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THE CUMULATIVE UNANTICIPATED CHANGE IN INTEREST RATES: EVIDENCE ON THE MISINTERMEDIATION HYPOTHESIS

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ABSTRACT

THE CUMULATIVE UNANTICIPATED CHANGE IN INTEREST RATES:
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The term structure of interest rates is carefully analyzed over the period 1947-77 in order to construct a monthly series on cumulative unanticipated changes in long-term interest rates. This series is a sort of synthetic interest rate, changes in which over several months or years represent entirely unanticipated changes in interest rates. The behavior of this series is examined over recognized business fluctuations, and it is found to be actually more reliably pro-cyclic than the raw long-term interest rate, in spite of Kessel's finding that the market tends to correctly predict the direction of change of interest rates over phases. That the series is pro-cyclic supports the hypothesis we have put forward in another paper, that business fluctuations may be caused by "misintermediation", by which we mean the traditional mismatching of asset and liability maturities on the part of financial intermediaries.

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THE CUMULATIVE UNANTICIPATED CHANGE IN INTEREST RATES: EVIDENCE ON THE MISINTERMEDIATION HYPOTHESIS

In an earlier paper (McCulloch 1977) we have argued that business fluctuations may arise as a consequence of the traditional mismatching of asset and liability maturities on the part of financial intermediaries. We call this mismatching "misintermediation."

Briefly, that argument runs as follows: In the Fisherian model of the determination of the term structure of interest rates, planned supply of aggregate output of consumption goods is assumed somehow to match planned demand for these goods point by point throughout the future.[1] As the economy moves forward in time, expectations regarding future interest rates, as reflected in the original term structure's implicit forward interest rates, will, barring unforeseen technological developments or "dynamic inconsistency" in tastes, be perfectly realized. Furthermore, all supply and demand plans will be perfectly realized, and the economy will develop without aggregate excess demand or aggregate excess supply of current output ever appearing. The economy's growth rate will be relatively steady, and any residual fluctuations in it will have been fully anticipated.

However, we actually live in a world of institutionalized misintermediation. For centuries banking has been a highly regulated industry, and this regulation has kept it in its traditional mold of borrowing short and lending long, in spite of the the risks that that practice entails. This misintermediation breaks the link between current plans for future demand and current plans for future supply, a link that would exist to a much greater extent in the world of balanced

[1] For a modern restatement of this model, see Hirshleifer (1970), 109-113.

intermediation. Although the present discounted value of planned future demand must equal the present discounted value of planned future supply, there is no reason why planned supply will equal demand point by point throughout the future. As the economy moves forward in time, planned supply of current output will not necessarily match planned demand. In the event of a recession (an excess supply of current output in terms of prior plans), an unanticipated fall in interest rates will be necessary to clear the market for current output. In the event of a planned excess demand (a disequilibrious boom), an unanticipated rise in interest rates will be necessary.[1]

It is well known that interest rates are pro-cyclic. In fact, the NBER uses the peaks and troughs in various interest rate series to help date the standard reference cycles.[2] If the yield curve were always flat, or at least had no systematic change in shape over business cycles, it would at once follow that the unanticipated changes in interest rates are in accord with the predictions of the misintermediation hypothesis.

However, Reuben Kessel (whose untimely death in 1975 was a great loss to the profession) demonstrated, in his classic work on The Cyclical Behavior of the Term Structure of Interest Rates, that at cyclic troughs the yield curve tends to be unusually upward sloping, so that immediately prior to an expansion, the market is expecting interest rates to rise. Furthermore,

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[1]Cagan (1969) investigates the relationship between interest rates and business cycles. We, in contrast, argue that it is not so much the level of interest rates that is important, but rather whether the current level was arrived at by unanticipated changes.

[2]Burns and Mitchell (1947).

at peaks, the yield curve is often "humped", reflecting a small liquidity premium at the short end together with anticipations of a fall in interest rates over the coming contraction (1965, 59-95). The casual evidence is therefore ambiguous. The market may be correctly anticipating the cyclical changes in interest rates, underanticipating these changes, or even over-anticipating them.

