have not covered will be discussed in the statistical section since most other contributions arise only as sidelights of statistical testing. We have covered the main theoretical approaches.

The contrast between these approaches is a sharp one. On the one hand, expectations theorists regard market participants as motivated entirely by expectations and a desire to maximize return over some indeterminate or arbitrary time horizon. Investors have no qualms about jumping from short maturities to long and back as their expectations demand, and feel perfectly safe in extending expectations well into the future. No quarter is allowed for hedging against a date when an investor might know with certainty he will exit the market. All securities are viewed as perfect substitutes.

The other hand offers the segmentation theorists, who regard market participants as having definite, fixed horizons which they try to match. Market participants do not trust their expectations beyond a very short period of time and generally do not act upon them because they are so uncertain. Securities of different maturity are not substitutes in any significant degree, but are attractive only to the extent that
they fill a specific maturity need. For the most part expectations are regarded as so uncertain and diverse that they exert no significant force over the long run. As a result, investors operate in a given maturity range which they will not leave under ordinary circumstances.

At the outset we questioned what could be done about the yield structure from a policy point of view. We are now in a position to notice that there are opposing points of view here. The expectations hypothesis implies that, since the term structure is insensitive to debt maturity structure, the monetary authorities can exercise policy only if they can influence expectations (46) (109). Alternatively, the segmentation hypothesis argues that securities are not perfect substitutes so that the term structure will react to supply changes. If this is the case, the monetary authority can influence the yield structure with open market operations. Which of these explanations holds is therefore not only a matter of theoretical concern, but is of eminent practical concern.

The current writer is not convinced that either explanation is complete. Each has objectionable features and each has its undeniable truths. The expectations hypothesis has impressive empirical support but has the objectionable horizon problem. Culbertson's approach, while introducing a much needed maturity preference clause, is decidedly not rigorous.
He maintains that the major portion of the yield curve can be explained by supply and demand for particular maturities, with expectations oriented activity having only a minor influence. But this is all put forth mostly by assertion. It will be the task of the next chapter to take a closer look at the segmentation approach and try to devise a blend of the two approaches. Following that we will review statistical work to date and then apply some additional tests.

1For syntheses already undertaken see Malkiel (55), Modigliani and Sutch (60) (61), and Meiselman (57), to be reviewed later.
It is the purpose of this chapter to present an addition to current term structure theory. We begin the chapter with a brief look at a pure segmentation hypothesis, and then develop a blend of the segmentations and expectations hypotheses.

The primary characteristic of a pure segmentation hypothesis is that participants on both sides of the market have maturity preferences which override all other considerations. That is, borrowers and lenders have maturity preferences which are generated by some non-market concern so that market forces alone are insufficient to move them from one maturity range to another.

In its purest form, the segmentation hypothesis posits that participants on both sides of the market are risk averse in the extreme. They are presumed to know exactly (or hold an estimate with certainty) the date upon which they wish to leave the market and are uninterested in speculating on returns in other maturities. The primary reason these risk averse participants are in the market at all is either to get necessary financing or to earn some rate of return greater than the zero (and sometimes negative) return on idle funds. The dominant consideration of lenders is the capital certainty which comes from matching a known liquidation date with a security of just that length. In this manner a lender can also assure
himself of a known rate of return. The borrowers know with
certainty the cost of borrowing by issuing securities which
have a maturity just matching the length of time for which the
funds are needed. In both cases there is no trade-off between
maturity and yield. Lenders are unwilling to trade certain
return and safety even though an alternative maturity might
offer higher expected returns. Borrowers are unwilling to
exchange the certainty associated with a given maturity even
though lower costs might be expected in an alternative matur­
ity.

The force which motivates behavior here is a non-market
force; participants subjugate lending and borrowing decisions
to what we might term a structure of "obligations". Lenders
know at what date their obligations require that their funds
be returned. For example, an insurance company knows just
when its policies become paid-up and, consequently, it knows
when it will need its funds back. Borrowers know at what
date the project to be financed will be completed. For ex­
ample, a manufacturer knows just when a machine will wear out
and, consequently, he knows how long he will need funds before
the machine has paid for itself.

But this pure segmentation approach can not explain ob­
served rate structures. The participants are assumed to act
wholly from non-market forces, and thus the provision that
there exists no trade-off between maturity and yield means
there is no market. A market requires a supply, a demand, and
a price to which both react. The pure segmentation hypothesis does not allow participants to react to price. The supply and demand for any maturity security consists entirely of two points; a supply point, and demand point.

To obtain fruitful results we must modify the pure segmentation hypothesis at least enough to establish a market. There are a number of modifications which could be introduced; the most obvious modification is to include some concern on the part of the participant about yield. Additionally, uncertainty should also be introduced. Properly introduced, these modifications should lead to a more plausible hypothesis.

If we examine the pure segmentation hypothesis behavior of the participants it becomes clear how to introduce yield concern and uncertainty. First, participants in the segmentation hypothesis are unconcerned about yield; any shifting done is for reasons other than yield. Behavior will obviously be altered if yield considerations are introduced. Second, there are two places where uncertainty can occur in this model: (1) participants may be uncertain about yield; and (2) they may be uncertain about the due dates of obligations. The introduction of (1) essentially introduces expectations. When yield comparisons are allowed we essentially allow the participants to speculate about alternative methods of financing for a known period of time. The only way to invest or borrow for a known period of time (say 10 years) with certainty of yield is to operate in that period (10 year) maturity. To
move away from that maturity by comparing alternative ways of financing for the period is to allow market participants to have expectations about the future course of yields. For example, the only way to invest for 10 years with certainty of return is to buy a bond which matures in 10 years and hold it to maturity. Should the investor consider investing for the same period by sequentially purchasing 2-five year bonds, he must invest in the second at an expected rate. This will be true of any combination of bonds leading to the end of the 10 year period.

The introduction of (2) injects uncertainty into that obligation structure which motivates market participation. A lender or borrower may not be certain about the length of time he wishes to be in the market. Rather than estimating time in the market as a point, he may estimate it as a range. This range will be narrower or wider as he is in greater or lesser degree certain of the obligation due date. This range of possible obligation due dates will be referred to as a "horizon".

A horizon can be viewed as an integral part of the decision-making mechanism not only for a participant with maturity preferences but for a speculator as well. Indeed a horizon is implicit in any decision an expectations-oriented participant makes. If, for example, rates are expected to rise they cannot reasonably be expected to rise indefinitely. The speculator must expect that at some point rates will level off or fall; he may simply refuse to form expectations beyond a point,
but any of these expected changes produces a horizon. Any expected rate change, for example, calls for one strategy to the change point and another after that point. But the time range in which the change is expected to occur serves the same function as a horizon determined by a non-market obligation structure. Similarly, the end of the range over which expectations are formulated acts as a horizon. Both become integral parts of the investment decision, and should not be established arbitrarily.

Let us now combine our yield and uncertainty modifications to the segmentation hypothesis in a somewhat more formal model. We first examine the demand side under the modifications. There are four general cases of uncertainty and yield expectations:

1. The lender is certain about the horizon and certain about the future course of interest rates.

2. The lender is certain about the future course of interest rates and uncertain about the horizon.

3. The lender is certain about the horizon and uncertain about the future course of interest rates.

4. The lender is uncertain about both the future course of interest rates and the horizon.

Case 1

Case 1 is uninteresting: since expectations are held with certainty and the horizon is certain, the lender need only pick the most profitable path for the known horizon.
This case is akin to that of pure segmentation behavior. Pure segmentation behavior is actually a special case where horizons are one point and known and lenders are certain about rates for only one path to the horizon. That path to the horizon which is certain is the purchase of a security which matures at the horizon. This is the only certain path while in the general case lenders are certain about all paths to the known horizon.

Case 2

Consider a lender who holds a set of interest rate expectations with certainty. We now assume that investors have some trade-off between yield and maturity. Since we have assumed certainty of expectations about interest rates the uncertainty is involved in the horizon. Uncertainty, however, is not to be equated with ignorance. We assume that the lender has some expectation about probable liquidation dates based, possibly, on past experience.

Suppose the lender has an expected liquidation date in mind. He expects, for any given obligation, that he will have to liquidate his holdings at time, \( t+k-i \leq t+k \leq t+k+j \), where \( t \) represents the current time, and \( k \) is some number representing that period in the future when the obligation is most likely to come due. Since the due date is not held with certainty, \( i \) and \( j \) represent the number of periods on either side of \( k \) in which the obligation might come due. Depending on the
investor, i and j may be equal or unequal.

We assume the lender expects the liquidation date to arrive in \( t+k-i < t+k < t+k+j \) periods and subjectively assigns a probability to the obligation falling due in each period. Further, we posit that this is a distribution covering the lender's entire range of expectations so the \( P(k-i) + P(k-i+1) + P(k-i+2) + \ldots + P(k) + P(k+1) + P(k+2) + \ldots + P(k+j) = 1 \) where \( P(k) \) is the probability of the event falling in that period. In principle, this distribution can be of any form, but for the examples a 3 period distribution will be used. For the following exposition assume: \( P(k-1) + P(k) + P(k+1) = 1. \)

There will be, to any given point in time, a number of possible investment paths. Since the investor expects with certainty a particular set of rates in the future, he can specify a return for each possible liquidation period on any given investment path. The lender is thus concerned only about the most profitable of these paths. The returns gotten by investing from time \( t \) to any of the three expected liquidation dates can be displayed in a square matrix as shown in Figure 2.1. The rows are possible liquidation dates, and the columns are the most profitable path to a given point.

For example, if the lender should pick the most profitable path to \( k-1 \) and the liquidation date should actually fall in \( k-1 \) periods, then the expected return would be \( a_{11} \). (The lender in this example assigns probability zero to the
Possible liquidation dates

<table>
<thead>
<tr>
<th></th>
<th>k-1</th>
<th>k</th>
<th>k+1</th>
</tr>
</thead>
<tbody>
<tr>
<td>k-1</td>
<td>a_{11}</td>
<td>a_{12}</td>
<td>a_{13}</td>
</tr>
<tr>
<td>k</td>
<td>a_{21}</td>
<td>a_{22}</td>
<td>a_{23}</td>
</tr>
<tr>
<td>k+1</td>
<td>a_{31}</td>
<td>a_{32}</td>
<td>a_{33}</td>
</tr>
</tbody>
</table>

Most profitable path to

Figure 2.1. Return matrix

obligation falling due before k-1 or after k+1 periods.)

Should he take the most profitable path for k periods when the liquidation date falls in k-1, the expected return is $a_{12}$.

---

1. This approach imposes certain restrictions on the matrix. The first restriction is:

   $a_{11} \leq a_{22} \leq a_{33} \leq \cdots \leq a_{nn}$.

   Condition 1

   $a_{22}$ cannot be less than $a_{11}$ because the investor could cover k periods by investing to k-1 and holding cash from k-1 to k, thereby making $a_{22}$ at least as large as $a_{11}$. The same reasoning holds for $a_{33}$ and $a_{22}$.

   Each of the off-diagonal elements must be equal to or less than its corresponding diagonal elements. Consider $a_{21}$, the return for an investor who invests short of the actual due date. On the assumption that he plans to hold cash if he guesses short, he gets $a_{11}$ but suffers the opportunity cost of having invested wrong. Had he invested correctly $a_{22}$ would have obtained so that (footnote continued on following page)
We assume that the lender's preference function is a function of profit and risk and can be represented by a Von Neumann-Morgenstern utility index. By comparing all of the

\[ a_{ij} = 2a_{jj} - a_{ii} \quad \text{all } i > j. \]

Since assumptions other than that the investor holds cash over the interum are permissable, however, Condition 2 may be altered or invalidated. We might, for example, assume that if he guesses short he invests sequentially in one period securities until the obligation falls due.

Because of Condition 1 and the investor's option to invest to a point and then hold cash:

\[ a_{ij} \leq a_{i+1,j} \quad \text{all } i > j \]

and

\[ a_{ij} \geq a_{i+1,j} \quad \text{all } i > j. \]

Elements in the lower left triangle both horizontally and vertically decline from (or are equal to) their diagonal elements.

The upper right triangle elements result from the lender being surprised long rather than short; he finds the obligation due before expected. These elements must be smaller than or equal to corresponding diagonal elements, but need not decline sequentially:

\[ a_{ij} \leq a_{ii} \quad \text{all } i < j \]

and

\[ a_{ij} \leq a_{jj} \quad \text{all } i < j. \]

As we proceed to later cases these conditions will alter.

This requires us to assume that under conditions of uncertainty the preference function has:

Transitivity: If AIB and BIC then AIC where A, B, and C are events and I represents the indifference relation.

Continuity of preference as a function of P: If A is preferred to B (footnote continued on following page)
outcomes in the matrix, the lender can assign Von Neumann-Morgenstern utility numbers to them. He must assign numbers to outcomes which involve risk, gains, losses, opportunity costs, and certainty. These may carry vastly different weights: losses may be weighted more heavily than gains, certain return may be weighted more heavily than uncertain return, real costs may be weighted more heavily than opportunity costs. Any number of possibilities such as these may be considered; the point is that the outcomes may be assigned Von Neumann-Morgenstern utility numbers. In Figure 2.2 U_11 is the utility number assigned to outcome a_11, U_32 is the utility number assigned to outcome a_32, and so on. The utility matrix may then be treated as the payoff matrix in a simple game against nature. The lender, as a player, is faced with the problem of selecting the best path or combinations of paths to travel.

(footnote continued from previous page) and B is preferred to C there exists a probability number P_a such that 0 < P_a < 1 and B {

\[ P_a : A, B \]

Independence: For ABCD if AIB and CID then \[ P : A, B \] I \[ P : B, D \] for any probability P.

For any A and B and probability numbers r and r' if A is preferred to B then \[ r : A, B \] is preferred to \[ r' : A, B \]; if and only if r > r'.

For any alternatives A and B and probabilities P, P_a, and P_b:

\[ P : P_a : A, B, P_b : A, B \] I \[ P : A, B \]

where r is a probability number given by:

\[ r = PP_a + (1-P)P_b. \]
Figure 2.2. Utility matrix

<table>
<thead>
<tr>
<th>Possible liquidation dates</th>
<th>k-1</th>
<th>k</th>
<th>k+1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$U_{11}$</td>
<td>$U_{12}$</td>
<td>$U_{13}$</td>
</tr>
<tr>
<td></td>
<td>$U_{21}$</td>
<td>$U_{22}$</td>
<td>$U_{23}$</td>
</tr>
<tr>
<td></td>
<td>$U_{31}$</td>
<td>$U_{32}$</td>
<td>$U_{33}$</td>
</tr>
</tbody>
</table>

Most profitable path to

over the unknown period of time. He must somehow allocate his funds, bearing in mind that whatever path he chooses, he is likely to miss his guess and end up with an off-diagonal payoff. Accordingly, the desirability of each path must be weighted by the probability of the obligation being due on the date in question. This is essentially what a game does.

The lender's strategy is thus a choice of path to a due date and nature's strategy is the manipulation of the due date. We assume that, as previously mentioned, the lender is experienced enough to attach probabilities to nature's behavior. Nature's strategy, when the due date is uncertain, is therefore

---

\[1]\text{We would expect that for the typical lender diagonal terms would have higher utility numbers than off-diagonal terms. \textit{Ceteris parabus,} to have one's expectations fulfilled is generally \textit{ex ante} more pleasant than to be surprised and receive an off-diagonal payoff. This is also true of the later cases. See previous footnote.}\]
a mixed one, but is known to the lender.

The general case of a two-person, constant-sum game is as follows. Each player selects a vector from a set of vectors as a strategy. The elements of the set must be vectors satisfying the following conditions:

Each $X_r$, $(r=1,2,\ldots,m)$, of vector $X$, where $X = (X_1 X_2 \ldots X_m)$, must be greater than or equal to zero and $\sum_{r=1}^{m} X_r = 1$. A pure strategy exists when one $X_r = 1$ and all others in the vector equal zero. The other player selects a vector $Y$ where $Y = (Y_1 Y_2 \ldots Y_n)$ and each $Y_s$ $(s=1,2,\ldots,n)$, is greater than or equal to zero and $\sum_{s=1}^{n} Y_s = 1$.

If nature's strategy is the vector $Y$ and the lender's strategy is the vector $X$ then the expected value of the game to the lender is

$$E(X,Y) = \sum_{r=1}^{m} \sum_{s=1}^{n} U_{rs}X_rY_s$$

where $U_{rs}$ is the $s^{th}$ element in the $r^{th}$ row of the payoff matrix. Restated in matrix terms: $E(X,Y) = X'UY$ where $X$ and $Y$ are column vectors and $U$ is the payoff matrix.

Since nature's strategy is known, and since the game is played only once, the solution follows easily. The lender wants to maximize the expected value of the game; his problem is to pick the strategy which does that. Assume he estimates that the chance of the obligation coming due in $k-1$ is .25, in $k$ is .50, and in $k+1$ is .25. Then the investor must pick a vector of $X$'s which maximizes the following:
Under these conditions, the lender's best strategy is a pure one:

\[
\begin{bmatrix}
X_1 & X_2 & X_3
\end{bmatrix}
\begin{bmatrix}
U_{11} & U_{12} & U_{13} \\
U_{21} & U_{22} & U_{23} \\
U_{31} & U_{32} & U_{33}
\end{bmatrix}
\begin{bmatrix}
\frac{1}{4} \\
\frac{1}{4} \\
\frac{1}{4}
\end{bmatrix}
\]

where \( C = X_1 U_{11} + X_2 U_{21} + X_3 U_{31} \)

\( D = X_1 U_{12} + X_2 U_{22} + X_3 U_{32} \)

\( E = X_1 U_{13} + X_2 U_{23} + X_3 U_{33} \).

Since \( \frac{1}{4}C + \frac{1}{4}D + \frac{1}{4}E \) is the value of the game to the lender, the problem is to select a strategy which maximizes \( \frac{1}{4}C + \frac{1}{4}D + \frac{1}{4}E \) subject to the constraint \( X_1 + X_2 + X_3 = 1 \). Assuming that \( U_{11}, U_{12}, \ldots, U_{33} \) are greater than zero and unequal, then at least one pure strategy is better than any mixed strategy. To compare any mixed strategy to any pure strategy we must note that elements \( C, D, \) and \( E \) would, for a pure strategy, be replaced by the strategy's corresponding row. That is, for pure strategy \( X_1 \), \( C, D, \) and \( E \) would be replaced by \( U_{11}, U_{12}, \) and \( U_{13} \) respectively, or the first row in the payoff matrix. \( X_2 \) as a pure strategy produces the second row in the place of \( C, D, \) and \( E \) and \( X_3 \) produces the third row. Now for any given mixed strategy to be better than all pure strategies \( C \) as
above must be greater than $U_{11}$, $U_{21}$, and $U_{31}$, or $D$ must be greater than $U_{12}$, $U_{22}$, and $U_{32}$, or $E$ must be greater than $U_{13}$, $U_{23}$, and $U_{33}$. A glance at the figures will assure the reader that none of these conditions can be fulfilled; where $X_1 + X_2 + X_3 = 1$, $C$ cannot be greater than each of its elements. The same reasoning holds for $D$ and $E$. Only when nature's strategy is unknown (which is not the same as assuming all states equally likely) can diversification beat a pure strategy. A pure strategy is also best in the face of equally likely states.

Once the lender has selected from his set of strategies that strategy which maximizes the expected value of the game, he has determined his demand for securities of a particular maturity. In other words, once a path has been chosen the lender will enter the maturity category of the first security on the path. For example, a lender might find the probability of the obligation coming due in $k$ high enough that he would hedge by entering the $k$ maturity market regardless of other considerations. It might be the case, however, that expectations of rate changes would nevertheless draw him into the short market or the long market. Rate changes will then affect estimates of profitability on particular paths and cause shifting on the demand side. Lenders are therefore now responsive both to price changes and to horizon effects.
Case 3

Suppose that the uncertainties are reversed: the lender is now certain of the liquidation date, but uncertain of future interest rates. He is now faced with estimating the return on alternative paths to the known liquidation date. In general there will be several paths to the known liquidation date, each of which has certain characteristics by which the lender ranks it. In other words, the lender has a subjective probability distribution of returns for each path to the known liquidation date and he must assign Von Neumann-Morgenstern utility numbers to these various distributions. Each distribution has, of course, an expected value and a variance. We suspect that the mean and variance would be the major decision variables, but this approach also allows consideration of skewness and kurtosis. All of these clearly may be relevant to the evaluation of a path.

These distributions of outcomes for all paths leading to the known liquidation date are then compared, and the lender simply picks the one with the highest utility number. This process can also be seen as a very simple game where nature has only one, pure strategy. The payoff matrix has only a single non-zero column, and the lender's best strategy remains a pure one:

\[
\begin{bmatrix}
X_1 & X_2 & X_3 \\
0 & U_{12} & 0 \\
0 & U_{22} & 0 \\
0 & U_{32} & 0 \\
\end{bmatrix}
\begin{bmatrix}
0 \\
0 \\
1 \\
0 \\
\end{bmatrix}.
\]
Again when the path has been selected, the lender's demand for securities of a particular maturity is determined. Again the lender can, in the face of rate changes, be convinced to move from one path to another. For example, changes in expected interest rates can alter the distribution of returns for any path, and thus alter its assigned utility number. The new utility number might lead to a new best path thereby altering the lender's demand for a given security.¹

Case 4

The final and most general case is that in which expectations about both future rates of interest and the liquidation date are not held with certainty. The lender in this case is faced with the problem of evaluating the distribution of outcomes for each path, and selecting a utility maximizing path to an uncertain point in the future.

The structure of the problem changes little for this case; the only difference between this case and Case 3 is that nature's mixed strategy is reinstated. As before, the lender compares the distribution of outcomes associated with each path and assigns Von Neumann-Morgenstern utility numbers to the distributions. The utility numbers of the best paths to the several possible liquidation dates be-

¹This case is essentially the Malkielian case where there is a known horizon but no variance about it. Malkiel arbitrarily assumes a one year horizon and allows his investors to move into either the short or long market based upon their expectations about rates over the year horizon.
come the diagonal elements. Nature again has a strategy which we assume the investor estimates. This strategy may cover any number of periods, and, in the case of an expectations-oriented lender, will probably cover a large number.