The purpose of this paper is to determine how unanticipated changes in interest rates really behave over the business cycle. We do this by carefully analyzing the term structure of interest rates, and constructing a monthly series on cumulative unanticipated changes in interest rates. This series is a sort of synthetic interest rate, changes in which over several months or years reflect entirely unanticipated changes in interest rates. We then examine how this series behaves over recognized business cycles, to see whether changes in it are in conformity with the misintermediation hypothesis.[1]

DEFINITIONS

For the specific purpose of investigating the misintermediation hypothesis, the present author has developed a technique of curve-fitting the term structure of interest rates from security prices, so as to determine implicit forward interest rates as precisely as possible. This technique is described in detail in two previous papers (McCulloch 1971, 1975b). Briefly stated, for each point t in time for which we have security price

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[1] If business fluctuations have any predictable regularity, their being associated systematically with certain unanticipated changes in interest rates violates the assumptions of rational expectations. However, in an earlier paper (McCulloch 1975c), we have presented evidence that business "cycles" have no such regularity. See also Anderson (1977), and Savin (1977).

data, we estimate a "discount function" $\delta(t, m)$ which gives the value at time t of a promise to repay one dollar at future date s, where

$$s = t + m \tag{1}$$

This function is constrained to obey

$$\delta(t, 0) = 1. \tag{2}$$

We would expect to find

$$\delta(t, m) > 0 \tag{3}$$

and

$$D_2\delta(t, m) < 0, \tag{4}$$

and in fact the empirical discount functions we estimated for this study all obey (3) and (4) without imposing them as constraints. This curve is roughly an exponential decay curve with respect to m, except that its rate of exponential decay need not be constant. Its average rate of decay is the <u>single payment yield</u> $\eta(t, m)$:

$$\eta(t, m) = -\frac{100}{m}\log\delta(t, m). \tag{5}$$

Its instantaneous rate of decay is the <u>instantaneous forward interest rate</u> $\rho(t, s)$:

$$\rho(t, s) = -\frac{100\,D_2\delta(t,s-t)}{\delta(t,s-t)} \tag{6}$$

We define this rate in terms of the future date s, rather than the term to maturity m, in order to emphasize the importance of comparing the movement over time of the forward rate for a <u>given date</u> in the future. This instantaneous forward rate corresponds to a hypothetical forward contract for a loan one instant in duration, so its value for any one s is not of any great macroeconomic significance. More important is the mean forward interest rate $r(t, s_1, s_2)$ on a loan to begin at future date s_1 and to end at future date s_2, defined by

$$r(t, s_1, s_2) = \frac{100 \log \left(\dfrac{\delta(t, s_1 - t)}{\delta(t, s_2 - t)}\right)}{s_2 - s_1} \qquad (7)$$

Mean forward interest rates are no problem to calculate, but they provide us with an unmanageable wealth of data, since we may pick any s_1 and s_2 obeying

$$t \leq s_1 < s_2 \leq s_{max}(t) \qquad (8)$$

where $s_{max}(t)$ is the maturity date of the longest term bond observed in the market at time t. This embarrassment of riches is somewhat alleviated by concentrating on the instantaneous forward rate instead, since because of the identity

$$r(t, s_1, s_2) = \frac{1}{s_2 - s_1} \int_{s_1}^{s_2} \rho(t, s)ds, \qquad (9)$$

it can be used as a two-dimensional summary of the three dimensional jumble of mean forward rates. Still, as t changes, $\rho(t, s)$ may go up for some values of s at the same time it goes down for other values of s. We want some sort of average of these forward rate movements for all maturities. With observations on the term structure Δt years apart, we could consider

$$s^*(t) = \min\left(s_{max}(t), s_{max}(t + \Delta t)\right), \qquad (10)$$

and compute the amounts $\Delta_\eta(t)$ by which the forward rate on a loan to begin at $t + \Delta t$ and to end at $s^*(t)$ is exceeded by the subsequently observed corresponding spot rate:

$$\Delta_\eta(t) = \eta\left(t + \Delta t, s^*(t)-t- \Delta t\right) - r\left(t, t + \Delta t, s^*(t)\right). \qquad (11)$$

Then the series

$$\eta^*(t) = \eta\left(t_0, s_{max}(t_0)-t_0\right) + \sum_{i=0}^{n-1} \Delta_\eta \, (t_0+i \, \Delta t), \; t = t_0 + n \, \Delta t \tag{12}$$

would behave like an interest rate, yet first differences in it would, after adjustment for a liquidity premium, reflect pure unanticipated changes in interest rates.

However, the series defined in (12) is not entirely satisfactory. In principle, with ideal data, we could estimate $\delta(t, m)$ and therefore $\rho(t, t+m)$ for arbitrarily large m, even several hundred years into the future.[1] The mean forward rate, because of its property (9), gives equal weights to $\rho(t, s)$ for all these maturities. We would prefer somehow to give greater weight to the immediate future, declining weight to the intermediate future, and little or no weight to the very distant future. Furthermore, in practice $\delta(t, m)$ can only be estimated with decreasing relative accuracy as m becomes very large. At some maturity, perhaps 60 to 80 years, any empirical estimate of it would be insignificantly different from zero, even though we believe that it is "really" still positive.[2] Beyond that point, mean forward rates defined by (7) lose all statistical significance.

Both these problems could be avoided by arbitrarily selecting a maturity, say 10 or 20 years, that one feels includes the most important forward rates. However, this procedure still gives equal weight to all included maturities. Furthermore, forward rates for the excluded maturities

[1]In the 1920's, there were railroad bonds outstanding with three, four, and even five hundred years to maturity.

[2]We have never actually used a data set with long enough maturities that this has happened, though in principle it should.

do affect to some degree the terms on which current output can be exchanged for aggregated future output. We would prefer not to disregard them altogether.

This problem can be solved by means of a new concept developed by Burman and White (1972), called the "par bond yield". It has long been well known that the notion of a "bond yield curve" is somewhat ambiguous, since unless the yield curve is flat, bonds with the same terminal maturity but different coupon rates should not in general have the same internal rate of return or "yield to maturity".[1] Even using the bond's "average duration" does not solve this problem. However, there is an unambiguous yield on bonds of maturity m that just happen to be selling at par. It does not equal the point payment yield, but is a well defined concept in its own right. It is now used by the Bank of England as the representative yield curve for coupon-bearing bonds, though it has not yet been officially adopted by the U.S. Treasury.

This par bond yield $y(t, m)$ can be computed straightforwardly from the discount function, using the fact that if a bond is selling exactly at par, its yield just equals its coupon rate. If we assume continuous coupons for the sake of simplicity, this coupon rate can be found by solving the equation[2]

$$y(t,m) \int_{o}^{m} \delta(t,\mu)d\mu + 100\ \delta(t,m) = 100 \tag{13}$$

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[1] See e.g. Buse (1970). Schaefer (1976) offers some new insights into this familiar problem.

[2] Cp. Burman and White (1972, 484), whose definition is in terms of a bond that pays semiannual coupons, and McCulloch (1975b, 822), where the definition is given in terms of an after-tax discount function.

for

$$y(t,m) = \frac{100[1-\delta(t,m)]}{\int_{o}^{m} \delta(t,\mu)d\mu} \quad . \tag{14}$$

The ideal properties of the par bond yield, from the point of view of the present study, arise from the following identity:

$$\begin{aligned} \int_{o}^{m} \rho(t,\ t+\mu)\ \delta(t,\ \mu)d\mu &= \int_{o}^{m} -\ 100D_2\delta(t,\ \mu)d\mu \\ &= -100[\delta(t,\ m)-\ \delta(t,0)] \\ &= \ 100[1-\ \delta(t,m)]\ . \end{aligned} \tag{15}$$

This identify implies that

$$y(t,m) = \frac{\int_{o}^{m} \rho(t,t+\mu)\ \delta(t,\ \mu)d\mu}{\int_{o}^{m} \delta(t,\ \mu)d\mu} \quad . \tag{16}$$

Equation (16) states that the yield on par bonds with terminal maturity m is a weighted average of the instantaneous forward rates for all maturities out to m, where the weights are the present value of a dollar at the maturity in question, and therefore serve as a good index of the importance of these rates for the current economy. The single payment yield to maturity $\eta(t,m)$ as defined in (5) does not necessarily approach an asymptotic value as m becomes large, since there is no telling what instantaneous forward rates will be in the very distant future, so long as they are positive. The par bond yield curve, on the other hand, must approach an asymptote, so long as perpetuities have finite prices.

Equation (16), incidentally, answers an objection that is sometimes raised against the hypothesis that long-term rates reflect averages of expected future short-term rates. Joan Robinson (1951, 102n.), for example, has protested that if this were true, anyone who buys a consol would have "to think he knows exactly what the rates of interest will be every day from now to Kingdom Come," which obviously no reasonable person does. However, he does not have to know these rates exactly in order to define the consol rate to any desired precision. In fact, for any given precision, his beliefs regarding these rates can dissolve into total ignorance beyond some finite horizon far short of Kingdom Come.[1]

The approach we adopt in this paper is to compute a forward par bond yield, and then compare it to the subsequently observed corresponding spot par bond yield one month later. These differences, adjusted for liquidity premium, are again pure unanticipated changes in interest rates. When we accumulate these forecasting errors, changes in the resulting one-dimensional series over business cycle phases will also represent unanticipated changes in interest rates.