To continue the 3 by 3 example, assume the lender estimates nature's strategy to be \( P(k-1) = 0.25, P(k) = 0.50, \) and \( P(k+1) = 0.25. \) Then the lender must pick the strategy which maximizes the expected value of the following game:

\[
\begin{bmatrix}
X_1 & X_2 & X_3 \\
U_{11} & U_{12} & U_{13} \\
U_{21} & U_{22} & U_{23} \\
U_{31} & U_{32} & U_{33}
\end{bmatrix}
\]

As before, since nature's strategy is assumed known, the lender's best strategy is a pure one. If we arbitrarily assign utility numbers, then the solution is a choice of pure strategies as follows:

\[
\begin{bmatrix}
X_1 & X_2 & X_3 \\
3 & 5 & 7 \\
2 & 6 & 4 \\
1 & 8 & 9
\end{bmatrix}
\]

yields

\[
\begin{bmatrix}
3 & 5 & 7 \\
2 & 6 & 4 \\
1 & 8 & 9
\end{bmatrix}
\]

for \( X_1 \) pure, or

\[
\begin{bmatrix}
3 & 5 & 7 \\
\frac{1}{2} & \frac{1}{2} & \frac{1}{2} \\
\frac{1}{2} & \frac{1}{2} & \frac{1}{2}
\end{bmatrix}
\]

for \( X_2 \) pure,
or $\begin{bmatrix} 1 & 8 & 9 \end{bmatrix} \begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix}$ for $X_3$ pure.

Clearly $X_3$ maximizes the value so that the choice made is to take the path to $k+1$. The lender will then demand the first security on that path. Obviously, different utility numbers would produce different solutions.

This completes the analysis of the demand side. We have modified our pure segmentation approach by allowing lenders to be concerned about returns and by allowing them to shift maturities on the basis of expected returns. We have assumed that the lender's preferences can be represented by a Von Neumann-Morgenstern utility function, and we have introduced an expected horizon. This approach accommodates a very wide range of lenders from those who are purely expectations-oriented to those who are purely segmentation-oriented. Those lenders who are pure speculators will have a very broad horizon and may regard all possible due dates in that horizon as equally likely. Segmentation-oriented lenders such as institutional lenders may have a well-defined obligation structure, in which case the horizon is likely to be a very narrow one with a particularly large probability placed upon one due date. Rigidity is thereby introduced, since it may take a large spread between rates to draw the lender out of a nearly certain haven.
At any time, the market could be comprised of any combination of these lenders. The sensitivity of the demand side to external forces would then depend upon that composition. It thus becomes an empirical question whether there are enough lenders with a strong maturity preference to make debt swaps effective in altering the yield structure.

II

In order to have a clearly-determined rate structure, it is necessary to examine the supply side of the market as well as the demand side. The same considerations which motivated the modification of the demand side also motivate the modifications to the supply side. We assume suppliers to be motivated to minimize risk, but to have some trade-off between risk and profit (in the form of cost reduction).

Much the same uncertainties beset the borrower as beset the lender. Borrowers have need of funds for a period of time, and there are penalties for arranging to have funds for too short or too long a time. Presumably a borrower issues debt in order to undertake a project which will in time exhibit positive net productivity. If the funds are borrowed for a time short of the mark, the borrower must refinance for the remainder of the chosen period. If he borrows for too long a period, he must either pay additional interest or redeem the debt at possibly unfavorable prices. In either case the cost of missing the point on the horizon may be
significant. The borrower is thus motivated to stay near the maximum probability point on his horizon. We assume, however, that the borrower is familiar enough with his operation to estimate the horizon by assigning probabilities to the event happening in each of the horizon periods. This in our established structure, becomes nature's strategy.

The other source of uncertainty can equally be introduced to the borrower's side. Since we assume the borrower has a trade-off between yield and risk he formulates expectations about future rates of interest. These expectations can cause the borrower to shift positions within his horizon. Particular expectations may well cause him to finance short of the most likely due date in the horizon because he expects to be able to reduce cost by refinancing in the latter periods. The same sort of considerations may draw him beyond the most probable date on the horizon. The borrower is thus beset by the same uncertainties as the lender and must, therefore, carry out the same sort of decision process.

As in the previous analysis the borrower is assumed to be able to assign Von Neumann-Morgenstern utility numbers to the list of outcomes for each of the paths to the various points on the horizon. The paths with the highest utility numbers become the diagonal elements in the payoff matrix. Nature's strategy is estimated by the borrower, and the game is played. As with the lender, it is to the borrower's advantage to play a pure strategy when nature's strategy is
known. Thus the borrower must maximize

\[
\begin{bmatrix}
Z_1 & Z_2 & Z_3 \\
V_{11} & V_{12} & V_{13} \\
V_{21} & V_{22} & V_{23} \\
V_{31} & V_{32} & V_{33}
\end{bmatrix}
\begin{bmatrix}
1/2 \\
1/3 \\
1/6
\end{bmatrix}
\]

where the \(Z's\) are the borrower's strategies, the \(V's\) are utility numbers and \(1/2, 1/3, 1/6\) is the borrower's estimate of nature's strategy.

Once the game is played and a path selected, the supply of securities in each maturity is determined. Changes in rates alter yield and risk elements in the distributions of outcomes. These changes then cause changes in the payoff matrix which in turn causes suppliers to shift maturities. Maturity shifts by suppliers consequently cause shifts in the rate pattern.

III

Now that we have introduced yield concern and uncertainty to both supply and demand sides, we must examine the resulting term structure of rates. These modifications are sufficient to allow an explanation of observed yield curves. Further, our results are consistent with at least three of the recognized theories of the term structure.\(^1\) An example with satisfactory detail would be tedious. In order to in-

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\(^1\)Malkiel (53), Modigliani and Sutch (60) (61), and to some extent Lutz (51) arrive at essentially the same conclusions.
dicate the general workings of the model we will present three simple examples from which the mechanism can be grasped.

**Example 1**

Imagine a debt market which is in an equilibrium such that the yield curve is level throughout. Suppose further that all participants expect rates to remain unchanged to the end of their horizons. This assumption allows us to isolate the effect produced by the existence of horizons. Let us further assume that all horizons on both sides of the market are identical distributions as pictured in Figure 2.3. We

\[
\begin{bmatrix}
\frac{1}{3} & \frac{1}{3} & \frac{1}{3} \\
\frac{1}{3} & \frac{1}{3} & \frac{1}{3} \\
\frac{1}{3} & \frac{1}{3} & \frac{1}{3}
\end{bmatrix}
\]

Lenders

\[
\begin{bmatrix}
\frac{1}{3} & \frac{1}{3} & \frac{1}{3} \\
\frac{1}{3} & \frac{1}{3} & \frac{1}{3} \\
\frac{1}{3} & \frac{1}{3} & \frac{1}{3}
\end{bmatrix}
\]

Borrowers

\[
\begin{bmatrix}
k-1 & k & k+1
\end{bmatrix}
\]

Figure 2.3. Example 1 horizons

assume that the 6 participants bargain for a period of time and at the end of that period, contracts are settled and securities are issued. When the bargaining period opens, in
this example, each borrower or lender finds that his counterparts are as indifferent to maturity as he is; no period on any horizon presents special due date attraction, nor is any maturity particularly advantageous because of expected rate changes. If we disregard factors other than rate expectations and horizons, the yield curve will emerge from the bargaining period unchanged. Any tendency for it to take a shape other than level will be arbitraged away.

Example 2

Let us now start as in Example 1 but introduce the horizon changes displayed in Figure 2.4. Now, even though rates are expected to remain unchanged, maturity is to no participant a matter of indifference. Lenders will gather at k-1 because: (1) that is the most likely due date; and (2) the no-rate-change expectation may not be held with certainty so
the path to k-1 minimizes risk. The same considerations motivate borrowers to gather at k+1. When bargaining opens, borrowers will have to induce lenders to move to k and k+1 by offering higher rates than the current equilibrium ones. Any lender who wishes to stay in k-1 will have to accept lower rates. By successive iterations of bargaining and re-estimations some lenders will be drawn to k and k+1 and some borrowers will be drawn to k and k-1. The equilibrium yield curve thus obtained will be an ascending one and the rise will have been produced solely by the existence of horizons since the expectations effects produce only a level curve.

Example 3

In this example we will use exactly the conditions which prevailed at the beginning of Example 2 with the single exception that all participants expect rates to rise to the end of their horizons. Lenders will again gather at k-1 because: (1) that is the most likely due date; and (2) shorter-term bond prices fall least for a given increase in rates\(^1\) so that taking the path to k-1 also minimizes risk. Also, by engaging in short contracts the lender can continually reinvest at even higher rates.\(^2\) Borrowers will gather at k+1 because: (1) that is the most likely due date; and (2) since rates are expected

\(^1\)We draw here upon the mathematics of bond price movements so clearly presented by Malkiel (53).

\(^2\)This disregards any transactions costs.
to rise, borrowers can finance themselves now more cheaply than at any time in the future. It is therefore to the bor­rowers' advantage to borrow long-term now rather than risk having to refinance for a few periods at the future's higher rates.

As the bargaining proceeds, borrowers will find they must induce lenders into $k$ and $k+1$ by offering higher rates than the current equilibrium rates. But now these higher rates must be high enough to overcome the effect of horizons and expectations as well. The result is that the yield curve will ascend more sharply than in Example 2. It will also ascend more sharply than in the case of pure expectations.

Had we used this same Example 3 but with rates expected to fall, rather than reinforcing one another, the horizon effect and expectations would exert opposite influences on the curve. Which of the two forces would dominate would depend on the strength of expectations and the horizon compositions. But whichever force dominated, the yield curve would be less steep than if the two were mutually reinforcing.

It is interesting to compare the implications of these examples, the Hicksian "constitutional weakness" argument, and observed yield curves. The constitutional weakness hypothesis argues that the prevailing horizon of lenders is shorter than that of borrowers (see Example 2). The result of this hor­izon disparity is that borrowers will consistently bid long­term rates above short-term rates. If, therefore, rates are
expected to rise, the yield curve will rise; if rates are expected to remain unchanged, the yield curve will rise; the yield curve can descend only if rates are expected to fall enough to offset the constitutional weakness. Since in two of three possible rate expectations cases the yield will rise, we would expect rising curves over time to dominate the yield structure. This observation assumes that all cases of rate expectation are equally likely. Observed yield structures over the last 40 years have been predominantly rising. The descending curves are concentrated mostly in the '30's. Observed yield structures are then consistent with the Hicksian constitutional weakness argument. These observations can, of course, also be accommodated by our model.

We could continue these examples by introducing different length horizons and various rate expectations, but they would simply be matters of going through the mechanism. These examples are sufficient to clearly establish the effect of a horizon.

We have thus introduced modifications which allow us to explain the observed yield structures. The major point to be gained from this exercise is that the yield structure is not completely at the mercy of any single determinant; it reflects the presence of expectations, uncertainty, and maturity preference. Our approach allows expectations and horizon effects to operate on all participants. In this manner we are able to explain the yield structure while remaining consistent with
other models. The major interest of this approach is the allowance of a specific time horizon which is an integral part of the decision-making process and need not be arbitrarily specified by the investigator. Combined with expectations, the horizon helps to explain behavior of participants on both sides of the market. Just what combination of horizon preference and expectations actually exists is a matter for empirical investigation.
I

In order to get a feel for testing procedures in this chapter we will review some of the statistical tests of term structure theory. There have been a number of tests of the expectations hypothesis, most of which put major emphasis on expectations and mention liquidity premia and other such segmentation considerations only residually. We will not try to review all contributors since there is much near-duplication. We will instead cover only the more prominent tests which have shown support for each of the two hypotheses.

Testing hypotheses about the term structure of interest rates involves a particularly tricky and intriguing problem. Indeed, the numerous tests which have been conducted have had to face the following problem: to test the expectations hypothesis one is put in the difficult position of having to discover ex ante expectations using ex post observations. One must look at data from the past and somehow explain what expectations must have been and how they made the yield structure what it was. For a long time this problem made term structure tests scarce.

The current debate over term structure hypotheses was largely limited to theoretical inquiry until the work of Meiselman (57). Meiselman was the first to produce anything
like an operational test of the expectations hypothesis.
Lutz (51) and Culbertson (23) both had tests before this,
but they are mostly casual observations about yield structures
which could hardly be called statistical analysis.

Meiselman's approach is to argue that if the market
operated according to expectations:

"If actual rates are higher than had been an-
ticipated, the market may systematically revise
upward expectations of what short-term rates in
the future are likely to be. Similarly, if actual
rates are lower than had been anticipated, then
the market may also systematically revise down-
ward expectations of future short-term rates."
(57, p. 20)

He then argues that forward or expected short rates change on
the basis of past forecasting errors.

Recall that under the expectations hypothesis, the ex-
pected future short-term rates are implicit in the yield curve.
Since long rates are only the geometric mean of expected fu-
ture short rates, the ratio of any adjacent long rates is the
expected future short rate between the two long rates:

\[ t+n^{R_{t}} = \frac{(1+t^{R_{n-t}})^n}{(1+t^{R_{n-t-1}})^{n-1}} - 1. \]

Meiselman's hypothesis is that the change in this expected
future short rate is a function of the forecasting error for
the current period's short rate. The hypothesis is expressed
as:

\[ t+n^{R_{t}} - t+n^{R_{t-1}} = f(t^{R_{t}} - t^{R_{t-1}}) \] or that
\[ \Delta_{t+n} r_{1t} = g(E_t) \] where \( E_t \) is the forecasting error. By assuming the relationship to be linear it can be expressed as \[ \Delta_{t+n} r_{1t} = a + bE_t. \] This error-learning model produced the first operational test for the presence of expectations.

Since forward rates of interest can be implied from the structure of rates at any point in time, Meiselman tested his model using the changes in implied forward rate from one to eight years in the future. His data were taken from Durand\(^1\) and cover the period 1901-1954. Table 3.1 gives Meiselman's results. The results may be summarized as follows: the regression coefficients are all positive and significant and fall with the rise in maturity; the correlation coefficients fall with the rise in maturity; and none of the constant terms is significantly different from zero (57, p. 22). These results are reasonably clear and may be interpreted in the following manner. The higher correlation coefficients indicate that the data are consistent with an expectations-error-learning mechanism. Much of the change in forward rates is explained by this model. Both the regression coefficients and the correlation coefficients decline the farther into the future are the forward rates. This seems reasonable on the grounds that near-term expectations are generally more firmly

\(^1\)In this and subsequent publications Durand figured a yearly yield curve for corporate debt (25).
Table 3.1. Meiselman's results

<table>
<thead>
<tr>
<th>n</th>
<th>Constant term (Standard error)</th>
<th>Regression coefficient</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.00 (.02)</td>
<td>.703</td>
<td>.952</td>
</tr>
<tr>
<td>2</td>
<td>.00 (.03)</td>
<td>.526</td>
<td>.867</td>
</tr>
<tr>
<td>3</td>
<td>-.01 (.04)</td>
<td>.403</td>
<td>.768</td>
</tr>
<tr>
<td>4</td>
<td>-.03 (.04)</td>
<td>.326</td>
<td>.682</td>
</tr>
<tr>
<td>5</td>
<td>-.02 (.04)</td>
<td>.277</td>
<td>.642</td>
</tr>
<tr>
<td>6</td>
<td>-.01 (.03)</td>
<td>.233</td>
<td>.625</td>
</tr>
<tr>
<td>7</td>
<td>-.02 (.03)</td>
<td>.239</td>
<td>.631</td>
</tr>
<tr>
<td>8</td>
<td>.01 (.03)</td>
<td>.280</td>
<td>.590</td>
</tr>
</tbody>
</table>

formed and likely to be more sensitive to the immediate past than long-term expectations. Finally, Meiselman contends that an intercept term not significantly different from zero implies that when expectations have proved correct, there is no revision in the forward rate. The Hicksian liquidity premium argument implies that maturities farther out on the yield curve should carry greater liquidity premia thus forward rates should constantly be revised upward. If the Hicksian
argument were correct $\Delta_{t+n} r_t$ should be a function not only of the error term, but should exhibit a liquidity premium over and above any revision due to forecasting error. Since Hicks argues a constitutional weakness in the market gives rise to these liquidity premia, they should exist for all rates except the current short rate, and should rise as $n$ rises. We would expect the rising liquidity premium to show up in a constant term which rises with the $n$ of the future short-term rate. Meiselman argues that a statistically insignificant intercept term does not support this contention, it rather indicates that, "...the risk premium on default-free claims is zero." (57, p. 46)

This brief review does Meiselman's work injustice, but it draws out the two major conclusions: the expectations hypothesis via error-learning is supported by the data, and there appears to be no support for the Hicksian liquidity premium. This work quickly became the focal point for a number of studies which we review. The remaining tests have stemmed, in one sense or another, from Meiselman, and these tests produce critics as well as supporters.

1Meiselman also tests the hedging pressure hypothesis and finds some support for this approach. He then argues that while there may be investors who are committed to a very narrow range, it is the marginal shifting in these overlapping ranges which allows the expectations hypothesis to hold. This observation is perfectly consistent with the theory developed in the preceding chapter.
One of the first responses was that of Wood (108) (109), who generally agrees with Melselman but observes that Melselman's conclusion that a zero intercept term is inconsistent with liquidity premia is in error. Paraphrasing from Wood, we can express the Hicksian liquidity premium model in the context of Melselman as follows:

\[ t+nF_{lt} - t+nF_{lt-1} = a + b(R_{lt} - tF_{lt-1}) \]

where \( t+nF_{lt} \) is the Hicks-Meiselman forward rate combination such that, \( t+nF_{lt} = t+nR_{lt} + t+nL_{lt} \), where \( t+nL_{lt} \) is the liquidity premium. Substituting liquidity premia and expected rates for forward rates,

\[ (t+nR_{lt} - t+nL_{lt}) - (t+nF_{lt-1} + t+nL_{lt-1}) = a + b(R_{lt} - tF_{lt-1} - tL_{lt-1}) \]

Rearranging,

\[ (t+nR_{lt} - t+nF_{lt-1}) + (t+nL_{lt} - t+nL_{lt-1}) = a + b(R_{lt} - tF_{lt-1}) - b(tL_{lt-1}) \]

Melselman distinguishes the expectations hypothesis from the liquidity premia hypothesis on the assumption that a zero forecasting error implies a zero forward rate revision. Allowing both to be zero in the above equation produces the following:

\[ t+nL_{lt} - t+nL_{lt-1} = a - b(tL_{lt-1}) \]

Meiselman's hypothesis that a zero intercept term is inconsistent with liquidity premia can be examined by introducing a zero inter-

\(^1\)Kessel (43) arrives independently at the same conclusion.
cept and seeing if the results are inconsistent with the existence of liquidity premia. When the intercept is zero, \( t+n^{l_{lt}} - t+n^{l_{lt-1}} = -b(t_{lt}^{l_{lt-1}}) \), where \( t+n^{l_{lt}} \), \( t+n^{l_{lt-1}} \), and \( t_{lt}^{l_{lt-1}} \) are the liquidity premiums for \( n \), \( n+1 \), and \( 1 \) periods in the future. If Hicks' hypothesis is correct then the liquidity premia should rise with maturity so that, \( t+n^{l_{lt}} - t+n^{l_{lt-1}} < 0 \). This condition is perfectly consistent with the above. Since both \( b \) and \( t_{lt}^{l_{lt-1}} \) are positive it follows that \( -b(t_{lt}^{l_{lt-1}}) < 0 \). A zero constant term is thus perfectly consistent with liquidity premia (108). Some doubt has been cast upon the strength and direction of Meiselman's conclusions.

Further criticism and modification were not long in coming. Much of the effort is focused on the most obvious shortcoming of Meiselman's test, the data. Criticisms of the data used however, apply no more to Meiselman than to other investigators who use data derived from yield curves.

Durand's data (25) (26) (27) has some shortcomings, considering the fine conclusions Meiselman draws from it. Durand's data is a series of "basic" yields of corporate bonds. For each of the over fifty bonds used in computing each year's curve the following six prices were obtained: the high and low selling price in each of the first three months of the year. These quotes were then averaged and
rounded to the nearest twentieth of one percent (25, p. 8). Yield curves were drawn in free-hand, but limited to four types: (1) monotonically decreasing at a decreasing rate, becoming horizontal at the end; (2) monotonically rising, becoming horizontal at the end; (3) rising in early stages then taking the shape of (1); and a horizontal line (25, p. 9). This is clearly a great deal of adjusting, and Grant (36) points out that,

"Durand was attempting not to fit to observed bond yields but to devise a simplified yield concept, a 'basic yield' at which a hypothetical corporate security of the highest possible standing could be traded. Because of this simplification all anomalies in the actual yield-maturity relationship were removed." (36, p. 60)

Grant further points out that Durand himself, in the 1958 Journal of Finance article, said his curves were not appropriate for the derivation of implied forward rates from them. They are so rude a measure and the equation

\[ 1 + t + n r_t = \frac{(1 + t R_{n+1})^{n+1}}{(1 + t R_n)^n} \]

is so sensitive to error, that the results are unreliable (36, p. 61).

The difficulty here is that yield curves as such do not exist. A yield curve implies at least one security coming due in each of the next n periods and, if there is more than one security maturing in a period, all must trade at the same
price. Were this the case we could interpolate between observed maturity dates fairly confidently. Figure 3.1 on the following page indicates this. The upper panel shows a yield curve derived under ideal conditions. All securities of a given maturity carry the same price and the relationship between maturity and yield seems reasonably clear. The lower panel represents a yield curve derived from raw data which generally come in the following form. Maturities are discontinuously distributed over the range; there are gaps and congregations. Moreover, due to such characteristics as tax status, call features, issuer reputation, etc., bonds of like maturity generally do not trade at the same price. In an effort to expose the relationships among what would exist if all securities had the same features and were continuously distributed over the maturity range, a smoothing and interpolation technique is undertaken. The results are shown in the lower panel in Figure 3.2. A curve which appears to summarize the relationship is drawn on the raw data, but it is not immediately clear what amount of this smoothing and interpolation actually lays bare the relationship which would exist if securities were homogeneous and evenly distributed on the maturity range; nor for that matter is it clear what relationship actually exists in the minds of investors. It also is not clear what sort of averaging should be used for individual price observations. Daily averages, monthly averages,
Figure 3.1. Ideal yield curve

Figure 3.2. Actual yield curve
and quarterly averages would all give rise to different yield curves. The true relationship among maturities is not a settled matter.