Three maturities are relevant here: m_1, the distance into the future the implicit forward contract is to begin (which we will set equal to Δt), m_2, the duration of the forward contract, and m_3, the distance into the future of the completion date of the forward contract. We have $m_1 + m_2 = m_3$. The forward par bond yield $b(t, m_1, m_3)$ is then the coupon rate that will make the value of a forward bond, evaluated at time t's term structure, just equal to par, discounted to time t using time t's term structure. To find this rate, we solve

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[1]The obverse of this proposition is that when $\rho(m)$ is inferred from actual bond prices, it has an intrinsic tendency to become increasingly poorly defined as m becomes very large.

$$b(t,m_1, m_3) \int_{m_1}^{m_3} \delta(t,\mu)d\mu + 100\ \delta(t,m_3) = 100\ \delta(t, m_1) \tag{17}$$

to obtain

$$b(t, m_1, m_3) = \frac{100[\delta(t, m_1)-\delta(t, m_3)]}{\int_{m_1}^{m_3}\delta(t,\mu)d\mu}{}^{1} \tag{18}$$

By an operation analogous to (15) and (16), it can be shown that this forward bond yield is an average of the forward rates $\rho(t, s)$ for s between $t + m_1$ and $t + m_3$, each weighted by $\delta(t, s-t)$. The differences

$$\Delta_y(t) = y\left(t+ \Delta t, s^*(t)- t - \Delta t\right) -b\left(t,\Delta t, s^*(t)-t\right) \tag{19}$$

then represent, after adjustment for liquidity premium, pure unanticipated changes in interest rates.[2]

DATA

In order to abstract completely from default risk, the data we use are for U.S. Treasury Securities. Price data were assembled for the last business day of each month, from the end of December 1946 to the end of May 1977, a total of 366 months. Since these dates represent the dividing line between two months, they could equally well be associated with either month. We will refer to them in this paper as representing the "beginning" of the subsequent month, i.e., January 1947 to June 1977. In fact, the quotations

1 Cp. (14) above and McCulloch (1975b, 825).

[2]Unfortunately, these differences of weighted averages of forward rates have no simple interpretation in terms of a weighted average of differences in forward rates, since the relative weights change between t and $t + \Delta t$. Nevertheless, it can be shown that an across-the-board increase in forward rates, whatever the shape of the forward curve, will lead to a positive value of $\Delta_y(t)$, even though the new term structure will be giving higher weights to shorter term forward rates, which might well be substantially lower than the longer term rates.

are for actual delivery and payment early in these months, about two business days after the quotation date. The data for January 1947 to April 1966 were collected by Reuben A. Kessel from the quotation sheets of Salomon Brothers, and were processed under the supervision of Merton H. Miller and Myron Scholes. The data for May 1966 to June 1975 were collected from Salomon Brothers quotation sheets by Joel Messina and obtained with the assistance of Jay Morrisson. The data for July 1975 to June 1977 were collected from Wall Street Journal composite dealer quotations by Krista Chinn under the direction of the present author.

All tax-exempt securities were rejected as being non-representative of the market as a whole. (By the mid-1950's all but a handful of these had disappeared). "Flower bonds" often sell at a price premium because they can be surrendered at par value in payment of estate taxes if they are owned by the decedant at the time of his death. It was not practical to omit all of them, because for many years they constituted most if not all of the long-term securities. The following compromise was adopted for flower bonds: Those that 1) were selling below par; 2) matured after 1982; and 3) were selling within \$4 per \$100 of face value of the lowest priced flower bond were excluded. Any that did not meet all three of these criteria were included.[1] No attempt was made to compensate for the price discount that existed on many bonds in the earlier part of the period because of their ineligibility for commercial bank purchase. This discount was greatly reduced after the Accord of March 1951, and most of these bonds became eligible by the mid-1950's. Except for the

[1] See McCulloch (1975b, 817-822) for further discussion of these estate tax bonds.

tax-exempts and selected flower bonds, almost all U.S. Treasury Bills, Notes, and Bonds were included.

From this data discount functions were fit using a cubic spline, tax-adjusted technique similar to that described in McCulloch (1975c).[1] This technique was slightly improved by setting the "flat" price equal to the present discounted value of the sum of the after-tax semi-annual interest payments plus the principal, rather than using our earlier simplification of setting the "and interest" price equal to the integrated present discounted value of the after-tax coupons plus the principal, which treats the coupons as if they arrived in a continuous stream. Before-tax equivalent instantaneous forward rates, single payment yields, and par bond yields were calculated from the parameters of this spline discount curve for selected standard maturities sufficiently close together to allow linear interpolation when desired.[2]

Appendix I indicates for each month the largest standard maturity less than or equal to the maturity of the longest outstanding security observed. For most months we have more than 20 and sometimes even 30 years of data, though there were a few years in the early 1970's when our rule for flower bonds forced us to cut back to 14 or even 13 years. Fortunately, these months had relatively high levels of interest rates so that forward rates beyond these maturities would have had relatively little weight in the par bond yield anyway. Appendix 2 shows the par bond yield for the longest available maturity for each month. This series also appears on

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[1] The tax adjustment is especially important in the late 1950's and 1960's, when the long term market was dominated by bonds selling well below par and having a substantial capital gains tax advantage.