The investigators under review generally criticize Meiselman for his data use. Each then inserts his own set of data with its own particular biases and tests that data. Grant (36) was one of the first to criticize Meiselman and substitute his own data.

He constructed a set of yield curves from British data which were gathered in fundamentally the same fashion as the Durand data, the major difference between the two being the smoothing technique between actual observations. Durand continuously smoothed the data until relatively constant differences were obtained. Grant interpolated linearly in the following fashion. Suppose there exists a ten year security yielding five per cent and an 11\frac{1}{2} year bond yielding 6\frac{1}{2} per cent with no bonds maturing between ten and 11\frac{1}{2} years. The yield for a hypothetical 11 year bond would be calculated as an average of the two observed yields, weighted inversely by the term between hypothetical and observed maturities. In this case the result would be 6 per cent (36, p. 60).

Grant then tested Meiselman's model and got significantly poorer results: the correlation coefficients were low, ranging from 0.43 to 0.64; the sign of the forecasting error was not well-synchronized with the sign of the forward
rate changes; and the constant terms showed no regularity (36, p. 62). As an addition to the Meiselman model Grant appended cubic and quadratic terms. The results were even poorer than before, but did not contradict Meiselman's results. Grant concluded, "There is clearly a relationship to be found in the data, and it is possible that hypothetical yield curves, constructed under different assumptions would have exhibited a stronger relationship." (36, p. 63)

Van Horne (99) carried out the same sort of test as Grant. Van Horne used data from the U.S. Treasury Bulletins rather than Durand data. In each month's Treasury Bulletin is published a free-hand drawn yield curve whose observations are over-the-counter closing quotations on U.S. Government bonds for the last day of the month in the New York Market.

Van Horne tested Meiselman's model on this data and got slightly better results in that the correlation coefficients ran consistently higher than Meiselman's (99, p. 346). More important to Van Horne's approach, the constant terms are everywhere significantly different from zero, implying (contrary to Meiselman's conclusions) that the data are consistent with an upward revision of the forward rate even when there is no forecasting error.

This observation leads Van Horne to a further test. If risk is inversely related to the actual rate level, then the residuals from the Meiselman model should exhibit a particular
pattern. When forward rates are low compared to the usual range, residuals should be positive, and when forward rates are comparatively high, the residuals should be negative (99, p. 347). Van Horne then fits the equation

\[ t \cdot n R_t - t \cdot n R_{t-1} = a + \beta (E_t) + b_2, \]

where \( b_2 \) is deviation of actual rates from a historically established normal level (99, p. 349). The addition of the risk variable, \( b_2 \), added little to Meiselman's results for shorter maturities, but raised the correlation coefficients significantly for longer maturities. The \( b_2 \) coefficients were statistically significant and increased with the variable maturity, suggesting, "...increasing importance of interest-rate risk as maturity increases." (99, p. 350) Again Meiselman's results are put into doubt; Van Horne finds evidence of liquidity premia where Meiselman did not.

Probably the most telling criticisms of Meiselman came from Buse (16) (17) (18). Buse (17) makes an independent test of the Meiselman model using British data (not Grant's) and then examines the effect of the data form for Grant's, Van Horne's, and Meiselman's tests. The results are most interesting and relevant.

After first demonstrating that liquidity premia can be generated in a Meiselman-type model independently of the value of the constant term, Buse then points out that liquidity premium investigation should not be limited to Hicks-
Keynes "backwardation" (17, p. 53). As Samuelson has pointed out: "...as a close reading of the literature will show, liquidity-preference analysis becomes more general and admits of a wider variety of empirical patterns....Hence, a priori reasoning cannot itself settle what are the most plausible patterns to look for..."^1

Buse next turns to the major concern of the paper, the relation of forward rates to the yield curve. Buse writes:

"For any given yield curve there is a set of associated forward rates which can be graphed in conjunction with that yield curve. The dependent variable of the Meiselman model,

\[ t+n^t - t+n^t-1 \]

is the difference between two such sets of forward rates, one of which has been moved one time unit along the horizontal axis of the yield-time coordinates. In order for this difference to decline systematically, given the error of prediction, the yield curve must conform to a particular pattern. Not surprisingly this pattern turns out to be a relatively smooth yield curve." (17, p. 54)

The implication is that Meiselman's results depend upon the smoothing and interpolation techniques used on the data.

The above allegation is supported by letting

\[ d = R_n - R_{n-1} \]

and substituting this into,

\[ 1 + r_n = \frac{(1+R_n)^n}{(1+R_{n-1})^{n-1}} \]

where \( R_n \) is the current \( n \) year rate, \( R_{n-1} \) is the current

\(^1\)P.A. Samuelson, Directors Comment in Kessel (43, p. 101).
n-1 year rate, and \( r_n \) is the short rate expected to prevail in year \( n \). After the substitution, solving for \( r_n \) by means of expanding the terms on the right gives simplified approximations for \( r_n \) which are much easier to use. Solving produces \( r_n \approx R_{n-1}+nd \) and \( r_n \approx R_n+(n-1)d \) where \( n \) as a subscript indicates the same number of years as when used as a coefficient. These equations, while only near approximations show that a positively sloped yield curve has forward rates above it and vice versa for a negatively sloped curve (17, p. 55). Buse then argues that \( r_n \) depends not only on the two adjacent maturities used, but on the level and slope of the curve as well. Obviously a smooth, monotonic curve generates a set of forward rates with a smaller range of fluctuation than would a non-monotonic curve (17, p. 55). Buse then concludes that Grant's use of linear interpolation in the data caused an erratic forward rate series which in turn caused Grant's poor results (17, p. 58).

Continuing, Buse notes that whether forward rates rise or fall depends upon the rate of change of the slope of the yield curve. Since, as we have seen, \( r_n \) is partly a function of the difference, \( d_{n-1}-d_n \), and this difference is changing in a smooth yield curve, forward rates will also change system-

\[ \text{1Buse also graphs the forward rate series for Grant, Buse, and Meiselman data. This test shows what was suspected, that Grant's series is very erratic while Buse's and Meiselman's are smooth.} \]
atically. Smoothed yield curves with diminishing slope produce forward rate curves with the same characteristics (17, p. 56).

Buse graphs the forward rates from British data, both smoothed and linearly interpolated, and concludes that the difference is "nothing less than spectacular" (17, p. 56). It is clear that the decline in Meiselman's regression coefficients and correlation coefficients in longer maturities depends upon the smooth shape of the yield curve.

To further establish this point, Buse questions whether Meiselman's results really indicate that the market is dominated by expectations-oriented participants. Could the same results arise from any historical yield curves whose variance diminishes with maturity? To test the point he randomly orders both the Durand data and his British data and retests Meiselman's model. The results, averaged over four random orderings of the yield curves for each set of data, have, "...all the characteristics associated with previous tests of the Meiselman model..." (17, p. 60). A further test was carried out by reversing the chronological order of the yield curves — putting the last year first, etc., — and retesting Meiselman's model. The results again are not significantly different from Meiselman's original test results.

In summary, Buse concludes:

"The Meiselman model is consistent with any set
of smoothed yield curves in which the short and long rates move together but in which short rates show greater variability. The correct chronological order is not vital to the result. The model cannot, therefore, be considered a useful test of the expectations theory because it does not discriminate between the behavior of investors acting on Meiselman postulates and alternative formulations which are consistent with the same pattern of observed rates." (17, p. 61)

What started out as a reasonably strong test of the expectations hypothesis has thus been weakened. The fundamental question at issue is the shape of the yield curve. If there is a yield curve, what shape is it? Do investors mentally smooth it? Do they interpolate linearly? Buse's criticisms are well-taken, but leave the issue open.1

An alternative test of the expectations theory (and also of the segmentation theory) has been carried out by Michaelson (58). This study is not of major importance, but indicates another approach to the testing problem. Michaelson tests three hypotheses about the term structure: "(1) Realized yields closely approximate anticipated yields; (2) when (1) does not hold, realized yields primarily reflect changes in expectaions; (3) realized yields primarily reflect shifts in non-expectational factors." (58, p. 449) The first hypothesis is expressed as $Y_{nt} = \alpha_{nt} + \varepsilon_{nt}$ where $Y_{nt}$ is realized

1Buse (16) (18) applies this same approach to other studies. We have reviewed this one as it is the most relevant to our inquiry.
holding period yield, $\alpha_{nt}$ is anticipated yield, and $\varepsilon_{nt}$ is a random error component which, in large samples, should average out to zero. Assuming the expectations hypothesis holds, the existence of liquidity premia can be tested by comparing means of interest rate series having different terms to maturity. On the assumption that the expectations hypothesis holds, anticipated yields can be inferred from the term structure. Yield series with different terms to maturity give average anticipated yields. Michaelson then argues that if these series means rise as maturity rises, this is evidence of risk premia. If the series are constant then this does not support liquidity premia (58, p. 449).

The second hypothesis is stated $y_{nt} = \beta_{nt}$ where $\beta_{nt}$ is the price change resulting from changes in expected short-term rates during the period. If the expectations hypothesis holds, so that expected short rates are highly correlated, then the windfall gains and losses should be larger the longer the term to maturity. Under this hypothesis realized yields will be mostly composed of $\beta$ components and the standard deviations of the realized yield series should be positively correlated with their terms to maturity. Also these series should be positively intercorrelated, with the highest correlation being between series closest in term to maturity, because adjacent series share the largest number of windfall terms. These windfall terms should not be systematically
related so the series should be serially independent (58, p. 451).

These hypotheses were tested using holding period data on governments. Realized holding periods were calculated as,

$$Y_{nt} = \ln \left( \frac{P_{nt+1} + C_{nt}}{P_{nt}} \right)$$

where $Y_{nt}$ is the realized yield over the $t$th week on an $n$ week security, $P_{nt}$ and $P_{nt+1}$ are prices at the beginning and end of the week and $C_{nt}$ is the week's coupon payment. Michaelson used a 13 week bill series, a 2.5, 5, 7.5, and 10 year bond series, and an average of each.

In general the data support the hypotheses advanced, but not much weight can be attached to the conclusions since the major part of the hypothesis had to be assumed to get the data. The bill-yield series rises with term to maturity, implying the existence of liquidity premia. The second hypothesis tested gives less clear results. While there is much intercorrelation between series (as expected) there is a positive serial correlation in the bill series (which was not expected) indicating a lack of speculative activity. Michaelson's approach also seems questionable to this writer on the grounds that the holding periods realized are realized only on paper. If investors actually tried to obtain these yields by liquidation, the analysis would be somewhat different. At best a few speculators could realize anticipated
yields, but the general market could not. We also suspect that Michaelson's conclusions are partly a function of the characteristics of yield curves discussed by Buse (17).

This review is sufficient to familiarize us with the tests of the expectations hypothesis. Having reached the end of this section it is apparent how difficult it is to justify the data. The problem of implying the existence of ex ante expectations from ex post data is a tricky one. The segmentation hypothesis, while having the same sort of data problems, is at least free from trying ex post to imply the existence of expectations. We turn now to a few tests of the segmentation hypothesis.

II

The usual procedure for segmentation hypothesis tests is to examine the data for effects of changes in the supply of various maturity securities. The segmentation hypothesis implies that the term structure is determined by the supply of and demand for securities in each of several market segments. Assuming demand conditions do not change, it should be the case that changes in supplies of securities change security prices; thus the term structure should show a sensitivity to the supply of securities and to changes therein.

Okun (84) tested for the presence and significance of supply effects and in general found less than encouraging
results. Basically Okun fit two equations, which may be summarized as follows:

\[ r = b_0 + b_1 S + b_2 L + b_3 A + b_4 X \]

and

\[ b = b_0 + b_1 S + b_2 L + b_3 X. \]

The first equation explains the long-term rate (an average rate on bonds due or callable after 12 years) using as independent variables \( S \), the supply of securities due in less than five years; \( L \), the supply due in five or more years; and \( A \), the average maturity of securities in \( L \). \( X \) is a vector of such things as money supply and income. The bill rate equation (the second one) uses the same independent variables, but has no average maturity measure.

The results, using quarterly data for 1946-1959, are summarized in Table 3.2 (84).

Table 3.2. Okun's results

<table>
<thead>
<tr>
<th></th>
<th>( S )</th>
<th>( L )</th>
<th>( A )</th>
<th>( R^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( r )</td>
<td>0.0219</td>
<td>0.0197</td>
<td>0.0046</td>
<td>0.935</td>
</tr>
<tr>
<td></td>
<td>(0.0042)^a</td>
<td>(0.0029)</td>
<td>(0.0023)</td>
<td></td>
</tr>
<tr>
<td>( b )</td>
<td>0.0576</td>
<td>0.0410</td>
<td></td>
<td>0.899</td>
</tr>
<tr>
<td></td>
<td>(0.0074)</td>
<td>(0.0068)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

^aStandard errors.

Several additional income and potential income variables were added, but none proved significant. First differences in \( S \)
and L were also fit, but proved insignificant.

As expected the coefficients of the debt variables are positive; a rise in the outstanding supply now increases the interest rate. The coefficient of S in the long rate equation is larger than that of L implying that an increase in the supply of short-term debt would raise the long rate by more than an increase in the supply of long-term debt. However, the difference between them is not statistically significant (84, p. 349).

Okun's results are not particularly strong, and as he points out, they might have been improved by a more sensitive average maturity measure (84, p. 349). The debt coefficients, while significant, are rather small and it is estimated that a simultaneous retirement of one billion in bills and an issue of one billion of 20-year bonds would increase the rate spread by less than 3 basis points, where a basis point is a hundredth of one per cent (0.01 per cent) (84, p. 357). Okun's conclusion is that, "...the long rate is relatively insensitive to changes in the maturity composition of the public debt." (84, p. 349)

Scott (90) has carried out the same sort of test as Okun but obtained better results. Scott is also critical of Okun's maturity variable. Okun included only the average maturity of securities coming due in five or more years. Scott argues that this ignores the effect of average maturity in the shorter class and that, combining very short-term debt
(Treasury bills, and securities maturing in less than one year) with all debt due in less than five years may have covered up liquidity effects associated with very short-term debt (90, p. 139).

Scott then fits various equations which, with the results, are summarized in Table 3.3 (90). As can be seen from the Table, the average maturity variable adds significantly to the results, and all the significant variables have the expected sign. The data cover the period 1952-1959 by monthly observations and so are not directly comparable to Okun's. It should also be noted that the average maturity variable shows a decrease in the long rate from an increase in debt maturity which means, as Malkiel points out, that the rate spread is increased by less than the decrease in the short rate (55, p. 228). This result is unexpected but does not invalidate Scott's work.

Scott's conclusion is that the long and short rates are sensitive to the average maturity of the debt so that increasing the average maturity of the debt by one month produces a reduction in the rate spread of 5.6 basis points (90, p. 137). These results are stronger than those of Okun but, as noted, not directly comparable because of different data spans. Scott's tests are more inclusive than Okun's in that many more relevant independent variables are used and the average maturity term is more inclusive. Also changes in
Table 3.3 Scott's results

<table>
<thead>
<tr>
<th></th>
<th>b_0</th>
<th>D^a</th>
<th>N^b</th>
<th>M^c</th>
<th>S^d</th>
<th>T_e</th>
<th>A^f</th>
<th>R^2</th>
</tr>
</thead>
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<tr>
<td>R_S^2</td>
<td>10.48</td>
<td>+ .020</td>
<td>+ .000</td>
<td>- .160</td>
<td>- .113</td>
<td>+ .031</td>
<td></td>
<td>.7935</td>
</tr>
<tr>
<td></td>
<td>(11.55)</td>
<td>(.943)</td>
<td>(.438)</td>
<td>(639)</td>
<td>(2.25)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R_S</td>
<td>9.42</td>
<td>+ .017</td>
<td>+ .000</td>
<td>- .081</td>
<td>- .134</td>
<td>+ .018</td>
<td>- .056</td>
<td>.8305</td>
</tr>
<tr>
<td></td>
<td>(10.28)</td>
<td>(.445)</td>
<td>(2.17)</td>
<td>(8.04)</td>
<td>(1.39)</td>
<td>(4.54)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R_L^1</td>
<td>7.50</td>
<td>+ .005</td>
<td>+ .000</td>
<td>- .086</td>
<td>+ .016</td>
<td>+ .009</td>
<td></td>
<td>.8430</td>
</tr>
<tr>
<td></td>
<td>(6.03)</td>
<td>(.407)</td>
<td>(4.90)</td>
<td>(1.91)</td>
<td>(1.31)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R_L</td>
<td>7.11</td>
<td>+ .004</td>
<td>+ .000</td>
<td>- .057</td>
<td>+ .008</td>
<td>+ .004</td>
<td>- .021</td>
<td>.8589</td>
</tr>
<tr>
<td></td>
<td>(4.82)</td>
<td>(.006)</td>
<td>(3.03)</td>
<td>(1.01)</td>
<td>(.599)</td>
<td>(3.34)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R_B^1</td>
<td>2.97</td>
<td>- .015</td>
<td>- .000</td>
<td>+ .074</td>
<td>+ .129</td>
<td>- .022</td>
<td></td>
<td>.7440</td>
</tr>
<tr>
<td></td>
<td>(11.83)</td>
<td>(1.01)</td>
<td>(2.80)</td>
<td>(10.13)</td>
<td>(2.25)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R_D</td>
<td>-2.31</td>
<td>- .013</td>
<td>- .000</td>
<td>+ .024</td>
<td>+ .142</td>
<td>- .014</td>
<td>+ .035</td>
<td>.7781</td>
</tr>
<tr>
<td></td>
<td>(10.59)</td>
<td>(.573)</td>
<td>(.871)</td>
<td>(11.53)</td>
<td>(1.48)</td>
<td>(3.85)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

^a  Debits to demand deposits.

^b  Change in borrowed reserve position of member banks.

^c  Money supply.

^d  Time deposits.

^e  U.S. Governments held by non-bank public.

^f  Average maturity of debt.

^g  Bill rate.

^h  t values.

^i  Bond rate, average of over 10 years maturity.

^j  R_L - R_S.
Scott's maturity variable produces 5.6 basis point rate changes while Okun's similar measure produces only a 3 basis point change.

III

One of the more recent and sophisticated tests of the expectations hypothesis is that of Modigliani and Sutch (hereafter referred to as M&S) (60) (61). We will pay particular attention to the technique involved here, as the statistical tests in the next chapter adopt this procedure. M&S fit essentially the same model in the two different instances cited, and we shall, in what follows, draw from both papers.

Their original study begins by advancing a loosely-hypothesized theory of the term structure, which they call the "preferred habitat" theory (61, p. 183). This theory, they argue, blends the expectations theory with elements of the segmentation theory, which is the same sort of undertaking we have tried to advance. The theory begins by positing, as does Lutz, that the safest position for an investor is a maturity "habitat" which matches security maturity to the period of time for which the investor expects to be in the market. Once in the habitat the investor must be offered some risk premium if he is to be drawn out of this habitat. M&S's model therefore implies that any current n-year rate is composed of two elements: (1) a pure expectations component; and (2) a positive or negative risk premium.
reflecting the difference between the supply of and demand for n period loans at the current rate (61, p. 184). ¹

Putting it another way, the habitat model implies that the rate spread, \( S(n,t) \), between the long rate, \( R(n,t) \), and the short rate, \( R(1,t) \), depends mostly on the expected change in the long rate \( \Delta R^e(n,t) \). \( R(n,t) \) is the rate of interest on an n year maturity bond at time t. \( R(1,t) \) is the rate on a one year security at time t, and \( S(n,t) \) is the spread between \( R(1,t) \) and \( R(n,t) \) at time t. However, \( S(n,t) \) is also influenced by supply and demand in each maturity category. Restated the model becomes:

\[
\text{Expected return on an n period bond} = R(n,t) \times \text{expected capital gain} = R(1,t) \times P_t
\]

where \( P_t \) stands for the supply effects. Taking the expected capital gain (loss) as proportional to the expected fall (rise) in the long rate and solving for \( R(n,t) \) we have:

\[
R(n,t) = R(1,t) + \beta \Delta R^e(n,t) + P_t. \quad \text{Equation 1}
\]

The authors point out that, if \( \beta \) is constant, \( \beta \Delta R^e(n,t) \) is actually an approximation for expected capital gain, but that \( \beta \) is a function of \( n \) and \( R(n,t) \) such that dealing with a fixed maturity \( n \) makes the effect of \( R(n,t) \) sufficiently

¹The reader will note that this conclusion, though not very rigorous, is essentially that reached by the current writer.
small to be neglected to a first approximation (61, p. 185).

In order to put Equation 1 into a testable form M&S draw upon the work of Frank de Leeuw (24). To obtain a model of expectations de Leeuw combined the Keynesian regressive hypothesis, that rates are expected to return to a long-run normal level, and the Duesenberry extrapolative hypothesis, that rates are expected to continue in the present direction. M&S modify his work slightly so that the regressive hypothesis is stated as:

\[ \bar{R}_t = \nu \sum_{i=1}^{m} \mu_i R_{t-1} + (1-\nu)c \quad 0 < \nu < 1 \]

where \( R_t \) is the long rate, \( \sum_{i=1}^{m} \mu_i R_{t-1} \) is a weighted series of \( m \) past long rates; the \( \mu_i \)'s are weights and \( \sum_{i=1}^{m} \mu_i = 1 \), and \( c \) is some very long-run normal rate level. \( \bar{R}_t \) is the normal rate level to which rates are expected to return and is composed of the weighted \( m \) past rates and \( c \). Since recent experience should presently exert more influence than past experience, M&S expect that the \( \mu_i \)'s will decline into the past as \( i \) rises. Formalized, the regressive hypothesis is:

\[ \Delta R^e_t = \alpha_1 (\bar{R}_t - R_t) = \alpha_1 \left[ \nu \sum_{i=1}^{m} \mu_i R_{t-1} + (1-\nu)c - R_t \right] \]

where \( \alpha_1 \) measures the speed with which \( R_t \) is expected to approach \( \bar{R}_t \).

The extrapolative hypothesis is stated as:

\[ R^e_t = \alpha_2 (R_t - \sum_{i=1}^{n} \delta_1 R_{t-1}) \quad \alpha_2 > 0, \]
where $\sum_{i=1}^{n} S_i R_{t-1}$ is a weighted series of $n$ past long rates; the $S_i$'s are weights and $\sum_{i=1}^{n} S_i = 1$. M&S expect that $n$ should be smaller than $m$ as extrapolation involves only the very recent past and, therefore, the $S_i$'s should decline rapidly (61, p. 186).

Noting, as does de Leeuw, that both hypotheses may hold, the two are simultaneously solved for $\Delta R^e_t$, the result being:

$$\Delta R^e_t = -aR_t + \sum_{i=1}^{n} b_i R_{t-1} + dc$$

Equation 2

where $a = (\alpha_1 - \alpha_2)$

$$b_i = \alpha_1 \mu_i - \alpha_2 S_i$$

$$d = \alpha_1 (1 - \nu)$$

with $S_i = 0$ for $i > n$.

The summation is not a simple lag, but is the difference between two separate lag structures; $\alpha_1 \sum_{i=1}^{m} \mu_i$ is the regressive lag ($\alpha_1$ and $\nu$ are constants) and $\alpha_2 \sum_{i=1}^{n} S_i$ is the extrapolative lag ($\alpha_2$ constant). M&S then hypothesize that the $S_i$'s should fall faster than the $\mu_i$'s, since the extrapolative lag supposedly exerts a shorter, weaker influence on current rates; thus the $b_i$'s should rise to a peak at $n$ (when the extrapolative lag weight becomes zero) and then fall back to zero as the $\mu_i$'s decline to zero (61, p. 186).

Equation 2, the statement for $\Delta R^e_t$, is substituted into
Equation 1, yielding:

\[ R_t = r_t - \beta a R_t + \sum_{i=1}^{m} \beta b_i R_{t-i} + \beta dc + F_t \]

where \( r_t = R(l,t) \). Solving for \( R_t \) produces:

\[ R_t = Ar_t + \sum_{i=1}^{m} B_i R_{t-i} + C + F_t' + \epsilon_t \quad \text{Equation 3} \]

where \( A = \frac{1}{1+\alpha a} \), \( B_i = \frac{\alpha}{1+\alpha a} b_i \), \( C = \frac{\alpha dc}{1+\alpha a} \), \( F_t' \) is the supply term, and \( \epsilon_t \) is the error term.

The model is now ready for estimation and testing. The major problem is that posed by the lag term. It is not of a familiar form which lends itself to ordinary tests. M&S rely upon a technique developed by Almon (4) which imposes few restrictions on the lag structure. The estimation technique involves calculation of Lagrangian interpolation polynomials, which are used to weight a specified number of past values of the variable to be used in the lag. The weighted averages are then entered in an ordinary least squares regression equation to fit the lag. The authors conclude that, since the lag was expected to rise to a single peak and then fall, a fourth degree polynomial would be "sufficiently flexible to closely reproduce the true structure" (61, p. 187). It would ordinarily take five Lagrangian polynomials and thus five "Almon" variables to fit the lag, but the a priori specification that the lag fall to zero allows estimation of only four of each.

One obstacle remains to the final estimation. \( R_t \) is
currently a function of lagged past values of itself and this, in the presence of a serially correlated error term, would lead to biased estimates of the coefficients. It would also likely lead to severe multicollinearity problems. M&S resolve the problem by expressing $R_t$ as a function of $r_t$ and a weighted average of $r_{t-1}$. This can be shown to be possible by using Equation 3 to express $R_{t-1}$ in terms of $r_{t-1}$ and $R_{t-2}$, and so on recursively. Therefore $R_t$ can be expressed as an average of a small number of lagged $r$ terms (61, p. 188).

The final equation to be estimated emerges as $^1$

$$R_t = \alpha + \beta_0 R_t + \sum_{i=1}^{m} b_i R_{t-1} + \eta_t,$$

Equation 4

where $R_t$ is the yield on long Governments (due or callable in over ten years), $r_t$ is the Treasury bill rate, and $\eta_t$ is the error term. This equation was fitted to quarterly data from 1952-I to 1961-IV. The actual data were fitted to the spread, $S_t = R_t - r_t$, which changes no statistical properties but makes $\beta_0$ now $(1 - \beta_0)$. The results reported by M&S are:

$$S_t = 1.239 - 0.684 r_t + 0.16 \frac{b_1}{(0.028)} R_{t-1} + \frac{b_1}{(0.030)} R_{t-1}.$$

$R^2 = .975$  $S_e = .093$  $DW = 1.42$

$^1$The authors note that the difference between Equation 3 and Equation 4 is that if Equation 3 has nonserially correlated errors, then Equation 4 will have an autoregressive error, and vice versa (61, p. 188).
The lag term was tried with lags from two to seven years, with the best result coming at four years. The 16 weights in this lag were all statistically significant and gave the predicted shape. The authors presented the results graphically, and a sketch of the lag shape is presented in Figure 3.3.

Figure 3.3. Modigliani and Sutch lag structure
The values of the standard errors are all much less than half of the coefficient values so that a band of plus and minus one standard error would follow the lag contour very closely. Results obtained from lag lengths other than 16 quarters were not reported.

Having successfully found a model for expectaions, the remaining task is to test for the presence of supply effects. The authors point out that the close fit of the model allows only small influence for $F_t$. M&S state that they have repeated the tests of many other investigators and are unable to find any influence attributable to supply effects (61, p. 192). Again, no test results are reported.

The major supply test reported by M&S is a test of the effects of a debt swap called Operation Twist. Briefly, the

---

1Operation Twist was a debt swap carried out from roughly 1961 to 1964 designed to reduce the interest rate spread on U.S. Governments and, hopefully, private debt. The Federal Reserve System was to release short debt and accumulate long debt, which would presumably raise the short rate and at least not raise the long rate. The rationale was to push up short rates to stem the large short-term capital outflows drawn to the European markets by institutionally higher short-term rates. This was to be done without pushing up the long rate, which presumably would have been detrimental to growth and capital formation.

The success of the operation clearly depended upon the market's positive reaction to supply changes. Ex post, the record of Operation Twist is not clear. An examination of Federal Reserve Bulletins (15) shows no noticeable change in the Federal's portfolio which could be interpreted as vigorous pursual of Twist objectives. M&S even point out that over the Twist period the average maturity of the debt rose from 4.3 to 5.7 years, which is opposite to what it should have (footnote continued on following page)
authors extrapolated the original equation (fitted from 1952-I to 1961-IV) into the Twist period (from 1962-I to 1965-II), and found that it predicted nearly as well in as out of the period. The implication is that no supply effects were present or the expectations part of the model would not have fit the data so well and something more would have been accounted for by the supply term. This finding is not surprising, as the authors themselves observe that Twist was not vigorously pursued (61, p. 192). The effects that were found in the latter part of the period were attributed to the successive rise in Regulation Q\(^1\) ceiling rates payable on time deposits. The

(footnote continued from previous page) done (61, p. 192).

Perhaps the proper conclusion from all of this is not that Twist failed, but that it was not tried. Had a vigorous policy of shortening the average maturity of the debt been carried out, we might have seen vastly different results. It is this possibility which leads us to pick the wartime period for examination.

Further discussion of Operation Twist may be found in Schlesinger (89), Gaines (34), and Yeager and Young (111).

\(^1\)Regulation Q is the regulation administered by the Federal Reserve System limiting the amount of interest which can be paid on time deposits. M&S fit a Regulation Q rate variable to their equation to account for that which was unaccounted for by expectations. The significance for the variable found, they argue, simply means that the rise in Q rates made Certificates of Deposit an effective alternative to short-term Treasury bills. This movement would have taken place even in the absence of debt swap, so that what should be attributed to Q rate influences has mistakenly been attributed to Twist.
authors conclude that supply changes are not effective, and even if they were they could only affect what is not determined by expectations which, in this model, is at most 20 basis points (61, p. 196).

While this test is an interesting one, the more relevant undertaking is M&S (60). In this study the authors fit essentially the same model to data from 1952-I to 1966-I and obtain:

\[ R_t = 1.491 + 0.259r_t + \sum_{i=1}^{16} b_i r_{t-i} \]

\[ R^2 = .959 \]

\[ \bar{S}_e = .128 \] (corrected for 6 degrees of freedom lost in estimation).

These results are essentially the same as those in their previous paper, except the long rate only is used as the dependent variable and the period covered is longer. The weights in the lag again are all significant and the structure looks much as before.

M&S's approach in this paper is that of fitting the expectations model and then examining the regression residuals for the presence of supply effects. Again only the results of the 16 quarter lag are reported. This lag, the authors state, "...proved optimal, in terms of the standard error of estimate." (60, p. 573) The residuals of the regression appear to have some systematic force working on them as evidenced by the low Durbin-Watson statistic of 0.582. Various supply
measures were appended to the original equation on the grounds that if $F_t$ had any influence on current rates, the supply variables would show up statistically significant.

The Flow of Funds section of the Board of Governors of the Federal Reserve System has computed weighted debt maturity measures which M&S used for $F_t$ variables. The four series employed are as follows:

- **Proportion of Short**
  Includes all securities maturing in one year plus proportions of those maturing between one and two years, the proportions falling linearly from 100 per cent for one year maturities to zero for over two years maturity.

- **Intermediate I**
  Includes a linearly rising from 0 to 100 per cent proportion of maturities of one to two years, all maturities of two to four years, and a linearly declining proportion of maturities of four to six years.

- **Intermediate II**
  Includes linearly rising proportions of those securities due in four to six years, all due in six to eight years, and linearly declining proportions of those due in eight to twelve years.

- **Long**
  Includes linearly rising proportions of securities due in eight to twelve years, and all due in over twelve years.

These measures, while not perfect, overcome the problem of arbitrary boundaries on debt categories (48). In this way there are no large discontinuities when an issue goes from (say) 10 years to 9 years and 364 days thus passing from "long" to "intermediate".
These debt variables and their first differences, along with average maturity, were added to the original equation in combinations and alone. The only reported results are for the variables alone, shown in Table 3.4. The authors argue that these results are inconsistent with \textit{a priori} expectations of supply effects. The average maturity sign should be positive since an increase in the average maturity should raise the long-term rate (60, p. 578). It may also be argued that an increase in the proportion of short to total debt should raise the short rate and reduce the spread so that the coefficient should be negative. Intermediate I should have a positive sign since it is closer to the short end than the long, but the level has the wrong sign and the change variable is insignificant. By the same argument Intermediate II and Long should have positive coefficients, but they either have the wrong sign, are insignificant, or both. We will have some comments in the next chapter which may shed light on these results.

Further tests were carried out due to the inadequacy of the original data. First, note that the long rate used is an average of rates on bonds due or callable in over 10 years. Supply effects may, therefore, be washed out in the averaging. That is, any rate changes induced by supply effects may be swamped by the movement of other rates in the average. Second, it may also be that debt management effects are more readily observable in intermediate maturities (60, p. 583).
Table 3.4. Results from Modigliani and Sutch's American Economic Review paper

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient and standard error</th>
<th>Level</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average maturity</td>
<td>-0.048 (0.042)</td>
<td>-0.098 (0.076)</td>
<td></td>
</tr>
<tr>
<td>Proportion of Short</td>
<td>0.178 (0.385)</td>
<td>1.715 (0.777)*a</td>
<td></td>
</tr>
<tr>
<td>Intermediate I</td>
<td>1.164 (0.334)*</td>
<td>-0.714 (1.048)</td>
<td></td>
</tr>
<tr>
<td>Intermediate II</td>
<td>-1.415 (0.323)*</td>
<td>-2.694 (1.186)*</td>
<td></td>
</tr>
<tr>
<td>Long</td>
<td>0.215 (1.440)</td>
<td>-1.535 (2.722)</td>
<td></td>
</tr>
<tr>
<td>Ratio of Long to Short</td>
<td>0.160 (0.136)</td>
<td>0.173 (0.134)</td>
<td></td>
</tr>
</tbody>
</table>

*aCoefficient is more than twice its standard error.

Debt management is not limited to long maturities, but is carried out on the entire range of debt maturity. To solve these two problems M&S obtained data from the Morgan Guarantee Trust which keeps daily records of its own dealings in Governments. They prepare a monthly average yield-to-maturity for each issue and then draw a smooth curve through these points. One can effectively obtain a monthly average for any maturity by reading off the curve. These data are far superior to Treasury or Durand curves as the former are drawn...
for one day and the latter for one year while Morgan data are averages of daily observations.

The authors fitted the 16 quarter lag to these data and found results nearly as good as previous results, but again failed to report on any other than the 16 quarter lag. The results for constant maturities of 2, 4, 8, and 12 years follow:

\[ R(2)_t = 0.409 + 0.852 r_t + \sum_{i=1}^{16} b_i r_{t-1} \]
\[ R^2 = .943 \quad \overline{S_e} = .232 \]

\[ R(4) = 0.726 + 0.661 r_t + \sum_{i=1}^{16} b_i r_{t-1} \]
\[ R^2 = .931 \quad \overline{S_e} = .233 \]

\[ R(8) = 1.064 + 0.465 r_t + \sum_{i=1}^{16} b_i r_{t-1} \]
\[ R^2 = .949 \quad \overline{S_e} = .174 \]

\[ R(12) = 1.234 + 0.368 r_t + \sum_{i=1}^{16} b_i r_{t-1} \]
\[ R^2 = .958 \quad \overline{S_e} = .146 \]

The weights in the lag were not given but the lags were graphed and had much the same shape as the lag in Figure 3.3.

In explaining the next test the authors state that, each maturity's rate should be most affected by debt supply in its own maturity range. Therefore, \( R(n, t) \) and \( r_t \) should be most affected by the ratio of debt in the \( n \) year maturity range to debt in the shortest range (60, p. 584). Each of the
maturities were then tested against the appropriate ratio and its change. The results are shown in Table 3.5. It should be noted that Short I is three months debt, not the Proportion of Short earlier defined. The other coefficients in the equation are not reported as they are not changed by the new variables (60, p. 586). While the 12 and 8 year rates are not encouraging, there is statistical significance and a proper sign associated with the 4 and 2 year categories. M&S state that a number of other tests were run but, "This battery of tests has, on the whole, proved as disappointing and inconclusive as those we have reported above..." (60, p. 587) None of the "other" tests were reported.

M&S conclude that the data support the expectations hypothesis and do not support the segmentation hypothesis. But there are some reservations about the data in general. In particular it is noted that the tests are carried out only with Government security data and this ignores a significant part of the debt market. This is indeed a shortcoming of all of these tests but, unfortunately, the data for more inclusive tests are not available.

The authors also point out in passing:

"Grounds for doubting that supply effects are totally absent are also suggested by specific episodes, such as the experience with pegging of the rate structure during the war and partial pegging in the pre-accord period. Cursory examination of the events suggests that the pegging was feasible, though it necessitated large accommodating changes in the age structure of the publicly held supply." (60, p. 589)
It is this period which we will examine in the next chapters.

Table 3.5. Results from Modigliani and Sutch's test of Morgan data

<table>
<thead>
<tr>
<th>Maturity</th>
<th>Variable</th>
<th>Coefficient and standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Level</td>
</tr>
<tr>
<td>12 years</td>
<td>Ratio of Long to Short I</td>
<td>0.189</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.162)</td>
</tr>
<tr>
<td>8 years</td>
<td>Ratio of Intermediate II to Short I</td>
<td>-0.234</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.105)*</td>
</tr>
<tr>
<td>4 years</td>
<td>Ratio of Intermediate I to Short I</td>
<td>0.469</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.084)*</td>
</tr>
<tr>
<td>2 years</td>
<td>Ratio of Intermediate I to Short I</td>
<td>5.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.082)*</td>
</tr>
</tbody>
</table>

\(^a\)Coefficient is more than twice its standard error.
HISTORICAL REVIEW

I

Data from the Federal bond market for the years 1941 to 1951 are used for the statistical tests of the theory presented in this dissertation. To get an accurate idea whether or not supply effects exist, it seems reasonable to look at a period when the supply operations being undertaken were known. (Scott, Okun, and M&S all test data when there were no particular supply changes going on. Operation Twist was not really tried and the others pick times when debt policy was inactive.) For our test period we have chosen the war period precisely because it was a period of massive intervention by the Federal Reserve and the Treasury. It was a period characterized by large changes in the volume and maturity structure of the public debt. It was a period characterized by massive and continual intervention aimed particularly at affecting the shape and level of the yield curve. In short it was a period when, if supply operations have any effect at all, they would almost surely appear. The period is usually rejected as atypical, or as a period when the market in general, and expectations in particular were extraordinarily disturbed. It is not rejected here because, as will be borne out by this chapter, the disturbing effects are partly those of supply operations. When one excludes from analysis periods of "unusual" intervention one excludes periods when supply oper-
ations were most vigorously undertaken, and this excludes supply effects \textit{a priori}. For these reasons 1941-1951 was selected as a test period.

Before examining the data, the events and conditions surrounding the market during this period will be briefly examined. It is the purpose of this chapter to examine the wartime finance conditions and thereby set the stage for empirical tests.

The war period, unique in monetary history, has been treated very lightly in the professional and popular literature. There are two major works extant which deal with the era in detail, both of which we rely upon heavily in what follows. \textit{National Debt in War and Transition}, by Henry C. Murphy (who at the time was Assistant Director of Research and Statistics for the U.S. Treasury), and \textit{Inflation in the United States 1940-1948}, by Lester V. Chandler, are the two works indicated. These works concern themselves with the general problems of war finance and only secondarily with bond market activity. The substantial volume of literature on term structure theory has bypassed the period almost completely.\footnote{There are two exceptions, Charles Walker (101) and the brief mention by Modigliani and Sutch (60).}

That the war period was a period of massive supply changes can hardly be doubted. As of April 30, 1941, after

\footnote{There are two exceptions, Charles Walker (101) and the brief mention by Modigliani and Sutch (60).}
War finance to aid England had begun but before the major finance thrust, the par value of the Public Marketable Interest Bearing Debt Issued or Guaranteed by the U.S. Government stood at 43,608 millions of dollars. At its peak on February 28, 1946, it reached $199,849 millions (98), an increase of about 450 per cent in five years. After the war the debt was moderately reduced. During the defense period from 1940-1945 the government raised $380 billion, of which 60 per cent was borrowings and 40 per cent taxation (14:1945). Of the borrowings about 80 per cent was in the form of Public Marketable Interest Bearing Debt Issued or Guaranteed by the U.S. Government (98:1946). By the Accord in March, 1951, it stood at $151,642 millions.¹

To issue this amount of debt in such a short period of time took a great deal of cooperation between the Treasury and the monetary authorities. The cooperation which did exist between the Treasury and the Federal Reserve System is by now almost legend. Even as war gradually broke out in Europe it was clear that the U.S. would soon be either directly involved or be called upon to give substantial aid to faltering England.

The market was not unprepared for the intervention which was to come. The Federal Reserve and the Treasury had been

¹It might be pointed out that these figures refer only to Public Marketable Interest Bearing Debt Issued or Guaranteed by the U.S. Government, and that total debt figures are somewhat different.
intervening in the market many years before the inception of official finance policy in 1942. During the '30's the Federal Reserve System had, for the first time, been active in protecting the yield on U.S. Government securities. Open Market Operations to maintain an orderly market were often used, so that the idea of intervention was certainly not new with WW II (20, p. 148). The entire prewar period monetary control was complicated by the huge free reserves which arose from the gold inflows of the '30's. The existence of these large reserves caused yields on governments to decline through the '30's so that at the outbreak of war rates were lower than they had been at any time in recent history. Excess reserves were so large in the prewar period that some issues of Treasury bills in 1939 and 1940 sold at negative yields.¹

In 1939 when war broke out with the German invasion of Poland, long-term governments fell 2 and 21/32, and the monetary authority then intervened. The Fed bought $60 millions of federal bonds from dealers to protect them from losses due to wartime market instability (62, p. 221). To insure stability, and to minimize the jeopardy of the commercial banks' portfolios, the System announced that it would advance funds

¹The catch of course is that funds held in U.S. Governments were not taxable, but that was also true of funds held in any government security including those with positive yield. This might be interpreted as a strong statement of maturity preference (97:1940, p. 110).
on U.S. Government Securities at par to all banks. Late in '39 the market recovered and continued to rise so that in December of 1940 the Fed asked Congress to raise the limit on reserve requirements to 26 per cent in central reserve cities, 20 per cent in cities, 14 per cent in country banks, and 6 per cent for all time deposits. This was necessary to absorb the volume of excess reserves outstanding. This was done. Through the remainder of 1939 and up to Pearl Harbor on December 7, 1941, the monetary authority intervened to stabilize capital markets, protect member banks from wide fluctuations in bond prices, and to prepare the market for the large financing that was surely coming.

With the Pearl Harbor tragedy the nation was shocked into the middle of a wartime emergency. The Federal Reserve responded with the following statement:

"The financial and banking mechanism of the country is today in a stronger position to meet any emergency than ever before. The existing supply of funds and of bank reserves is fully adequate to meet all present and prospective needs of the Government and of private activity. The Federal Reserve System has powers to add to these resources to whatever extent may be required in the future. The System is prepared to make use of its powers to assure that an ample supply of funds is available at all times for financing the war effort and to exert its influence toward maintaining conditions in the United States Government Security market that are satisfactory from the standpoint of the Government's requirements.

Continuing the policy which was announced following the outbreak of war in Europe, Federal Reserve Banks stand ready to advance funds on United States Government Securities at par to all banks."