[2] These series, together with a batch version of the FORTRAN IV program that generated them, will be available from the NBER in New York, together with further description. The author takes sole responsibility for them, however.

Chart I.* Although these rates (and the other rates discussed below) are at best accurate to 1 or 2 basis points (.01 or .02 percent per annum), we have tabulated them to the nearest tenth of a basic point, to prevent their stochastic properties from being affected in any way by rounding errors.

THE LIQUIDITY PREMIUM

For all 365 pairs of adjacent months, $\Delta_y(t)$ was computed as in (19), using the longest maturity available both at time t and (by interpolation) at time $t + \Delta t$. Appendix 3 shows the accumulated sum of these increments. We have arbitrarily started the series at 2.241%, the longest available par bond yield at the beginning of January 1947.

Changes in this series are not pure unanticipated changes in interest rates, since forward rates are known to exceed expected future spot rates by a liquidity premium. Long (1972) has recently refuted the traditional Hicksian explanation of this premium in terms of risk aversion in the face of interest rate uncertainty, thus confirming the intuition of Bailey (1964, 554) that risk aversion can just as easily lead to a "solidity premium" (negative liquidity premium) as a positive liquidity premium. Nevertheless, the evidence indicates that a positive liquidity premium does exist at the very short end of the term structure. This sort of premium could be due to the demand for liquid secondary reserves on the part of traditional banks, as suggested by Lutz (1940, 48), or perhaps to interaction with the demand for money, as argued by Kessel (1965, 44-58).

For the specific purpose of being able to adjust forward interest rates to infer participants' expectations of future interest rates, we

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*Because of reduction difficulties, Chart I is not included with this draft.

have, in a separate paper (McCulloch 1975a), measured the size of this liquidity premium for a broad range of maturities, using data from 1947 to 1966. We found that if the term premium is not constrained to have any particular shape with respect to maturity, it cannot be estimated with any usable accuracy for implicit forward contracts longer than a year or so in duration. However, if we define the premium $\pi(m)$ on an instantaneous forward rate $\rho(t, t + m)$ as the difference between this forward rate and the market's expectation, as of time t, of the future "spot" interest rate $\rho(t + m, t + m)$,

$$\pi(m) = \rho(t, t + m) - E_t\rho(t + m, t + m), \tag{20}$$

we found that this premium does not differ significantly from the functional form

$$\pi(m) = b(1-e^{-am}), \tag{21}$$

where

$$a = 6.059 \text{ yr}^{-1}$$

and

$$b = .4335 \text{ percent per year.}$$

This functional form implies that the typical shape of the forward curve, as well as that of the yield curve, increases monotonically towards an asymptote 43 basis points above its lowest value. For the forward curve, it more than half-way approaches this asymptote in 2 months (1/6 year). The yield curve approaches the same asymptote, but more slowly. A premium like this, that monotonically increases toward an asymptote, is consistent with the theories of Lutz and Kessel, so for present purposes we accept this functional form as valid.

Equation (21) implies a very small liquidity premium for forward contracts of long maturity. If m_2 is the duration of the forward contract

$(s_2 - s_1$ in definition (7)$)$, it can be shown that the premium is, at the .95 confidence level, less than $10/m_2$ basis points, regardless of the distance into the future the forward contract is to begin (McCulloch 1975a, 115). Thus, on a 10 year single payment implicit forward contract, the premium is less than 1 basis point, hardly worth bothering with by itself.

However, in the present paper we propose to accumulate 365 forecasting errors, so these liquidity premia may add up to a substantial sum. In order to adjust for this premium, we must derive the premium in a forward par bond yield implied by formula (21). Since expectations must fluctuate randomly (see McCulloch 1975a, 98 text and n.6), we just have

$$E_t\rho(t+m,\ t+m) = E_t\ [E_{t+m_1}\ \rho(t+m,\ t+m)] \tag{22}$$

for all m greater than m_1. Therefore

$$\begin{aligned}\rho(t,\ t+m) &= E_t\rho(t+m,\ t+m) + \pi(m)\\ &= E_t[E_{t+m_1}\rho(t+m,\ t+m)] + \pi(m)\\ &= E_t[\rho(t+m_1,\ t+m) - \pi(m-m_1)] + \pi(m)\\ &= E_t\rho(t+m_1,\ t+m) + \pi(m) - \pi(m-m_1),\end{aligned} \tag{23}$$