(14:1941, p. 1)
Just after Pearl Harbor the Federal Open Market Committee bought $45 million of '51-'55 and '67-'72's bonds, $12 million of bills, and $13 million of various issues in support of the bond market (14:1941, p. 65). This intervention and statement signaled the beginning of formal war finance, and adjustments came very quickly thereafter.

One of the first moves into war finance was the cessation of tax exempt security issues. After March 1, 1941, interest on all federal securities issued after that time was subject to federal income and excess profits tax. At the same time the issuing of guaranteed securities ceased, making debt control somewhat easier from the Treasury's point of view.

Once the initial shock of war had passed, the problem of financing an extended war arose. After extensive debate within and between the Treasury and Federal Reserve System (62, pt. 2), it was decided that the major share of the war would be financed by voluntary borrowing. (The institutional processes and reasons behind this decision make an interesting study, but are beyond our scope.)

It was at once clear that the major source of wartime credit was to be the commercial banking system. Treasury and Fed officials unanimously agreed that the preferred ranking of fund sources would be as follows:

1. individuals
2. non-financial corporations
3. non-bank financial corporations
4. commercial banks
5. Federal Reserve Banks

The sources at the top of the list would be the least inflationary places to borrow. A very large effort indeed was exerted to place the debt at the top of the list, but it was known that eventually it would be necessary to fall back on choices 4 and 5. Ideally, idle funds would be taken out of the hands of individuals and corporations and used by the Government for war purchases. It was hoped also that an effective borrowing program would lower marginal propensities to consume, and thus not only soak up existing private saving, but create additional saving.

The rejection of any compulsory finance limited the Treasury's ability to place the debt where it desired. Heavy reliance on taxation and compulsory borrowing were rejected because the latter was an unfamiliar device and the former invited disincentive effects (20, p. 144). Disincentive effects from high tax rates were clearly something which a wartime effort could not stand. It is also the case that taxation was not heavily used from simple underestimation of the cost of the war.

Given the voluntary approach it was up to the Treasury and the Federal Reserve to produce an atmosphere of safety and certainty so that lenders would willingly trade funds for securities. The first half of 1942 was devoted to bringing about this atmosphere. Effective February 28, the discount
rate was lowered to 1 per cent and reserve requirements were lowered by several steps to 20 per cent for central reserve city banks, 18 per cent for reserve city banks, and 13 per cent for country banks. These moves assured, for the moment, that the banking system could maintain adequate reserves in the face of growing finance demands.

The Federal Reserve and the Treasury next turned to the method of finance. How best to insure stability in the market and instill confidence in lenders? The mutually acceptable approach was that of a frozen yield curve but the Treasury and the Fed had some difficulty deciding exactly where the curve should be (62, pt. 2). The long end was fairly-well agreed upon, but the short end brought some debate. The Treasury argued that the current level of short rates were somehow "normal" rates which the market would accept\(^1\), and this view prevailed. The result was that on April 30, 1942, the bill rate was posted (officially announced as a policy measure) at 3/8 per cent and the remainder of the yield curve, while not posted, was supported (carried out but not announced) at 7/8 per cent for 12 months maturities, 2 per cent for 10 years, and 2½ per cent for 25 years (62, p. 103). This decision set the pattern of rates and directed the finance effort for the remainder of the war.

There were a few alterations of this pattern which

\(^1\)For a sharply opposing view see Walker (101).
remained in force throughout the defense period. The most important change was the adoption of the repurchase agreement.

"Supplementing the direction of April 30, 1942, issued by the Federal Open Market Committee to the Federal Reserve Banks to purchase all Treasury bills that may be offered to such Banks on a discount basis at the rate of 3/8 per cent per annum, any such purchases shall, if desired by the seller, be upon the conditions that the Federal Reserve Bank, upon the request of the seller before the maturity of the bills, will sell to him Treasury bills of like amount and maturity at the same rate of discount." (14:1942, p. 105)

After the lender figured out this statement, what it did was to make bills as liquid as cash at the guarantee of the Federal Reserve System. One could be gotten for the other at any time. More of this presently.

Simultaneous with the bill repurchase agreement a buying rate, but not a repurchase agreement, for 7/8 per cent certificates was posted. Though no guarantee for the rest of the curve was posted, it soon became evident that the Federal was indeed pegging the yield curve on one side; that is, rates were not allowed to rise above the previously mentioned levels, but they could and did fall so long as the fall was not drastic. When rates rose to the ceiling the Federal Reserve purchased enough to stop the rise at the ceiling.

In October of 1942 the Federal Reserve System established a preferential discount rate of 1/2 per cent of discounted maturities of 1 year or less (14:1942, p. 105). This preferential rate was hardly advantageous since it was cheaper to discount
bills at 3/8 per cent than to discount at 1/2 per cent. In April 1943, the Federal Reserve Act was amended to allow limited direct purchases by the Fed from the Treasury and, more importantly the act was amended to delete reserve requirements from U.S. Government deposits arising as a result of subscriptions for U.S. Government securities.

With these final two alterations the pattern of war finance was set. Emphasis was placed on injecting certainty into the marketplace by freezing the rate structure. Heavy emphasis was also placed on insuring that the banking system had adequate reserves to purchase new securities. In keeping with efforts to maintain liquidity in the banking system, the 2½'s of '52-'55 issued February 25, 1942, was the last issue of over 2 per cent, over 10 years maturity securities for which banks were allowed to compete. Securities subsequently issued were restricted from bank ownership until the securities had 10 or less years to first call or maturity. Securities issued before February 25, 1942, were unaffected by the restriction.

On May 4, 1942, an issue of 2½'s of 1962-1967 was well-received and this nailed down the proposed rates (62, p. 107). Only once did the professional market balk at the rate pattern. In October 1942, a financing nearly failed apparently because the market seemed to expect a rate rise. The situation came to the point that Treasury and Federal Reserve officials had to call on friends in the commercial banking
world to increase their subscriptions under the guarantee that the Federal would take the securities off their hands if desired. This episode quelled suspicion of a rate rise and financing went smoothly thereafter (62, p. 120).

The rationale for official policy was twofold: (1) the semi-stable yield structure was designed to inject certainty into the market by protecting investors from wide price fluctuations; (2) the posted bill rate, complete with repurchase option, guaranteed that the banking system would have sufficient reserves to handle Treasury financing needs. To insure an adequate volume of eligible securities was available the Treasury began issuing 12 month certificates of indebtedness at 7/8 per cent per annum, and it increased its weekly bill offering from $150 million to $600 million (14:1942, p. 10). During 1942 the following amounts of debt were absorbed by the indicated sources:

<table>
<thead>
<tr>
<th>Source</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Banks</td>
<td>$19.5 billion</td>
</tr>
<tr>
<td>Federal Reserve Banks</td>
<td>3.9</td>
</tr>
<tr>
<td>Mutual Savings Banks</td>
<td>0.9</td>
</tr>
<tr>
<td>Life Insurance Companies</td>
<td>3.0</td>
</tr>
<tr>
<td>Others</td>
<td></td>
</tr>
<tr>
<td>marketable</td>
<td>5.2</td>
</tr>
<tr>
<td>non-marketable</td>
<td>12.6</td>
</tr>
<tr>
<td>Federal Agencies and Trusts</td>
<td></td>
</tr>
<tr>
<td>special issues</td>
<td>2.0</td>
</tr>
<tr>
<td>public issues</td>
<td>0.7</td>
</tr>
<tr>
<td>Total</td>
<td>$47.8</td>
</tr>
</tbody>
</table>

Perhaps the most important aspect of this policy for our purposes is that it made the Federal a sort of money-vending machine. All a federal security holder need do was insert a security and the machine paid off — at par. If
the security happened to be a bill the investor could even get it back if he didn't like the money. In essence, the Federal Reserve lost all control over the money supply and became a residual debt holder, holding what debt the public didn't want. Even though the Fed had only pledged itself to a price floor, it occasionally sold securities to maintain this pattern, although this practice was not vigorously or even systematically pursued (20, pp. 189-191).

Against this framework the Treasury had to finance the war effort. The financing took place through seven war loans and a so-called Victory Loan. In these loans were securities of varying characteristics which fit the supported yield pattern. A summary of the war loans from the Treasury Bulletin of August 1945 is presented in Figure 4.1.

The choice of voluntary borrowing and low reliance on taxation or any other compulsory means of financing severely constrained the Treasury's available alternatives. It had, somehow, to make its wares attractive enough to draw funds from the primary targets (individuals, non-financials, and non-bank financials) while discouraging bank purchases. It had, in brief, to design its securities to be most attractive to the group which was the target.

The war loans consisted of a mix of securities, each designed for a particular group. Nonmarketable issues, series E bonds, were sold only to individuals and carried a higher rate than any marketable bond. The return was designed to be
Figure 4.1. Comparison of sales in the seven war loans, by investor classes and by issues.
Table 4.- Comparison of Sales in the Seven War Loans, By Investor Classes and by Issues

<table>
<thead>
<tr>
<th>Part A - Sales of Each Issue in Each War Loan</th>
</tr>
</thead>
<tbody>
<tr>
<td>(In millions of dollars)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Series &amp; Savings bonds: 1/</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st War Loan</td>
</tr>
<tr>
<td>2nd War Loan</td>
</tr>
<tr>
<td>3rd War Loan</td>
</tr>
<tr>
<td>4th War Loan</td>
</tr>
<tr>
<td>5th War Loan</td>
</tr>
<tr>
<td>6th War Loan</td>
</tr>
<tr>
<td>7th War Loan</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Series F and G Savings bonds: 1/</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st War Loan</td>
</tr>
<tr>
<td>2nd War Loan</td>
</tr>
<tr>
<td>3rd War Loan</td>
</tr>
<tr>
<td>4th War Loan</td>
</tr>
<tr>
<td>5th War Loan</td>
</tr>
<tr>
<td>6th War Loan</td>
</tr>
<tr>
<td>7th War Loan</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Series C Savings Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st War Loan</td>
</tr>
<tr>
<td>2nd War Loan</td>
</tr>
<tr>
<td>3rd War Loan</td>
</tr>
<tr>
<td>4th War Loan</td>
</tr>
<tr>
<td>5th War Loan</td>
</tr>
<tr>
<td>6th War Loan</td>
</tr>
<tr>
<td>7th War Loan</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treasury Bills: 10/</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st War Loan</td>
</tr>
<tr>
<td>2nd War Loan</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7/84 Certificate of Indebtedness:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st War Loan</td>
</tr>
<tr>
<td>2nd War Loan</td>
</tr>
<tr>
<td>3rd War Loan</td>
</tr>
<tr>
<td>4th War Loan</td>
</tr>
<tr>
<td>5th War Loan</td>
</tr>
<tr>
<td>6th War Loan</td>
</tr>
<tr>
<td>7th War Loan</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>11/65 Treasury Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st War Loan</td>
</tr>
<tr>
<td>2nd War Loan</td>
</tr>
<tr>
<td>3rd War Loan</td>
</tr>
<tr>
<td>4th War Loan</td>
</tr>
<tr>
<td>5th War Loan</td>
</tr>
<tr>
<td>6th War Loan</td>
</tr>
<tr>
<td>7th War Loan</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1/12 Treasury Bonds: 11/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part B - Sales to Nonbank Investors</td>
</tr>
<tr>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Total to all investors</td>
</tr>
<tr>
<td>Total to nonbank investors</td>
</tr>
<tr>
<td>Individual investors</td>
</tr>
<tr>
<td>Corporations and other investors</td>
</tr>
<tr>
<td>Savings banks</td>
</tr>
<tr>
<td>Corporations and associations, and savings and loan associations</td>
</tr>
<tr>
<td>Dealers and brokers</td>
</tr>
<tr>
<td>State and local governments</td>
</tr>
<tr>
<td>Treasury investment accounts</td>
</tr>
</tbody>
</table>

Non-marketable Issues

<table>
<thead>
<tr>
<th>Treasury Bills: 10/</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st War Loan</td>
</tr>
<tr>
<td>2nd War Loan</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7/84 Certificate of Indebtedness:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st War Loan</td>
</tr>
<tr>
<td>2nd War Loan</td>
</tr>
<tr>
<td>3rd War Loan</td>
</tr>
<tr>
<td>4th War Loan</td>
</tr>
<tr>
<td>5th War Loan</td>
</tr>
<tr>
<td>6th War Loan</td>
</tr>
<tr>
<td>7th War Loan</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>11/65 Treasury Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st War Loan</td>
</tr>
<tr>
<td>2nd War Loan</td>
</tr>
<tr>
<td>3rd War Loan</td>
</tr>
<tr>
<td>4th War Loan</td>
</tr>
<tr>
<td>5th War Loan</td>
</tr>
<tr>
<td>6th War Loan</td>
</tr>
<tr>
<td>7th War Loan</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1/12 Treasury Bonds: 11/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part B - Sales to Nonbank Investors</td>
</tr>
<tr>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Total to all investors</td>
</tr>
<tr>
<td>Total to nonbank investors</td>
</tr>
<tr>
<td>Individual investors</td>
</tr>
<tr>
<td>Corporations and other investors</td>
</tr>
<tr>
<td>Savings banks</td>
</tr>
<tr>
<td>Corporations and associations, and savings and loan associations</td>
</tr>
<tr>
<td>Dealers and brokers</td>
</tr>
<tr>
<td>State and local governments</td>
</tr>
<tr>
<td>Treasury investment accounts</td>
</tr>
<tr>
<td>Loan Type</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>War Loan</td>
</tr>
<tr>
<td></td>
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<td></td>
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<tr>
<td></td>
</tr>
</tbody>
</table>

Unrestricted Marketable Issues

<table>
<thead>
<tr>
<th>Loan Type</th>
<th>Series F and G Savings Bonds</th>
<th>Treasury Bills</th>
<th>Marketable Securities</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>War Loan</td>
<td>1st War Loan: 2</td>
<td>3</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>2nd War Loan: 3</td>
<td>4</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>3rd War Loan: 4</td>
<td>5</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>4th War Loan: 6</td>
<td>7</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>5th War Loan: 8</td>
<td>9</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>6th War Loan: 10</td>
<td>11</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>7th War Loan: 12</td>
<td>13</td>
<td>14</td>
<td>15</td>
</tr>
</tbody>
</table>

Total - All Issues
Figure 4.1 (Continued).
Table 4. Comparison of Sales in the Seven War Loans, by Investor Classes and by Issues - (Continued)

Part B - Summary

<table>
<thead>
<tr>
<th>Issue Type</th>
<th>Total Sales to All Investors</th>
<th>Total Sales to Nonbank Investors</th>
<th>Sales to Corporations and Other Investors</th>
<th>Sales to Insurers</th>
<th>Savings and Loan Associations</th>
<th>Dealers and Brokers</th>
<th>State and Local Governments</th>
<th>Treasury Investment Accounts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-marketable issues:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Series E savings bonds</td>
<td>17,734</td>
<td>17,734</td>
<td>17,734</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Series F and G savings bonds</td>
<td>5,173</td>
<td>5,173</td>
<td>5,173</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Series H savings notes</td>
<td>3,415</td>
<td>3,415</td>
<td>3,415</td>
<td></td>
<td></td>
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<td></td>
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<td>Total</td>
<td>26,322</td>
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<td>26,322</td>
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<td>Unrestricted marketable issues:</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treasury bills</td>
<td>1,776</td>
<td>1,776</td>
<td>1,776</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>7 1/4% certificates of indebtedness</td>
<td>32,067</td>
<td>32,067</td>
<td>32,067</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1% Treasury notes</td>
<td>34,987</td>
<td>34,987</td>
<td>34,987</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 1/4% Treasury bonds</td>
<td>1,169</td>
<td>1,169</td>
<td>1,169</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2% Treasury bonds</td>
<td>22,747</td>
<td>22,747</td>
<td>22,747</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Total</td>
<td>56,468</td>
<td>56,468</td>
<td>56,468</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Marketable issues restricted as to bank ownership:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2% Treasury bonds</td>
<td>6,548</td>
<td>6,548</td>
<td>6,548</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2 1/4% Treasury bonds</td>
<td>24,786</td>
<td>24,786</td>
<td>24,786</td>
<td></td>
<td></td>
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<tr>
<td>Total</td>
<td>31,334</td>
<td>31,334</td>
<td>31,334</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total - All issues in all war loans combined</td>
<td>135,749</td>
<td>125,353</td>
<td>115,463</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sales by major types of issue for each war loan

Non-marketable issues:
- 1st War Loan: 2,349, 2,149, 1,130, 1,219, -
- 2nd War Loan: 2,792, 2,792, 2,792, 2,792, -
- 3rd War Loan: 6,443, 6,443, 6,443, 2,500, 38
- 4th War Loan: 2,425, 2,425, 2,425, 2,425, -
- 5th War Loan: 2,166, 2,166, 2,166, 2,166, -
- 6th War Loan: 2,876, 2,876, 2,876, 2,876, -
- 7th War Loan: 2,876, 2,876, 2,876, 2,876, -
- Total: 38,345, 38,345, 38,345, 38,345, -

Unrestricted marketable issues:
- 1st War Loan: 7,766, 6,869, 2,869, 2,869, -
- 2nd War Loan: 11,575, 11,575, 11,575, 11,575, -
- 3rd War Loan: 5,015, 5,015, 5,015, 5,015, -
- 4th War Loan: 4,497, 4,497, 4,497, 4,497, -
- 5th War Loan: 13,294, 13,294, 13,294, 13,294, -
- 6th War Loan: 15,126, 15,126, 15,126, 15,126, -
- 7th War Loan: 6,674, 6,674, 6,674, 6,674, -
- Total: 48,848, 48,848, 48,848, 48,848, -
### Non-mortgagable issues of 1940-45 War Loans

<table>
<thead>
<tr>
<th>Year</th>
<th>Issue</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1941</td>
<td>Savings</td>
<td>17,716</td>
</tr>
<tr>
<td>1941</td>
<td>Savings</td>
<td>17,716</td>
</tr>
<tr>
<td>1941</td>
<td>Savings</td>
<td>17,716</td>
</tr>
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<td>17,716</td>
</tr>
<tr>
<td>1941</td>
<td>Savings</td>
<td>17,716</td>
</tr>
</tbody>
</table>

### Unrestricted marketable issues

<table>
<thead>
<tr>
<th>Issue</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treasury</td>
<td>1,176</td>
</tr>
<tr>
<td>Certificates of deposit</td>
<td>4,498</td>
</tr>
<tr>
<td>Treasury notes</td>
<td>3,494</td>
</tr>
<tr>
<td>Treasury bonds</td>
<td>1,690</td>
</tr>
<tr>
<td>Treasury bonds</td>
<td>2,058</td>
</tr>
<tr>
<td>Treasury bonds</td>
<td>22,368</td>
</tr>
<tr>
<td>Total</td>
<td>64,493</td>
</tr>
</tbody>
</table>

### Marketable issues restricted as to bank ownership

<table>
<thead>
<tr>
<th>Issue</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treasury</td>
<td>8,408</td>
</tr>
<tr>
<td>Treasury notes</td>
<td>25,374</td>
</tr>
<tr>
<td>Treasury bonds</td>
<td>32,768</td>
</tr>
<tr>
<td>Total</td>
<td>69,550</td>
</tr>
</tbody>
</table>

### Total all issues in all war loans combined

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1941</td>
<td>135,749</td>
</tr>
</tbody>
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### Sales by major types of issue for each war loan

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<thead>
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<th>Total</th>
</tr>
</thead>
<tbody>
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<td>1,176</td>
</tr>
<tr>
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<td>1,176</td>
</tr>
<tr>
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<td>Savings</td>
<td>1,176</td>
</tr>
<tr>
<td>1941</td>
<td>Savings</td>
<td>1,176</td>
</tr>
<tr>
<td>1941</td>
<td>Savings</td>
<td>1,176</td>
</tr>
</tbody>
</table>

### Unrestricted marketable issues

<table>
<thead>
<tr>
<th>Issue</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treasury</td>
<td>1,176</td>
</tr>
<tr>
<td>Certificates of deposit</td>
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</tr>
<tr>
<td>Treasury bonds</td>
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<tr>
<td>Treasury bonds</td>
<td>22,368</td>
</tr>
<tr>
<td>Total</td>
<td>64,493</td>
</tr>
</tbody>
</table>

### Marketable issues restricted as to bank ownership

<table>
<thead>
<tr>
<th>Issue</th>
<th>Total</th>
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</thead>
<tbody>
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</tr>
<tr>
<td>Total</td>
<td>69,550</td>
</tr>
</tbody>
</table>

### Total all issues in all war loans combined

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1941</td>
<td>135,749</td>
</tr>
</tbody>
</table>

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1. Marketable bonds include those held directly by nonbank investors and those held by agents and trust funds in the United States, but not by state or local governments. They also include bonds held in the United States by foreign governments and their agencies and trust funds which handle their own investments. These are included in the column "corporations and associations" and do not amount to as much as $100 million during any war loan.

2. Commercial banks were included in 1st and 2nd War Loans only.

3. Savings bonds are shown at issue price.

4. Banks were arbitrarily assigned to corporations and associations.

5. Figures represent not increases in Treasury bills outstanding but the amounts purchased by the Federal Reserve Banks and commercial banks from the public for Treasury Department.

6. Figures represent not increases in Treasury bills outstanding but the amounts purchased by the Federal Reserve Banks and commercial banks from the public for Treasury Department.

7. Omitted are the amounts held by agencies and trust funds which handle their own investments, included in the column "corporations and associations."
very low if the bond were cashed early, but rose to 2.9 per cent if held to its maturity of 10 years. Series F and Series G bonds had much the same characteristics but had slightly different maturities and slightly different yields. In addition they were available to non-individuals on a limited basis. Series C Treasury Tax Savings Notes had a less than 3-year maturity at 1 per cent and were used mostly by corporations as tax anticipation notes. Each of these was designed to sell to a particular group and absorb savings.

The marketable securities included bills at 3/8 per cent and certificates at 7/8 per cent, which have already been mentioned. Included also for diversity were notes from 1 to 5 years maturity carrying yields of 0.90 per cent for less than 1 year, 1.25 per cent for 3 years, and 1.5 per cent for 5 years. The longest securities were bonds of over 5 years (mostly between 10 and 25 years) which carried yields of 2 per cent, 2½ per cent, and 2½ per cent depending on their length (20, ch. 8).

All of the securities noted above were included in each war loan except bills, which were excluded after the second, and notes, which were offered only in the fifth and sixth loans. The goal of fitting the securities to the investor was well-served by this diversity of offering.

For the December 1941 financing the Treasury announced a set of new guides for subscriptions. Bank and Trust company subscriptions for their own accounts were not to exceed
50 per cent of surplus and capital. Non-bank financials were allowed up to 10 per cent of total resources. Corporations, brokers, and dealers were allowed up to 50 per cent of net worth. Individuals were allowed subscriptions for up to 50 per cent of net worth if cash was not deposited with the subscription or 100 per cent of cash deposited with subscriptions. No preferential allotments were made to those who deposited cash with the subscriptions as opposed to those who opted for payment on delivery (97:1942, p. 22). Banks were, after the second war loan, excluded from subscription, but could hold all but bank restricted securities as soon as they reached the secondary market. By May 1942 these limitations were dropped and never reinstated.

Throughout the entire war period the Treasury kept an emphasis on having the debt in short-term maturities, and issuing at and maintaining low interest rates. The Treasury argued that short-term debt was less costly, easier to refund, and easier to manage in a post-war period. For this reason issues of Treasury bills and certificates continued at a high level. For the entire war period about 36 per cent of the debt was due in 1 year or less, and well over half was due in less than 10 years. In the later war loans, Treasury bills were not counted as part of the loan but were nevertheless continually offered. About $11 billion of bills were issued during the war period which were not counted as part of war loans. Other nonmarketable issues were also continually
on sale but not listed as part of the war loans (98).

This discussion of the war loans has been brief because the only concern of war loans was the primary market. Once the securities had passed the primary market they were redistributed by market forces. All the careful planning and sales effort to place the debt with the desired investor classes was something less than foolproof. Much to the Treasury's consternation there was a huge flow of securities back to the banking system via the secondary market. We find, for example, in the Annual Report of the Board of Governors of the Federal Reserve System for 1943:

"The outstanding characteristic of bank investment during 1943 continued, as in 1942, to be a growth both in amount and proportion to total portfolio in holdings of short- and medium term Government securities. At the end of the year 24 per cent of the marketable Government securities held by commercial banks had maturities of less than one year and 86 per cent were to mature within 10 years, compared with 10 per cent and 63 per cent respectively at the end of 1941." (14:1943, p. 15)

The banking system continued to absorb through secondary markets more of the debt than the Treasury liked, but given the voluntary borrowing approach there was no help for it. The only strong and effective limitation used was the issuance of bank-restricted securities.

With the single exception of over-absorption by the banking system the preceding pattern of finance is what the Treasury intended. The entire procedure was designed around four principal tenets of war finance.
First, funds should be raised to minimize the risk of inflation. The least inflationary sources are individuals, non-financial corporations, etc. down to banks. Thus, the effort to keep securities out of banks.

Second, liquidity of financial institutions should be maintained to aid reconversion and fend off postwar depression. The finish of other major wars had been followed by rising unemployment and falling income as the large wartime demand fell off. It was expected that this war would be no different and that financial institutions should therefore be in a position to rapidly expand credit when the time came. It is, by now, a well-known story that failure to examine the extent of private savings led to this unfortunate suspicion, but it was a motivation for the Treasury to keep issues short and liquid. Along with this we see expressed time and time again the desirability of low interest rates which will help avoid postwar stagnation. It was fully expected by most Treasury officials that when the war ended we would again be faced with depression conditions. This expectation led to the low rate-short debt approach so vigorously pursued.

Third, small investors should be protected from undue losses arising from market fluctuations. This tenet gave rise to the pegged market.

Fourth, the cost of finance should be kept at a reasonable level (97:1942, p. 22). This along with the depression and stagnation fears brought forth the peg at the lowest interest
rates in history.

Another guarantee to both the small and large investor was that, at the request of the Fed, dealers limited the price movements on governments in any one day to $\frac{8}{32}$ of 1 per cent. This restriction did not prevent price movements, it merely slowed them.

For the most part, the financing went successfully. The Federal Reserve managed to carry out its peg, and the Treasury had no difficulty in getting an adequate amount of subscriptions. Usually the war loans went well over the stated goal. Probably the major problem was maintaining an adequate demand for very short debt which, due to the peg, had become as liquid as money. As we will see later, it was only reasonable for investors to abandon Treasury bill issues and move into the more profitable longer-term securities. The demand for short debt dropped considerably but never made the Treasury bill financing fail. Even at the low point bill issues were oversubscribed by 122 per cent (62, p. 212).

The medium-term securities were the ones which picked up most of the activity which would normally have occurred in the very short market. These security yields fell the most while longs, at the war's end, were only slightly above their beginning level. Figures 4.2 and 4.3 display charts from the November 1941 and February 1946 Treasury Bulletins which show the yield curves on Government securities as of November 15, 1941, and December 31, 1945, respectively.
YIELDS OF TREASURY BONDS AND NOTES
Based on Mean of Closing Bid and Asked Quotations

Figure 4.2. Yields of Treasury bonds and notes Nov. 15, 1941
OF TREASURY BONDS AND NOTES NOV. 15, 1941
Based on Mean of Closing Bid and Asked Quotations

For taxable bonds, yields are computed to, and issues plotted as of, the earliest call date if the bond is selling above par, and as of the final maturity date if the bond is selling below par. The smooth curves are fitted by eye.

Dollar amounts shown in descriptions of issues are in millions. Issues for which an exchange offer has been made and has expired are excluded. The prices of taxable securities are not reflected by the curves.

ury bonds and notes Nov. 15, 1941
Figure 4.3. Yields of Treasury securities Dec. 31, 1945.
YIELDS OF TREASURY SECURITIES DEC. 31, 1945
Based on Mean of Closing Bid and Asked Quotations

<table>
<thead>
<tr>
<th>PERCENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taxable Issues</td>
</tr>
<tr>
<td>Partially Tax-Exempt Bonds</td>
</tr>
</tbody>
</table>

BANK ELIGIBLE
- Fixed maturity issues
- Callable bonds

BANK RESTRICTED
- Callable bonds
The points represent yields to call date when prices are above par, and to maturity date when prices are at par or below. The smooth curves for the various classes of points are fitted by eye. Issues for which an exchange offer has been made or which are due or callable in less than 3 months are excluded.
With the announcement of the Victory Loan on October 29, 1945, the war finance drive came to an end. Secretary of the Treasury Morgenthau was succeeded by Secretary Vinson whose interests were more in the fields of taxation and international affairs. Even so, little shift in departmental policy resulted from the change in Secretaries (62, p. 151). The Victory Loan was conceived only to tide the Government over the last days of the war. It was immediately over-subscribed and may not have been necessary.

With the war emergency at an end and the pressure for massive borrowing removed, the Treasury and the Federal Reserve System turned to the problem of postwar debt management. In official statements, and in the annual reports of both the Treasury and the Fed, concern about adequate postwar liquidity and low interest rates is constantly repeated. Both agencies exhibit an overriding concern that the financial institutions be liquid enough to facilitate conversion to peacetime activities. Time and again this is the reason given for financing so much of the war by the issue of very short debt and for the maintenance of low rates. In the Annual Report of the Secretary of the Treasury for the Fiscal Year Ended June 30, 1945, for example, we find the following statement which is typical of statements in this period:

"The particular securities of which the debt is composed have been devised as part of a conscious effort to fit the debt to the needs of the classes of investors who hold it. Accordingly, about 90
percent of the securities held by commercial and Federal Reserve Banks mature within ten years; similarly, about 95 percent of the securities held by nonfinancial corporations mature within ten years. On the other hand, in the case of insurance companies and savings banks, long-term securities predominate, and about 60 percent of the holdings for these two groups of investors do not mature until after ten years." (97:1945, p. 5)

The Treasury, then, was well-prepared to begin the reconversion process. Its first steps were to begin reducing the accumulated debt by using the excess funds remaining from over-borrowing. About $23 billion of the $280 billion public debt was paid off in 1946 by reducing the Treasury's war loan accounts which were still swollen from the proceeds of the Victory Loan (14:1946, p. 3).

It is at this point that the seeds of discontent between the Treasury and the Fed were germinated. When in full bloom they would lead to the Accord of 1951. When the emergency push was over, the Federal Reserve wanted off the hook; it disliked being bound to a particular yield structure which effectively took the control of the money supply out of its hands. The Fed wanted gradually to return the market to natural forces. The Treasury, however, was faced with massive refunding problems and had an interest in keeping rates low. There was also the fear of the postwar depression which was expected to come, and it was argued that this could only be made worse by higher rates. Finally, if rates were allowed to rise there would simply be too much cost involved.

The two sides battled back and forth, mostly behind
closed doors. We are given some insight into the discussions (which were not at the time public) by Murphy (62) and by the recently released Minutes of the Federal Open Market Committee 1936-61 (28). The debate seems to have centered on the above issues, but none of it leaked into public circles. This period of uncertainty began early in 1946 when it was evident that the emergency financing had come to an end and that the reconversion would begin.

The Federal Reserve's first move toward freedom was to remove the ½ per cent preferential discount rate on governments due or callable in less than a year. This rate, it was argued, was clearly a wartime emergency measure and no longer had a function. The Treasury however feared that such a move would be interpreted as a forerunner of generally higher rates. To turn loose such an expectation would do the refinancing effort no good. Murphy has the following to say of the spat:

"The controversy came to a head with a long and strong letter sent by Secretary Vinson to Chairman Eccles at the end of March, reaffirming the Treasury's position (a much milder draft written by the author was over-ruled). In the middle of April the Federal Reserve replied in an equally long and strong letter informing the Secretary that it proposed to eliminate the rate and assuring him that it would not allow this elimination to disturb the security markets. On April 24, 1946, action to eliminate the rate was taken by the first Federal Reserve banks, and Secretary Vinson issued a press release saying that 'The Treasury was fully informed of the proposal to eliminate the preferential discount rate' — leaving the public to form its own judgement of previous interagency negotiations." (62, p. 220)
The board then removed the preferential discount rate by issuing the following statement:

"The board has approved discontinuance of the preferential rate because it has served the purpose of facilitating the war-financing program for which it was adopted in 1942. The board does not favor a higher level of interest rates on U.S. securities than the Government is now paying. Discontinuance of the special rate will not involve any increase in the cost to Government of carrying the public debt." (14:1946, p. 93)

This action caused some larger banks to slightly raise rates on loans secured by governments of one year or less maturity, but generally the rate removal was quietly received. This was the first of several minor alterations which were to occur before the full Accord. This is also typical of the sort of relationship which existed between the Treasury and the Fed postwar.

When war finance and the war expenditure ended, the Treasury turned to the task of retiring the debt while the Fed concentrated on other than bond market aspects of reconversion. Federal expenditures fell rapidly from $100 billion in 1945 to $63.7 billion in '46 to $42.5 billion in '47 and $36.3 billion in '48. Most of the debt retirement efforts were concentrated on the Federal Reserve System and the commercial banking system.

In July of 1947, when the predicted depression was apparently not to materialize, the 3/8 per cent peg and repurchase agreement on Treasury bills were removed. The short rate was allowed to rise, but not too rapidly. The Federal
Reserve System restricted "by ear" the rise in order to maintain market stability. At no time was there a hint that the long rate would be allowed to rise. In August of 1947 the peg on certificates was removed and the certificate rate gradually rose to 1.13 per cent while the bill rate rose to around 1 per cent.

The war's end brought on a powerful bull market; the yield on long term securities plunged the maximum allowable — i.e., to the point where the Federal stopped the fall. The situation was entirely psychological. No more war loans were forthcoming, and belief that adequate investment opportunities could be provided by American industry was at an all-time low (62, p. 224). But the situation reversed itself just as quickly, and the Federal again had to exercise the rate ceiling. In late '47 and early 1948 major corporations were beginning to creep into the market with new issues and this encouraged life insurance companies and holders of long-term governments to shift out of governments and into the corporate issues. As quickly as the market had become bull it became bear and rates rose again to near-support levels.

"On December 24 [1947] prices of Treasury bonds were permitted to decline to a new level, which maintained the 2½ per cent yield on the longest-term Treasury bond and yields on other issues at appropriate levels in relation to this rate and to the 1 1/8 per cent rate on Treasury certificates. The Federal Reserve System became an active buyer at the new level.

Large amounts of Treasury Bonds were purchased by the Reserve Banks during December 1947 and the early weeks of 1948 in providing support to the
market. A substantial portion of these purchases were from banks. At the same time banks, as well as other investors, increased their holdings of Treasury bills, certificates, and notes. Since these were largely purchased from Federal Reserve accounts and since during the period the Treasury had a substantial cash surplus, which it continued to use to retire securities held by the Federal Reserve Banks, the total Federal Reserve portfolio of Government securities declined during the early weeks of 1948." (14:1947, p. 6)

All during 1948 there were two major forces at work on the federal bond market. First, the Treasury was at every opportunity retiring debt from the Federal Reserve and the commercial banks. During 1948, $30.7 billion of debt held by Federal Reserve Banks and commercial banks was retired. Most of this, the Treasury claimed, was due to the massive issuance of short debt which is easily retired (97:1948, p. 2). The second major force was a movement by investors out of longs and into shorts. Most life insurance companies and holders of long debt shifted into private long-term issues, dumping governments on the Federal while the Federal thus lost short-term debt to bank investors and the Treasury retirement program.

By the middle to latter part of 1948 the inflation, which had been raging through the entire period, and the instability in the long-term debt market had abated. With this new-found stability came the System's exit from pegging a fixed rate structure.

"The Federal Open Market Committee, after consultation with the Treasury, announced today [June 29, 1949] that with a view to increasing the supply
of funds available in the market to meet the needs of commerce, business, and agriculture it will be the policy of the committee to direct purchases, sales, and exchanges of Government securities by the Federal Reserve Banks with primary regard to the general business and credit situation. The policy of maintaining orderly conditions in the Government security market, and the confidence of investors in Government bonds, will be continued. Under present conditions the maintenance of a relatively fixed pattern of rates has the undesirable effect of absorbing reserves from the market at a time when the availability of credit should be increased." (14:1949, p. 8)

This statement constituted the final break with a rigid rate ceiling, but by no means was an exit from the market. There was still heavy emphasis on maintaining orderly conditions in the market. The long rate rose slowly and stabilized itself around 2.8 per cent when the Federal exited, and this move was made only with the permission of the Federal Reserve System and was allowed only because it was consistent with orderly market conditions. The real difficulty was that maintaining orderly market conditions was not consistent with open market operations of any magnitude except those necessary to maintain order. While the Fed had managed to get away from fixed yields, it was still obliged to support the market regardless of credit conditions.

When the Korean conflict broke out, the Fed was in no better position than it was in 1949. On August 18, 1950, the Fed issued another policy statement which again shows its delicate position on the razor edge between the abysses of market support on one side and credit control on the other. It was again caught between the need to support an orderly market
and the need to control wartime inflation. These appeared to be mutually exclusive undertakings:

"Within the past six weeks loans and holdings of corporate and municipal securities have expanded by 1.5 billion dollars at banks in leading cities alone. Such an expansion under present conditions is clearly excessive. In view of this development and to support the Government's decision to rely in major degree for the immediate future upon fiscal and credit measures to curb inflation, the Board of Governors of the Federal Reserve System and the Federal Open Market Committee are prepared to use all the means at their command to restrain further expansion of bank credit consistent with the policy of maintaining orderly conditions in the Government securities market." (14:1950, p. 2)

Immediately after the above statement the System purchased $8 billion of short maturities to insure that a forthcoming Treasury financing would succeed. Also during 1950 the commercial banking system dumped about $5 billion into the Federal's lap in order to have funds for the war. This was fairly common practice throughout the entire period since the Federal Reserve was supporting, if not pegging, the market closely enough so that no one stood liable to sustain large capital losses.

The above was the general tenor throughout '49, '50, and into '51 to the Accord. The Treasury had its problems with constantly refinancing the war debt and getting that debt into such a form that it would be held rather than being constantly shifted about. The Treasury was now also faced with the problem of financing another war. The Federal Reserve, on the other side, had pledged to aid the Treasury in the
form of market support, but also had the responsibility for controlling inflation. The Federal's position was made untenable by the failure of its non-market discretionary controls to slow down the credit expansion. It had raised the discount rate, raised reserve requirements, and engaged in some moral suasion to prevent credit expansion, all to little avail. An adjustment in the Federal's position was obviously necessary.

After a long series of sometimes heated debate, the Accord came on March 4, 1951. The general public was, for the most part, unaware of the intensity of the strife and only rumors leaked into the press. Actually it was some time before the Accord took effect, since the Fed wanted to back out gently.

The explanation of the Accord follows.

"The fundamental problem which both the Treasury and the Federal Reserve faced in the postwar period developed out of the serious issue created by the existence of a huge public debt in a period of growing private demand for goods and services. Liquidation of Government securities on the part of holders was an important source of funds for current spending and for credit expansion. In order to give some assurance to investors that their securities would not be subject to severe declines in prices and to encourage the holding of such securities and to aid Treasury refunding operations, the Federal Reserve had been following a policy of supporting the market for Government securities. In view of the recurrent heavy demands for funds during the period, these purchases had the effect of monetizing substantial amounts of Government securities. Creating bank reserves, and laying the basis for excessive credit expansion." (14:1951, p. 98)
By way of not leaving the Treasury completely in the lurch, the Federal Open Market Committee (FOMC) agreed to help support in the coming transition, and it also agreed to help to some extent during future refundings. The FOMC stated that it would let short rates alone and expect them to stabilize around the discount rate. It finally agreed that more frequent conferences should take place in the future to avoid the sort of conflict which had just occurred.

Thus ended the bondage of the Federal Reserve System. The change, for a while, was more one of form than of substance. Support was only gradually withdrawn and was bound to return, at least temporarily, whenever the Treasury engaged in refunding. But in principle the two agencies once again became separate.

There was a considerable amount of debate during and after the episode over the financing approach taken. Ex post, it is reasonably clear that more of the burden of finance could have been borne by taxation and that some much-feared compulsory measures would not have been harmful. Yet, Murphy writes:

"But was the war borrowing program a success? There can be no doubt that it was. In the author's opinion it was by a wide margin the best handled and most successful which the country has ever seen. Throughout the entire period war finance was, as it always should be, the servant of war industry and not its master. There were no financial bottlenecks to the mobilization of the country's human and industrial resources. When resources were available to be purchased, the money was always there to pay for
them. The financial markets were orderly, and the credit of the government was never questioned in the slightest." (62, p. 287)

One suspects that the final sentence is the most telling of all.

II

What has the foregoing to do with the term structure theory under examination? This period is unique in that it represents the Federal Reserve System’s largest intervention to date. We have here a period when the Federal Reserve and the Treasury carried out market policy by debt supply changes. Rates were neither legislated nor imposed by legal price floors or ceilings; the Federal supported the rate structure by changing the supply of various maturities available in the market. It was a period when the Federal Reserve System decided upon a yield structure and maintained it.

The interesting features of this undertaking are two: (1) the manner in which the yields were pegged; and (2) the particular shape of the chosen structure. While there was some internal controversy about how the yields were to be pegged¹, as it emerged only the bill and the certificate rate pegs were made known to the general public. Both of these rates were clearly announced in the Federal Reserve communications. The

¹This debate is reflected in the microfilmed minutes of the FOMC meetings. The Treasury seems to have had some fear of too boldly announcing the structure. The Federal didn’t seem worried.
bill rate, as we have seen, experienced a two-sided peg in
that the Fed stood ready to either buy, sell, or make a re-
purchase agreement at a stated yield. The bill rate could
neither rise nor fall so long as the Federal's policy suc-
cceeded. The certificate rate, while stated, was only a one-
sided peg. The remainder of the structure was not stated to
the market directly, but when one observed the Federal's
buying pattern, and particularly the unchanged rates on new
Treasury issues, it must have been clear to any investor what
was going on. It is also interesting to note that, as men-
tioned, the peg was, except for bills, not a complete one.
Federal never undertook consistently to sell when an issue
began to rise in price. Occasionally it would enter and sell
when one issue appeared to be out of line, but in the stag-
nationist and war finance thinking of the times, the lower
the rates the better.

What is of interest to us is the market response which
this policy occasioned. The received theory on the term
structure of interest rates gives several alternative explana-
tions, but these fall into expectations and segmentation
responses. The purest expectations hypothesis would say the
policy should fail. A rising yield curve implies that ex-
pectations are that rates will rise. But if expectations were
as they almost surely must have been, that rates would remain
unchanged, then the pegged rate structure must have been in-
consistent with the pure expectations hypothesis. It can, of course, be argued that market participants were either unaware of the policy or didn't believe it could be done or would last. This seems difficult to believe of professional bond traders who make a living by knowing what is going on in the bond market. We will examine the available evidence on expectations of rate changes shortly.

For the moment, assume that investors believed the Fed and expected that rates, particularly the bill rate, would not rise. If these investors were motivated by purely expectational considerations we would expect to observe a particular sort of market behavior; we would expect that investors would flood the long-term end of the market. If rates are not to rise, but long maturities yield more than short maturities, why not move to the long end for superior yield and no loss of liquidity? Furthermore, we would expect to see this shift continue until the long rate (and all intermediate rates) fall to equivalence with the nailed-down bill rate.

There is another alternative. If rates, for some reason, do not fall, then we would expect the shifting to continue until the Federal ends up holding all of the short debt. Either or both of these results should be observed during the period under examination if the pure expectations hypothesis holds. To some extent both the above modes of behavior were observed. About this there is no argument; the real issue is to what extent this was observed behavior.
Proponents of the pure expectations hypothesis would argue that before either of the modes of behavior mentioned occurs, expectations that rates will not rise must be held with certainty. If expectations are not held with certainty, the pure expectations hypothesis has nothing to say.\(^1\) There is no way in the pure expectations models for a participant to expect, but not with certainty, that rates will rise or fall. Once he has made his judgement it must be held with certainty if he is to act at all.