whence

$$b(t,m_1,m_3) = \frac{\int_{m_1}^{m_3} \rho(t,t+m)\delta(t,m)dm}{\int_{m_1}^{m_3} \delta(t,m)dm}$$

$$= \frac{\int_{m_1}^{m_3} E_t\rho(t+m_1,t+m)\delta(t,m)dm}{\int_{m_1}^{m_3}\delta(t,m)dm} + P(t,m_1,m_2)$$

$$\approx E_tY(t+m_1,m_2) + P(t,m_1,m_2) \tag{24}$$

where

$$P(t,m_1,m_2) = \frac{\int_{m_1}^{m_3} [\pi(m) - \pi(m-m_1)]\delta(t,m)dm}{\int_{m_1}^{m_3}\delta(t,m)dm} \tag{25}$$

is the approximate value of the liquidity premium in the forward rate on a par bond of maturity m_2, to be bought or sold in m_1 years, and m_2 is again m_3-m_1.

This approximate premium is a function of the exact shape of the discount function at time t, which makes it difficult to evaluate. However, by a further approximation, we can obtain a simple expression for it. Suppose that R(t) is the "general level" of interest rates at time t (expressed as a fraction of unity rather than as a percentage), so that

$$\delta(t,m) \approx e^{-R(t)m} . \tag{26}$$

Then (21) and (25) imply

$$P(t,m_1,m_2) \approx \frac{\int_0^{m_2} [b(1-e^{-a(m+m_1)}) - b(1-e^{-a(m)})]e^{-R(t)m}dm}{\int_0^{m_2} e^{-R(t)m}\, dm}$$

$$= \frac{R(t)b\left(1-e^{-am_1}\right)}{1-e^{-R(t)m_2}} \int_0^{m_2} e^{-\left(a+R(t)\right)m} \, dm$$

$$= \frac{R(t)b\left(1-e^{-am_1}\right)\left(1-e^{-\left(a+R(t)\right)m_2}\right)}{\left(a+R(t)\right)\left(1-e^{-R(t)m_2}\right)} = p(R(t),\ m_1,\ m_2) \qquad (27)$$

Note that although our specification (21) of the liquidity premium on instantaneous forward rates (and therefore on single payment forward rates as in (9)) does not depend on the level of interest rates, the derived approximate premium $p\left(R(t),\ m_1, m_2\right)$ in (27) does depend on this level. This is because the forward par bond yield gives higher weight to shorter term $\rho(t,s)$'s, (which have the largest liquidity premia), the higher the level of interest rates. It will therefore be an increasing function of the level. To illustrate, if m_1 is 1/12 years, m_3 is 20 years, and interest rates stand at 2½% $\left(R(t) = .025\right)$, the premium will be 0.18 basis points (0.0018%). At 5% interest, the premium will rise to 0.22 basis points, and at 10%, to 0.32 basis points. By themselves, these adjustments are well less than the measurement error in the forward par bond yield, but they will accumulate to a noticeable amount over 30 years.

Appendix 4 shows the accumulated sum of the increments $\Delta_y(t)$, to each of which has been added a liquidity premium adjustment calculated with (27). For each month the current value of y(t, s*(t)-t)/100 was used as R(t). As with the series in Appendix 3, we arbitrarily start this series at the initial level of the longest available par bond yield, 2.241%. In this case, however, it rises to 3.918%, instead of to 3.203%, a difference of 71.5 basis points over 365 months. This difference averages to about 0.20 basis points per month.

Our adjusted sum of increments still leaves a little to be desired. First, there is no reason why it could not go negative, and thus behave unlike an interest rate series. To illustrate, suppose that initially the one-year rate stands at 2% and the two-year rate at 3%, so that participants expect next year's one-year rate to be 4% (abstracting from liquidity premium). If instead next year's one-year rate is 1%, there will have been an unanticipated fall of 4 - 1 = 3%. This fall will take the cumulative sum to -1%, even though all actual interest rates and expected rates are in fact positive. Nothing this extreme actually occurs, though we can find intervals when a rise in yields to maturity was actually overanticipated, and therefore represents an unanticipated fall in interest rates. There are only a few individual months for which this occurred, though it is not uncommon over periods of several months. One example is the period from January 1947 to August 1954, when the long term par bond yield rose from 2.241% to 2.549%, a rise of 30.8 basis points, yet the cumulative sum of unanticipated changes fell from 2.241% to 1.853%, an unanticipated fall of 38.8 basis points.