Let us then face the issue squarely and assume that investors expected with certainty that rates would not rise. We should then have seen a shift to the longest end of the debt structure until the longest rate fell to equality with the bill rate. It will not do to argue that investors might employ a cautious policy and shift only part way out. If investors shift at all why would they stop short of the maximum attainable yield? Unless a horizon or some similar

\(^1\)The exception to this is Malkiel (55). Malkiel's development allows consideration of rate movement in either direction but then allows investors to move only to the "long" and "short" ends of the market depending upon where the "most to be hoped" lies. Thus when the "most to be hoped" end is determined investors unhesitantly move there. This is rather the same as acting from certainty. The investor is not allowed to hedge or change his horizon when faced with the uncertainty of rate movement. Once the maximum expectation of gain is established the investor would move to the longest or shortest end available just as would an investor in the pure expectations hypothesis.
consideration is introduced the expectations hypothesis implies that, if the expectation that rates will not rise is held with certainty, investors will flood the longest end of the market. This did not happen. Immediately the cry arises that investors didn't expect the war to last forever. Maybe they only expected the war to last five years. But this is an appearance of the horizon concept which is absent from pure expectations hypotheses. Suppose we allow that investors thought the pegging would end in five years and then rates would rise. In this case we should have seen everything from bills to five year maturities yielding the same. This did not happen either.

In short, the pure expectations hypothesis would argue that the peg should fail. Either the long rates should have fallen to equality with the short rates or the Federal should have ended up holding all of the short debt. But the peg did not fail. Throughout the entire period, for virtually every month, the yield curve displays an upward slope.¹ Further, at no time do these yield curves display the sort of falling long rates we would expect. There are, of course, fluctuations in the long and intermediate-long rates, but they are fluctuations, not constant falls. The intermediate and intermedi-

¹The yield curve referenced here is that drawn free hand and published in the Treasury Bulletins 1941-1951. At the time there were both taxable and tax exempt securities outstanding, both of which display upward sloping curves.
ate-short rates show the greatest tendency to fall, but again not to the extent the pure expectations hypothesis would suggest. Figure 4.4 shows the relationship between rates.

The contention that if rates were expected not to rise the Federal would be loaded up with all of the short debt is, to some extent, borne out during the period. There was considerable shifting to the longer end, but not enough to ruin the peg. This sort of shifting took place in both the primary and the secondary market.

Shifting long in the primary market is only of passing interest to us since it can occur only on new issues, but has no effect on the secondary market. The term applied to this shifting in the primary market is "free riding". Free riding in the broadest sense of the term applied to anyone who subscribed to governments with the intention of a quick resale rather than a permanent investment. The free rider, under certain circumstances, could subscribe to governments, sell his allotment in the early days of trading, and take a profit while having used no collateral other than the securities (62, p. 177).

The interest rate peg made conditions right for this sort of activity. A trader could be assured that, due to the peg, his securities would trade at a premium when trading opened and a profit could be taken. When a 2.50 per cent security was issued, the peg guaranteed that its price could not decline below par, but if rates were below the peg, as they were,
Figure 4.4. Yields on U.S. Government securities
CHART 9
YIELDS ON U.S. GOVERNMENT SECURITIES

MONTHLY AVERAGES OF DAILY FIGURES

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<th>1932</th>
<th>1934</th>
<th>1936</th>
<th>1938</th>
<th>1940</th>
<th>1942</th>
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† BREAKS IN LINES REFLECT CHANGES IN ISSUES INCLUDED.
its price would immediately rise above par thus profit could be taken. Needless to say, this led to huge over-subscription by free riders. The Treasury fought the practice by varying the offers in each war loan, by limiting bank loans for the purposes of buying securities, and by appeals to patriotism, none of which was very successful (62, p. 192).

The shifting in the secondary market is of somewhat greater concern to us, and some considerable amount did take place. The Federal's peg made the System a residual buyer in the market. Any security which the public did not want could be peddled to the Federal at par. On the following page Table 4.1 (15) shows the composition of the Federal's portfolio, which we take to be a mirror image of the public's desired holdings. We see that there is indeed a massive shift out of short-term securities so that the Federal's holding of short-term debt reached 75 per cent during the peg and 80 per cent at one time after the peg. It would be folly not to expect some of this, but notice that not all of the System's portfolio was short-term. Its holdings of intermediates declined as expected, but its holdings of longs for the most part rose! This is clearly not expected.

These figures are somewhat misleading unless we also look at the composition of the outstanding debt. Table 4.2 (15) does this by comparing the amount of Treasury bills outstanding throughout the war with the amount held by the Federal Reserve. It will be seen that at no time is the Federal
Table 4.1. Maturity distribution of the Federal Reserve portfolio 1941-1951

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<tr>
<td>III</td>
<td>4.6</td>
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<td>IV</td>
<td>4.7</td>
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<td>IV</td>
<td>25.0</td>
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<td>1943 I</td>
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<td>II</td>
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aQuarterly average of monthly data.
Table 4.2. Total Treasury bills outstanding and those in the Federal's portfolio

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<td>1953</td>
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<td>3663</td>
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<td>Oct.</td>
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<td>Nov.</td>
<td>1703</td>
<td>10</td>
<td>5721</td>
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<td>6171</td>
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<td>11880</td>
<td>17026</td>
<td>12611</td>
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<td>2002</td>
<td>--</td>
<td>6627</td>
<td>13072</td>
<td>6788</td>
<td>16428</td>
<td>11154</td>
<td>17037</td>
<td>12636</td>
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<td>--</td>
<td>7423</td>
<td>13101</td>
<td>6962</td>
<td>16403</td>
<td>11383</td>
<td>17042</td>
<td>12872</td>
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<tr>
<td>Feb.</td>
<td>2002</td>
<td>--</td>
<td>8232</td>
<td>13112</td>
<td>6360</td>
<td>16399</td>
<td>11841</td>
<td>17032</td>
<td>13052</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

^aMillions of dollars.

^bNot available.

^cInsignificant.
holding all of the bills outstanding even though they were pegged both top and bottom. There was always some demand for short debt. Even in the worst financing years for bills, at the low point, new bill issues were over-subscribed by 122 per cent (62, p. 213).

While the demand for Treasury bills fell more than the demand for any security, there was adequate demand for other short-term debt. Much of this demand for short debt stemmed from the banking system which for the most part refused to move out into the long end even as far as it was allowed.

Early in the war period banks were restricted from holding new issues which had more than 10 years maturity. We would expect banks to be closer to the bond market than most participants since banks are daily operators therein. We find, however, that banks did not shift even as far out as they could have. The data in Table 4.3 from Chandler (20, p. 176) illustrates the point. Commercial banks continued to hold the vast majority of their assets in 1-5 year maturities despite opportunities to move into 5-10 year and old issues of more than 10 years. This we would not expect of a purely expectations-oriented bank.

It can, of course, be argued that the market was either ignorant of the Federal's policy, or didn't believe it could be carried out. Were this the case, the observed yield curve may well have been consistent with the purely expectations
Table 4.3. Bank holdings of debt

<table>
<thead>
<tr>
<th></th>
<th>Marketable</th>
<th>less bank equals</th>
<th>less bank eligible held by the Federal and eligible surplus</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>governments</td>
<td>direct and</td>
<td>eligible held by the</td>
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<td>restricteds</td>
<td>held by the Federal and</td>
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<tr>
<td></td>
<td></td>
<td>directly and</td>
<td>government agencies</td>
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<tr>
<td></td>
<td></td>
<td>guaranteed</td>
<td>held by the Federal and government agencies</td>
</tr>
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<td>June 30</td>
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<tr>
<td>1941</td>
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<td>39,741</td>
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<td>55,122</td>
<td>882</td>
<td>54,240</td>
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<td>1943</td>
<td>99,403</td>
<td>8,711</td>
<td>90,692</td>
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<td>141,917</td>
<td>21,161</td>
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<td>1945</td>
<td>181,728</td>
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<td>1946</td>
<td>190,073</td>
<td>53,459</td>
<td>136,614</td>
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<td></td>
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<td></td>
<td>26,837</td>
</tr>
</tbody>
</table>

^Millions of dollars.
hypothesis. Had rates actually been expected to rise throughout the whole war period — had investors believed failure of the Fed's policy was eminent or that the Federal would, without warning, discontinue the peg — then the pure expectations hypothesis may be the complete explanation of the term structure. The available evidence suggests that this is not the case.

There are two elements to be questioned here: (1) were investors aware of the peg and did they believe it could and would be maintained? And (2) if the peg failed or the policy was discontinued, would rates have been expected to rise or fall? For the pure expectations hypothesis to be consistent with observation, investors must have believed both that the peg would fail, and that rates would rise. There is, of course, no satisfactory way ex post to determine ex ante expectations. The only light which can be shed on this comes by making an examination of what seemed reasonable during the time.

The writer has made a survey of literature during the period in order to determine the extent to which the pegging policy was known, and the reactions to it. It seemed reasonable to examine the popular literature which was widely circulated, and so The New York Times (64) (65)...(83) and Banking (8) (9)...(12) were chosen. The pegging and postwar support policies were widely discussed both in the sources mentioned
and in the academic literature as well (35) (88) (91) (92) (93) (103) (104). It may safely be said that the policy of support which the Federal pursued as a peg and support thereafter was well-known. Not only was it well-known, but there appears to have been no significant doubt of the Federal's ability to carry out the peg. Further, in none of the articles mentioned is there any suspicion that the policy would be discontinued before the war's end, and in a majority of cases it was recognized that financing and stability needs would not end with the war. Generally the policy was expected to continue throughout the war and for some time into the reconversion period. These statements were made both by private financiers and by Treasury and Federal Reserve officials.

When the peg finally ended, some time after the war's end, the expectation seems to have been that rates would fall rather than rise! It was not clear to anyone that we had successfully overcome the depression and, particularly in the academic literature, postwar stagnation was all the rage. The Treasury constantly reiterated that it was financing the war at low rates with short-term securities to keep financial corporations liquid for rapid reconversion, and as a stimulant to fight stagnation (97). Certainly rates would have risen had the peg been removed in the midst of massive war finance, but this happenstance is not once mentioned!

The first speculation about a change in the Federal's policy begins after the war in late '46 and early '47. New
Issues of private securities carrying attractive higher rates made governments non-competitive. Also the bill rate peg became highly inflationary. In due time it became clear that the short rate would be allowed to rise as it indeed was in July of 1947. But at no time was it expected that the Federal would let the long rate rise. Any adjustment to be made was thought to be exclusively the realm of the short-term market. And when, after short rates were unpegged but still supported, the long market got into trouble, the Federal again supported the long rate at 2.50 per cent while letting short rates go where they would. This policy continued to the Accord.

It appears, then, from this too-brief examination, that the Federal's policy was known, believed, and thought reasonably long-term. This observation does not allow us to conclude that rates were not expected to rise or that there was no uncertainty about the Federal's policy. The evidence here presented must be taken with some caution, but that there appear virtually no statements of disbelief, doom, or forthcoming failure of the peg can hardly be ignored.

What are we to conclude about the period? It seems reasonably clear that there is expectations-oriented behavior displayed. While adequate demand for short debt did exist, it was no more than adequate. There was considerable shifting in accordance with the expectations hypothesis. Clearly there were those willing to move out of a natural habitat to scrape
up the profits to be had. Undeniably the expectations hypothesis and its variants can explain a good deal of the behavior during the period — but not all of it. The Federal's supply changes appear to have been the deciding element concerning the shape of the yield curve. The implication is that even in the period of reasonable certainty about the future course of rates, there are some investors habitually bound enough to allow such a peg to work.

As we saw at the beginning of this chapter, the period is one in which there were massive supply changes brought about by the combined Treasury-Federal Reserve policy. The question we now face is whether we can separate the effect (if any) of these massive supply changes from the expectations elements.

We proceed in the next chapter to statistically examine the available data.
The purpose of this chapter is twofold: (1) to present the results of statistical tests carried out on wartime data; and (2) to provide an alternative test of the M&S model. We have chosen to use data from the war period specifically because if there are any supply effects, we would expect to find them here. Our approach is slightly different from M&S's approach in that we propose a slightly different hypothesis.

M&S fitted their model to postwar data and then appended various supply measures to see if these could explain what was unexplained by the lag term. The lag actually estimated was:

\[ R_t = \alpha + \beta_0 r_t + \sum_{i=1}^{m} \beta_i r_{t-1} + \eta_t, \]

where the notation is the same as in Chapter 3. With the additions of the supply terms the model became:

\[ R_t = \alpha + \beta_0 r_t + \sum_{i=1}^{m} \beta_i r_{t-1} + F_t + \eta_t. \]

In both trials of the model cited, the authors failed to find any strong, consistent evidence of supply effects. This lack of positive results is not surprising since as the authors themselves conclude in one of their papers, Operation Twist was really not tried. More to the point, there appears to be

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1 The reader is referred to M&S's test results reported in Chapter 3.

2 See discussion of M&S, Chapter 3.
a flaw in the structure of their model. Fitting the lag and then appending the supply variable as the only measure of supply effects assumes that the lag term and the supply effects are independent. This procedure assumes that all of the relevant effects of supply activity can be summed up in the several computed supply measures.

Rather than the lag term and supply effects being independent, we would expect the lag to be affected by supply activity. What significance investors attach to past rates should certainly be affected by any supply activity in progress. This suggests that we examine the lag structure for evidence of supply effects. This is not to say that the only effect of supply will be on the lag structure, but we would expect the general shape of the structure to be affected by major supply activity.

To test the above allegation we must first look closely at M&S's lag structure and then compare our results with theirs. M&S explained their lag structure by hypothesizing that the $S_1$ (extrapolative) lag falls faster and is shorter than the $M_1$ (regressive) lag. This produces a $b_1$ structure which rises to a single peak and then falls to zero. Figure 5.1 presents their $b_1$ structure in the upper panel and some possible $S_1$ and $M_1$ shapes in the lower panel. It must be emphasized that the shapes of the $S_1$ and $M_1$ structures are arbitrary. We have empirical evidence only on the difference between structures, and this difference is, of course, con-
Figure 5.1. Modigliani and Sutch lag structure
sistent with a number of alternatives. The only a priori specification we can comfortably make is that the weights will decline into the past. But the rate of descent and exact shape of either lag cannot be determined from the available evidence.

The author duplicated M&S's results as a procedural check before fitting the model to wartime data. The wartime data subsequently examined includes observations from the first quarter of 1941 through the first quarter of 1951. The short rate, $r_t$, used is the market yield in per cent per annum converted to a bond yield equivalent. The long rate, $R_t$, is the average per cent per annum yield of Treasury bonds due or callable in over 15 years.

In general, the lag structure fits the data well. Lags of between 5 and 20 quarters in length were fitted to the 40 observations. Lags between 5 and 10 quarters were generally unsatisfactory. The structures made no sense and the statistical fits were weak; the Almon variables were not significant, nor were the F values, and the correlation coefficients remained below .60. Lags between 13 and 20 quarters produced significantly better results; 3 and sometimes 4 Almon variables were significant, all F values were significant, and the correlation coefficients ranged from .87 to .94. The best results, which consistently emerged at 18 quarters are presented, along with the lag structure, in Figure 5.2.
Figure 5.2. Wartime lag structure

\[ R_t = 1.859 + 0.110 R_t + \sum_{i=1}^{18} \beta_i R_{t-i} \]

*standard error of the coefficient

\[ R^2 \text{ (correlation coefficient)} = 0.941 \]

\[ S_e \text{ (standard error of estimate)} = 0.038 \]

\[ DW \text{ (Durbin-Watson statistic)} = 2.14 \]

\[ t \text{ values for Almon variables} = 3.34, -2.98, 4.82, 2.94 \]

Lag coefficients and their standard errors:

\[ \begin{array}{ccccccccc}
0.184 & 0.098 & 0.019 & -0.046 & -0.091 & -0.115 & -0.117 \\
(0.069) & (0.029) & (0.028) & (0.028) & (0.025) & (0.024) & (0.039) \\
-0.097 & -0.058 & -0.003 & 0.062 & 0.130 & 0.192 & 0.239 \\
(0.037) & (0.031) & (0.023) & (0.028) & (0.027) & (0.050) & (0.073) \\
0.257 & 0.233 & 0.153 & 0.0 \\
(0.037) & (0.086) & (0.061)
\end{array} \]
On examination of Figure 5.2 we find, as expected, a significantly different lag structure than exists postwar. Plotted below the lag are arbitrary choices for the $\mathcal{E}_1$ and $\mathcal{M}_1$ structures. These $\mathcal{E}_1$ and $\mathcal{M}_1$ structures are arbitrary only in the sense that they are not the only structures which are consistent with the fitted lag. However, other structures consistent with the fitted lag must have roughly the same form; the major source of difference would be the level of the structures.

We observe that the $\mathcal{E}_1$ (extrapolative) structure now not only declines more slowly than the $\mathcal{M}_1$ (regressive) structure, but actually overcomes it for 8 periods so that the difference between them becomes negative before resuming a "normal" relationship. Note also that the $\mathcal{E}_1$ structure is extended from 9 to 15 periods. This structure is one structure we would expect if there were an interaction between the lag structure and supply operations. One explanation of this structure is that the Federal Reserve-Treasury policy of support to the bond market made investors much more sensitive to the recent past and less sensitive to any long run "normal" rate. This is consistent with a strong expectation that rates would continue doing what they had recently been doing; thus, while the $\mathcal{E}_1$ structure is still shorter than the $\mathcal{M}_1$ structure, it is given a much greater weight in determining current rates than in the postwar period.

In order to fully examine the period and the model in
question, a number of additional tests were carried out. M&S, in both papers cited, fitted only a fourth degree polynomial for the lag structure. On the suspicion that a fourth degree polynomial might somehow bind the lag structure to a particular shape, a third degree polynomial was also fitted. The results are presented and the lag plotted in Figure 5.3. These results reveal a different emphasis, but the characteristic shape — where the lag structure becomes negative, then rises to a single peak and falls back to zero — still emerges as it will in all of the tests.

As was the case with the fourth degree polynomial, the lags between 5 and 10 quarters produced rather poor results with the best results still at 18 quarters. The structures around 18 quarters all have similar shapes, but the results deteriorate on either side of 18 quarters. Thus while the third degree polynomial reveals different emphasis, the model doesn't appear to be completely bound to a particular polynomial.

M&S, in one paper, tried another test which is tried by the current author. Recall that M&S substituted for their original long rate (the Treasury average of yields on bonds due or callable after 10 years) several long rates of specific maturity. The justification for this was that averaging may have obscured the true supply effects. Any supply effects may have been swamped by the movement of other rates in the average. For this reason M&S obtained specific maturity data
Figure 5.3. Wartime lag structure on third degree polynomial

\[ R_t = 1.957 + 0.112 r_t + \sum_{i=1}^{18} B_i r_{t-i} \]

\[ R^2 = 0.870 \quad s_e = 0.049 \quad DW = 1.32 \]

Lag coefficients and their standard errors:

\[
\begin{array}{ccccccc}
2.463 & 1.823 & 1.297 & 0.872 & 0.540 & 0.290 \\
(1.013) & (0.766) & (0.562) & (0.395) & (0.263) & (0.162) \\
0.112 & -0.004 & -0.086 & -0.091 & -0.083 & -0.053 \\
(0.089) & (0.039) & (0.015) & (0.017) & (0.018) & (0.013) \\
-0.013 & -0.029 & 0.061 & 0.073 & 0.057 & 0.0 \\
(0.009) & (0.016) & (0.024) & (0.027) & (0.020) & \\
\end{array}
\]
Lag in quarters
from the Morgan Guarantee Trust. The data obtained were monthly averages of daily observations on rates for the specific maturities 2, 4, 8, and 12 years. The model was fitted with these maturity rates as long rates, and the results were nearly as good as the previous ones.