A more important problem is that changes in the cumulative sum of unanticipated changes series reflect the actual unanticipated change in terms of percentage points, so that relative changes in this series do not reflect similar relative differences between the expected par bond yield and the subsequent spot yield. For example, a rise from 6% to 8% represents the same percentage change in the price of a perpetuity (which a long term par bond approximates) as does a rise from 3% to 4%. Yet if the cumulative sum series happened to stand at 3% at the beginning of a month when the market was anticipating a 6% par bond yield for the end of the month, an 8% realization would drive the cumulative sum series to 5%, the same percentage point change, but twice the relative change, that actually occurred.

In order to correct both these problems, the series we should actually concentrate on is the <u>multiplicatively cumulative unanticipated change in long term par bond yields</u>, which we will call $y^*(t)$. We again start this series at 2.241%, and thereafter define it by multiplying its previous value by the ratio of the realized spot yield to the previously anticipated corresponding yield, adjusted for liquidity premium:

$$y^*(t+\Delta t) = y^*(t)\frac{y(t+\Delta t,\ s^*(t) - t-\Delta t)}{b\left[t,\Delta t,\ s^*(t)-t\right]-p\left[R(t),\Delta t,s^*(t)-t-\Delta t\right]}\ . \tag{28}$$

Relative changes in this series, even over several months or years, then represent the actual cumulative relative change in interest rates, even for periods when its value has drifted far away from the actual current level of interest rates.

In order to make it available for other researchers, we have shown the full series in Table 1, page 21. It is never accurate to within less than a basis point, but we have again indicated the tenths of basis points so that its stochastic properties will be unaffected by rounding considerations.

If all changes in interest rates were correctly anticipated by the market, our series would never change, regardless of the behavior of current long-term interest rates. We therefore see from our series, that while minor fluctuations in interest rates were almost entirely unanticipated, the secular rise from 2.24% in 1947 to around 4.2% in 1965 was almost entirely anticipated by the market. On the other hand, the large rise in rates from 1965 to well over 7% five years later (following the adoption of inflationary financing to help accommodate the Viet Nam war), was almost entirely unanticipated, since it is accompanied by almost exactly the same proportionate change in y*. The slight rise in rates from 1970 to 1977 was actually somewhat overanticipated, as indicated by a slight decline in y*.

EVIDENCE ON THE MISINTERMEDIATION HYPOTHESIS

Now let us turn to the object of our investigation, the direction of unanticipated changes in interest rates over historical business fluctuations. The misintermediation theory predicts unanticipated falls during disequilibrious contractions, and unanticipated rises during disequilibrious booms. Now the growth rate of the economy during a period of perfectly equilibrious development need not be constant. It probably will not be negative, but even that is not certain. Nevertheless, it seems safe to assume that recognized historical business "cycles", at least the larger ones, represent unanticipated changes in the growth of output of consumption goods, and therefore represent the sort of disequilibrium booms and recessions we are looking for.

Table 2, page 22 indicates the recently revised standard NBER "reference cycle" peak and trough dates for the period of our series, and the corresponding value of y*. Since the peak and trough dates represent extreme activity during the <u>course</u> of the month indicated, while our y*(t) series refers to the <u>beginning</u> of each month, we have used the average of y* at the beginning and end of the month in question as being representative of the month as a whole. For each contraction and expansion,

TABLE 1

Multiplicatively Cumulative Unanticipated

Change in Interest Rates (y*)