This writer obtained data from the same source but for the war period 1941-I through 1951-I. Rates for maturities of 2, 3, 5, 8, and 15 years were used as the dependent variable, and the results, with one exception, are not significantly different from those obtained with the original dependent variable. The exception is $R_2$ where the results were altogether insignificant. M&S find this same result, though not so dramatically, and argue:

"This finding is not surprising in light of our model. It is reasonable to suppose, in fact, that expectations about the course of interest rates in the near future should reflect a good deal more information than is provided by the past history of rates appearing in the weighted average. On the other hand, when it comes to the more distant future, the past may still tend to be regarded as providing the most useful guide. Since the influence of yearly expectations dominates the shorter rates and becomes less and less important as we move to longer rates, it is understandable that the weighted average term should prove more useful in explaining the behavior of long-term rates than of short-term ones." (60, p. 584)

The wartime period results improve and gain significance in the 3, 5, 8, and 15 year maturities. As before, the 18 quarter lag turns out consistently to have the most sensible lag structure and the most significant variables. Figures 5.4, 5.5, 5.6, and 5.7 present the results for $R_3$, $R_5$, $R_8$, 
Figure 5.4. R₃ Morgan data lag structure

\[ R₃ = 0.438 + 0.199rₜ + \sum_{t=1}^{18} \beta_{1_t} r_{t-1} \]

\( R^2 = 0.913 \quad DW = 1.47 \quad s_e = 0.084 \)

t values for Almon variables = 1.81, 1.88, 4.16, 2.09

Lag coefficients and their standard errors:

\[
\begin{array}{cccccccc}
0.036 & 0.199 & 0.487 & 0.575 & 0.529 & 0.406 \\
(.387) & (.181) & (.111) & (.152) & (.159) & (.135) \\
0.250 & 0.099 & -0.021 & -0.092 & -0.106 & -0.067 \\
(.094) & (.055) & (.038) & (.048) & (.053) & (.045) \\
0.016 & 0.121 & 0.217 & 0.263 & 0.211 & 0.0 \\
(.026) & (.026) & (.042) & (.070) & (.059) &
\end{array}
\]
Lag in quarters
Figure 5.5. $R_5$ Morgan data lag structure

$$R_5 = -0.721 + 0.128 r_t + \sum_{i=1}^{18} \beta_i r_{t-i}$$

$$R^2 = 0.89 \quad DW = 1.52 \quad Se = 0.090$$

t values for Almon variables = 2.34, 1.91, 3.89, 1.86

Lag coefficients and their standard errors:

0.058 .129 .510 .647 .618 .488 (.415) (.162) (.119) (.163) (.170) (.144)

-0.313 .137 -.008 -.099 -.127 -.092 (.101) (.058) (.041) (.001) (.007) (.048)

-.006 .108 .217 .275 .225 0.0 (.028) (.028) (.056) (.075) (.063)
Lag in quarters
Figure 5.6. Rg Morgan data lag structure

\[ R_g = 1.057 + 0.093 r_t + \sum_{i=1}^{18} \beta_i r_{t-i} \]
\[ (.169) \]

\[ R^2 = .89 \quad DW = 1.50 \quad S_e = .095 \]

t values for Almon variables = 2.65, 1.94, 3.33, 1.80

Lag coefficients and their standard errors:

\[ .064 \quad .094 \quad .503 \quad .659 \quad .641 \quad .517 \]
\[ (.437) \quad (.170) \quad (.126) \quad (.172) \quad (.179) \quad (.152) \]

\[ .343 \quad .163 \quad .012 \quad -.087 \quad -.125 \quad -.098 \]
\[ (.106) \quad (.062) \quad (.043) \quad (.054) \quad (.060) \quad (.051) \]

\[ -.020 \quad .089 \quad .185 \quad .255 \quad .212 \quad 0.0 \]
\[ (.029) \quad (.029) \quad (.059) \quad (.079) \quad (.067) \]
Lag in quarters
Figure 5.7. $R_{15}$ Morgan data lag structure

$$R_{15} = 1.512 + .079 r_t + \sum_{i=1}^{18} \beta_i r_{t-i}$$

(.137)

$R^2 = .90$  $DW = 1.60$  $S_e = .077$

t values for Almon variables = 3.00, 1.88, 2.90, 1.86

Lag coefficients and their standard errors:

\[
\begin{align*}
.051 & \quad .080 & \quad .406 & \quad .534 & \quad .524 & \quad .428 \\
.353 & \quad .138 & \quad .102 & \quad .139 & \quad .145 & \quad .123 \\
.292 & \quad .149 & \quad .027 & \quad -.056 & \quad -.091 & \quad -.077 \\
.086 & \quad .050 & \quad .035 & \quad .043 & \quad .049 & \quad .041 \\
-.022 & \quad .058 & \quad .138 & \quad .184 & \quad .155 & \quad 0.0 \\
.024 & \quad .023 & \quad .048 & \quad .064 & \quad .054 & \quad .054
\end{align*}
\]
Lag in quarters
and $R_{15}$ respectively. The one feature to be noted about the Morgan data is that it uncovers a different relationship in the early periods of the lag. The lag relationship now takes the "normal" rising form for the first 4 quarters, but then the shape characteristic of the entire war period again appears. Interestingly, M&S find the Morgan data gives them slightly different lag shapes in the early quarters also, but in all cases, a characteristic shape returns to dominate the structure.

Another test was conducted to ensure that the war period results were not determined or limited by the form of the data. The Morgan data were taken from an arbitrarily smoothed yield curve which raises the suspicion that Buse's criticism (17) might be applicable. The model was fitted to three different Buse-style random orderings and the results vanished. None of the Almon variables was significant, and the highest $F$ value obtained was 2.3.

It seems reasonably clear that the lag structures presented so far are consistent with the data from the war period. Putting it another way, our evidence suggests that supply operations affects expectations; monetary policy carried out by supply changes in the market could be the reason for the shape of the observed lag structures.¹ These results com-

¹See Wood (109) and Luckett (46) for evidence of how expectations i.e. the weights, are formed. Also Allen Soltow has preliminary results along Luckett's lines indicating a supply-expectations connection.
pare favorably with M&S's results. In the following we will see what other effects can be uncovered by applying supply terms directly to the lag structure.

II

Supply variables, both those used by M&S and some other variables to be mentioned shortly, were added and the original model was re-estimated. The supply variables, Proportion of Short, Intermediate I, Intermediate II, and Long, as defined in Chapter 3 were computed for the war period. When these variables were fitted with the lag structure, they produced the results shown in Table 5.1. For all presented,

Table 5.1. Modigliani and Sutch supply variable results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient and Standard error</th>
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</thead>
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<tr>
<td>Proportion of Short</td>
<td>-1.307 (0.528)*</td>
</tr>
<tr>
<td>Intermediate I</td>
<td>2.250 (0.713)*</td>
</tr>
<tr>
<td>Intermediate II</td>
<td>-0.744 (1.534)</td>
</tr>
<tr>
<td>Long</td>
<td>-0.234 (1.073)</td>
</tr>
</tbody>
</table>

*The coefficient is more than twice its standard error.
the Almon variables remained significant, the correlation coefficients remained above .90, the DW's remained over 1.70, and the lag structures maintained their previous shape.

The coefficients, signs, and standard errors are typical of those obtained when these variables were fit with lags between 14 and 21 quarters long. However, Proportion of Short, and possibly Intermediate I are the only variables with the correct sign. Since increases in the Proportion of Short debt should raise the short rate and reduce the rate spread, a negative sign for this variable is what we would expect. In this case, a one per cent increase in Proportion of Short decreases the rate spread by 1.3 basis points. This result supports the hypothesis that the rate structure is significantly sensitive to debt maturity for open market operations to be effective in altering the rate pattern.

Intermediate I has the proper sign only if we are prepared to argue that increases in the proportion of debt in any category except short should increase the spread between short-term and long-term rates. Otherwise, since Intermediate I is nearer the short-term end than the long, we would expect a negative sign. If we do argue that Intermediate I's sign should be positive, then that same argument must apply even more strongly to Intermediate II and Long since they are closer to the long-term end of the market. This hypothesis makes Intermediate II and Long coefficients have the wrong sign while being insignificant as well. First differences of
all four variables were fitted but produced even poorer results than the variable level, consequently the first difference results are not reported.

The author computed a second set of supply variables from debt information published in the U.S. Treasury Bulletins 1941-1951 (98). A quarterly series of the per cent of the Federal's portfolio held in Under 1, 1-5, 5-10, 10-15, and 15-20 years maturity as a ratio to the per cent of Public Marketable debt in these maturity categories was computed to substitute for the previous supply variables. While the new variables have the objectionable feature of fixed boundaries discussed in Chapter 3, it was thought they would provide a summary measure of the Federal Reserve's policy. These variables were estimated with the lag structure and the results are summarized in Table 5.2. With these additions the lag structure remained the same general shape, and the DW's, the correlation coefficients, and the standard errors stayed in the same range as before. These supply variables produce significant coefficients only in the 5-10 and 10-15 year maturity ranges, and again there are sign problems. We would expect the shorter debt variables to have positive signs: an increase in the Federal's holding of debt in a short-term category relative to the total debt in the category should lower short-term rates and increase the rate spread.

The sign which the 5-10 year maturity category should have is not clear. Changes in intermediate debt could either
Table 5.2. Federal Reserve supply variable results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient and Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 1</td>
<td>-0.053 (.030)</td>
</tr>
<tr>
<td>1-5</td>
<td>0.027 (.057)</td>
</tr>
<tr>
<td>5-10</td>
<td>-0.431 (.117)*</td>
</tr>
<tr>
<td>10-15</td>
<td>0.646 (.205)*</td>
</tr>
<tr>
<td>15-20</td>
<td>0.102 (.201)</td>
</tr>
</tbody>
</table>

*The coefficient is more than twice its standard error.

Increase or decrease the rate spread, but whichever it does, the same effect should be exhibited by the category just below or above it. If the negative sign is proper — that is, if 5-10 acts like long-term debt — then 10-15 and 15-20 should also have negative signs which they do not. If the negative sign for 5-10 is not proper, then the positive sign for 10-15 may be proper; both 5-10 and 10-15 may act like short debt. Even so, this does not help the lack of significance or the unambiguously wrong signs gotten for Under 1 and 15-20. First differences of these variables were also fitted and they produced results equally as weak as did the original variables' first differences.
The results of these direct supply effects tests are roughly the same as those of M&S. We have found a significant variable with the proper sign in Proportion of Short, but the remainder of the tests produced spotty significance and erratic signs as did M&S's tests. The strongest evidence of supply effects is still in the shape of the lag structure.

To apply supply variables to the Morgan data requires a new rationale. M&S argue that each Morgan long-term rate ($R_2$, $R_3$, $R_5$, $R_8$, $R_{15}$) should be most affected by supply activity in its particular range. The spread between any $R_i$ and the short rate should then be most sensitive to debt maturity changes in the $i$ year category and the short category. Thus to each of $R_3$, $R_5$, $R_8$, and $R_{15}$ for the war period was fitted the lag term and the ratio of Proportion of Short to Intermediate I, Intermediate II, or Long. The results are presented in Table 5.3. The addition of these variables changed significantly none of the lag structures, correlation coefficients, DW's, or Almon variables. The debt variables themselves, however, show the strongest results yet. All signs here are expected to be negative: a comparative rise in the Proportion of Short should raise the short rate and reduce the rate spread. The short-term coefficients have the proper sign and $t$ values around 3.00 while the remaining variables have the proper sign, but lack statistical significance.

---

1Note that these ratio variables are the reciprocal of those fitted by M&S.
Table 5.3. Ratio of supply variable results

<table>
<thead>
<tr>
<th>Maturity</th>
<th>Variable</th>
<th>Coefficient and Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 years</td>
<td>Proportion of Short Intermediate I</td>
<td>-.240 (0.066)*a</td>
</tr>
<tr>
<td>5 years</td>
<td>Proportion of Short Intermediate I</td>
<td>-.257 (0.071)*</td>
</tr>
<tr>
<td>5 years</td>
<td>Proportion of Short Intermediate II</td>
<td>-.108 (0.930)</td>
</tr>
<tr>
<td>8 years</td>
<td>Proportion of Short Intermediate II</td>
<td>-.132 (0.958)</td>
</tr>
<tr>
<td>15 years</td>
<td>Proportion of Short Long</td>
<td>-.169 (0.185)</td>
</tr>
</tbody>
</table>

*The coefficient is more than twice its standard error.

...cance. For the short-term variables, a 5 per cent rise produces just over a 1 basis point reduction in the rate spread. This is a small reaction, but supports the hypothesis that supply variations can affect the rate pattern.

III

In order to determine the effect of the entire debt structure on the rate spread, a set of orthogonal contrasts was fitted for each group of supply variables. For both the M&S supply variables and the Federal Reserve supply variables

1Two polynomials, \( a_1X + a_2X^2 \ldots \) and \( b_1X + b_2X^2 \ldots \), are said to be orthogonal if, for a specified values of \( X \), 
\[
\sum_{i=1}^{n} \sum_{j=1}^{n} a_i b_j = 0 \quad i \neq j
\]
a set of orthogonal polynomials reduced the effects to three: linear, quadratic, and cubic.

When fitted to the original model (using the Treasury’s average long rate) the orthogonal contrasts of Federal Reserve variables generally showed up rather poorly. The linear term was significant in one place (14 quarters lag) but elsewhere no orthogonal term could muster a significant value. The orthogonal contrasts of M&S variables produced only marginally better results. The quadratic term was nearly significant with t values consistently around 1.80, but never showed clear significance. The best fit was again 18 quarters lag and the results are presented together with the lag structure in Figure 5.8. Notice that the orthogonal variables tend to uncover in the original lag the same effects found in the early quarters of the lag on Morgan data. The structure rises for four quarters before exhibiting the shape characteristic of the war period. This effect in the original lag has been produced by none of the other variables. A possible explanation is that the orthogonal variables offset the Treasury averaging technique.

The Morgan data was subjected to the same M&S and Federal Reserve variable orthogonal contrasts, and the results were significantly better. In Figures 5.9, 5.10, 5.11, and 5.12 are presented the results for M&S variable orthogonal contrasts for R, R5, R8, and R15. R2 was dropped because of consistently poor results and Federal Reserve variable orthog-
Figure 5.8. Lag structure for Modigliani and Sutch variable

$R_t = 1.991 + .081 r_t + \sum_{i=1}^{18} \beta_i r_{t-i} + .037 L$

\[-.753 Q + .133 C\]

$L = \text{linear effect} \quad Q = \text{quadratic effect} \quad C = \text{cubic effect}$

$t$ values for Almon variables = 2.22, -2.24, 4.22, 2.40

Lag coefficients and their standard errors:

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>.018</td>
<td>(.007)</td>
</tr>
<tr>
<td>.082</td>
<td>(.113)</td>
</tr>
<tr>
<td>1.141</td>
<td>(.492)</td>
</tr>
<tr>
<td>1.532</td>
<td>(.660)</td>
</tr>
<tr>
<td>1.437</td>
<td>(.641)</td>
</tr>
<tr>
<td>1.064</td>
<td>(.508)</td>
</tr>
<tr>
<td>-.557</td>
<td>(.336)</td>
</tr>
<tr>
<td>.037</td>
<td>(.222)</td>
</tr>
<tr>
<td>-.402</td>
<td>(.264)</td>
</tr>
<tr>
<td>-.698</td>
<td>(.358)</td>
</tr>
<tr>
<td>-.817</td>
<td>(.412)</td>
</tr>
<tr>
<td>-.754</td>
<td>(.407)</td>
</tr>
<tr>
<td>-.533</td>
<td>(.348)</td>
</tr>
<tr>
<td>-.209</td>
<td>(.261)</td>
</tr>
<tr>
<td>.134</td>
<td>(.196)</td>
</tr>
<tr>
<td>.383</td>
<td>(.182)</td>
</tr>
<tr>
<td>.375</td>
<td>(.152)</td>
</tr>
<tr>
<td>0.0</td>
<td></td>
</tr>
</tbody>
</table>
Lag in quarters
Figure 5.9. \( R_3 \) Modigliani and Sutch variable orthogonal contrasts

\[
R_3 = .254 + .042 r_t + \sum_{i=1}^{18} B_i R_{t-i} - .040 L^i - .830 Q + .474 C
\]

\( (.015) (.177) (.348) (.638) (.307) \)

\( R^2 = .959 \quad S_e = .066 \quad DW = 2.70 \)

t values for Almon variables = 2.35, -2.41, 6.18, 3.84

Lag coefficients and their standard errors:

\[
.025 \quad .043 \quad 1.41 \quad 1.89 \quad 1.76 \quad 1.26
\]

\( (.012) (.178) (.772) (1.36) (1.006)(.799) \)

\[
.615 \quad .041 \quad .574 \quad .903 \quad .988 \quad .830
\]

\( (.527) (.348) (.415) (.568) (.647) (.639) \)

\[
- .472 \quad .004 \quad .474 \quad .774 \quad .698 \quad 0.0
\]

\( (.546) (.410) (.307) (.287) (.239) \)
Lag in quarters
Figure 5.10. Modigliani and Sutch variable orthogonal contrasts

\[ R_5 = 0.683 + 0.022t + \sum_{i=1}^{18} \beta_i t_{-1} - 0.127L \]
\[ - 1.36q + 0.358c \]
\[ R^2 = 0.952 \quad S_e = 0.069 \quad DW = 2.70 \]

\textbf{t values for Almon variables = 2.82, -3.10, 5.92, 3.62}

\textbf{Lag coefficients and their standard errors:}

\begin{align*}
0.003 & \quad 0.022 & \quad 1.89 & \quad 2.55 & \quad 2.38 & \quad 1.70 \\
(0.001) & \quad (0.187) & \quad (0.811) & \quad (1.08) & \quad (1.05) & \quad (0.839) \\
0.791 & \quad -0.127 & \quad -0.888 & \quad -1.378 & \quad -1.540 & \quad -1.370 \\
(0.554) & \quad (0.366) & \quad (0.436) & \quad (0.590) & \quad (0.680) & \quad (0.671) \\
-0.918 & \quad -0.289 & \quad 0.358 & \quad 0.809 & \quad 0.797 & \quad 0.0 \\
(0.373) & \quad (0.431) & \quad (0.323) & \quad (0.301) & \quad (0.251) & \quad (0.251)
\end{align*}
Lag in quarters
Figure 5.11. \( R_8 \) Modigliani and Sutch variable orthogonal contrasts

\[
R_8 = 1.13 + 0.033t + \sum_{i=1}^{18} \beta_i t - 1 - 0.163L
\]

\[
- 1.75Q + 0.2500
\]

\[ R^2 = 0.954 \quad S_e = 0.071 \quad DW = 2.51 \]

t values for Almon variables = 3.17, -3.28, 5.37, 3.14

Lag coefficients and their standard errors:

\[
0.004 \quad 0.033 \quad 2.26 \quad 3.05 \quad 2.84 \quad 2.03
\]

\[
(0.001) \quad (0.191) \quad (0.828) \quad (1.11) \quad (1.07) \quad (0.856)
\]

\[
0.945 \quad -0.164 \quad -1.092 \quad -1.704 \quad -1.929 \quad -1.758
\]

\[
(0.565) \quad (0.373) \quad (0.444) \quad (0.062) \quad (0.694) \quad (0.685)
\]

\[
-1.248 \quad -0.517 \quad 0.251 \quad 0.810 \quad 0.750 \quad 0.0
\]

\[
(0.585) \quad (0.439) \quad (0.329) \quad (0.307) \quad (0.256)
\]
Lag in quarters
Figure 5.12. $R_{15}$ Modigliani and Sutch variable orthogonal contrasts

$$R_{15} = 1.56 - .003t + \sum_{i=1}^{18} \beta_i t_{i-1} - .309 L$$

$$- 1.43Q + .267C$$

$R^2 = .959 \quad S_e = .056 \quad DW = 2.60$

t values for Almon variables = 3.37, -3.29, 4.87, 2.96

Lag coefficients and their standard errors:

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>Standard Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>.003</td>
<td>(.001)</td>
</tr>
<tr>
<td>.004</td>
<td>(.151)</td>
</tr>
<tr>
<td>1.711</td>
<td>(.657)</td>
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<tr>
<td>2.290</td>
<td>(.881)</td>
</tr>
<tr>
<td>2.093</td>
<td>(.856)</td>
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<tr>
<td>1.430</td>
<td>(.679)</td>
</tr>
<tr>
<td>-.560</td>
<td>(.448)</td>
</tr>
<tr>
<td>-.310</td>
<td>(.296)</td>
</tr>
<tr>
<td>-1.024</td>
<td>(.553)</td>
</tr>
<tr>
<td>-1.476</td>
<td>(.478)</td>
</tr>
<tr>
<td>-1.613</td>
<td>(.550)</td>
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<tr>
<td>-1.434</td>
<td>(.543)</td>
</tr>
<tr>
<td>-.985</td>
<td>(.464)</td>
</tr>
<tr>
<td>-.368</td>
<td>(.349)</td>
</tr>
<tr>
<td>.268</td>
<td>(.261)</td>
</tr>
<tr>
<td>.718</td>
<td>(.244)</td>
</tr>
<tr>
<td>.710</td>
<td>(.203)</td>
</tr>
<tr>
<td>0.0</td>
<td></td>
</tr>
</tbody>
</table>
Lag in quarters
onal contrasts fitted to Morgan data are not reported as the results were not statistically significant. Notice that for \( R_5, R_8, \) and \( R_{15} \) the quadratic term is statistically significant. A simple linear relationship is insufficient to describe the connection between the rate spread and supply variables.

These tests are not particularly encouraging as far as direct effects are concerned. The Federal Reserve variables generally produce weak results. The M&S variables, especially when used on Morgan data, produce significantly better results. The strongest direct effects appear for the Morgan data in combination with the ratios fitted as reported in Table 5.3. Significant results are also obtained for the quadratic term when the orthogonal contrasts are fitted to the Morgan data. These results are spotty and inconclusive at best, but do indicate that some direct affects exist.

These results are summarized and a few concluding observations are made in the final chapter.
CONCLUSIONS

We have, at this point, carried out the purposes of this dissertation. In Chapter 1 the literature was reviewed, in Chapter 2 we examined the effects of a horizon on market behavior. After having concluded that both play a role in determining the term structure of interest rates, the supply effects, which are enhanced by the effect of the horizon, were separated from the expectations elements. This was done by adopting the Modigliani and Sutch model.

While the results are not perfect, two reasonably strong conclusions can be drawn: (1) the distributed lag model we have used is indeed effective in explaining interest rate behavior. Both independent tests of the model lead to this conclusion. (2) Supply effects are clearly in evidence in the war period data, and they appear in two forms. The direct supply effects exist, but as both this study and K&S find, they are erratic at best. The strongest supply effects appear in the lag term. Indeed it appears that one of the reasons the Fed's wartime bond market support succeeded was its ability to influence expectations. This conclusion points out the need for further study on the effects of policy on expectations.

At the outset of this work we questioned whether anything could be done about the shape of the yield curve. We
questioned whether the two ends of the market were rigidly linked together or whether they could be treated as separate segments. We also had questions about the tools which should be used in the bond market. The primary emphasis of this paper has not been on developing policy prescriptions, but a few observations seem to be in order.

Our evidence indicates that supply operations can affect the structure of rates as well as the level. This being the case, it is then not a matter of indifference in what maturities open market operations are carried out. While much of supply operations appears to affect the entire yield curve, there also appears to be an underlying maturity preference structure which makes open market operations effective in shaping the yield curve. These conclusions arise from our examination of wartime data where it was found that large supply changes could bring about the desired yield curve.

We have perhaps thrown some light on the mechanism by which policy activity affects the targets at which it aims. But the evidence we have exposed is not yet ready for policy prescriptions; much remains to be done. Most of the evidence of supply effects found were found because we went searching for them. To find supply effects we had to go to an exceptional period in history. Whether the reaction exhibited to wartime policy could be induced in modern times must remain a moot question until such time as the Federal Reserve again undertakes a concerted effort to regulate the market. If,
when undertaken, the effort is to be effective, our evidence leads us to conclude it must be a sizeable effort. But at least the evidence that intervention could be effective, with perhaps less emphasis on direct controls and more on affecting the expectations mechanism, seems to be relevant information for policy makers.


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