Beginning of:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1947	2.241	2.230	2.210	2.179	2.184	2.172	2.199	2.196	2.160	2.161	2.222	2.264
1948	2.333	2.327	2.321	2.301	2.294	2.246	2.281	2.290	2.285	2.281	2.276	2.255
1949	2.233	2.209	2.183	2.176	2.177	2.173	2.099	2.057	2.015	1.998	1.991	1.974
1950	1.940	1.980	1.994	2.015	2.033	2.035	2.061	2.050	2.041	2.067	2.080	2.071
1951	2.072	2.060	2.067	2.089	2.174	2.209	2.183	2.155	2.092	2.135	2.168	2.191
1952	2.184	2.172	2.223	2.218	2.090	2.093	2.112	2.101	2.160	2.229	2.143	2.151
1953	2.209	2.218	2.282	2.299	2.428	2.451	2.396	2.460	2.471	2.353	2.321	2.325
1954	2.221	2.190	2.056	2.048	2.012	2.055	1.966	1.929	1.938	1.942	1.960	2.000
1955	1.987	2.081	2.120	2.093	2.080	2.072	2.075	2.117	2.131	2.114	2.090	2.120
1956	2.084	2.072	2.081	2.122	2.193	2.132	2.106	2.182	2.268	2.217	2.311	2.359
1957	2.469	2.280	2.313	2.311	2.410	2.432	2.500	2.515	2.532	2.574	2.616	2.521
1958	2.205	2.240	2.181	2.183	2.101	2.061	2.117	2.296	2.416	2.461	2.414	2.388
1959	2.449	2.526	2.524	2.524	2.542	2.562	2.582	2.561	2.595	2.585	2.564	2.607
1960	2.715	2.677	2.590	2.462	2.582	2.516	2.381	2.260	2.319	2.321	2.320	2.344
1961	2.270	2.318	2.245	2.236	2.198	2.190	2.279	2.288	2.346	2.338	2.317	2.329
1962	2.345	2.352	2.369	2.281	2.2 6	2.268	2.288	2.392	2.307	2.284	2.260	2.259
1963	2.253	2.273	2.281	2.292	2.308	2.291	2.289	2.267	2.268	2.313	2.329	2.329
1964	2.344	2.331	2.335	2.352	2.347	2.321	2.312	2.335	2.334	2.331	2.318	2.327
1965	2.332	2.326	2.330	2.330	2.330	2.333	2.327	2.337	2.359	2.392	2.396	2.439
1966	2.493	2.533	2.660	2.568	2.588	2.625	2.666	2.674	2.824	2.687	2.628	2.697
1967	2.561	2.499	2.612	2.545	2.668	2.698	2.819	2.820	2.867	2.893	3.031	3.140
1968	3.129	3.031	3.065	3.205	3.107	3.102	3.032	2.961	2.954	3.035	3.135	3.200
1969	3.432	3.492	3.453	3.446	3.367	3.554	3.468	3.416	3.382	3.561	3.527	3.677
1970	3.733	3.685	3.477	3.556	3.952	3.994	3.841	3.801	3.819	3.704	3.689	3.311
1971	3.311	3.110	3.205	3.002	3.152	3.318	3.479	3.542	3.225	3.088	3.036	3.011
1972	3.044	3.210	3.136	3.107	3.092	3.046	3.067	3.130	3.159	3.216	3.130	3.069
1973	3.094	3.153	3.152	3.143	3.142	3.220	3.257	3.465	3.348	3.234	3.398	3.304
1974	3.367	3.413	3.460	3.613	3.753	3.755	3.721	3.791	3.898	3.864	3.724	3.662
1975	3.636	3.559	3.536	3.745	3.797	3.682	3.659	3.708	3.759	3.841	3.644	3.718
1976	3.577	3.553	3.557	3.482	3.488	3.560	3.501	3.495	3.419	3.384	3.357	3.216
1977	3.119	3.281	3.329	3.286	3.271	3.245						

TABLE 2

Cumulative Unanticipated Change in Interest Rates over Reference Cycles

Peaks	Troughs	y*	- 100Δlog y* - Contractions	Expansions
11/48		2.266		
	10/49	1.994	-12.8	
7/53		2.428		+19.7
	5/54	2.034	-17.7	
8/57		2.524		+21.6
	4/58	2.142	-16.4	
4/60		2.522		+16.3
	2/61	2.282	-10.0	
12/69		3.705		+48.5
	11/70	3.500	- 5.7	
11/73		3.351		- 4.4
	3/75	3.640	+ 8.3	

Source for dates: Zarnowitz and Boschan (1975, 28, and 1976, 26).

we have indicated the percentage change in y*. We have computed this change logarithmically, as 100 times the change in the natural logarithm of y*, so that a 10% rise followed by a 10% fall will leave y* exactly where it started. Since a long-term par bond approximates a perpetuity, whose price is the reciprocal of its yield, these percentage changes roughly indicate the unanticipated fluctuations in the value of current output relative to a constant stream of future output. Thus, output in April of 1958 was worth 16.4% less in terms of future output than the market anticipated it would be worth eight months previously.

We see that in all but two of the eleven phases considered, the unanticipated change in interest rates is, indeed, in the direction predicted by the misintermediation hypothesis. Although, as Kessel determined, the market generally correctly determined the direction of change in interest rates, it systematically underestimated the total change, and did not overanticipate it. The evidence is therefore consistent with the assertion that most postwar U.S. business fluctuations were caused by the mismatching of intertemporal consumption and production plans brought about by misintermediation.

The two exceptions are the contraction that set in as a consequence of the Arab oil embargo in late 1973, and the preceding expansion that was interrupted by the oil situation. Since it seems safe to assume that the Arab oil embargo was not caused by the maturity structure of the balance sheets of U.S. financial institutions, we may conclude that misintermediation is not responsible for <u>all</u> business fluctuations. Nevertheless, in every case when the unanticipated change in the value of output relative to future output is 10% or larger, the change <u>is</u> in the direction predicted by this hypothesis.

Because the Burns-Mitchell reference cycle concept only recognizes absolute reductions in output as contractions, it may overlook disequilibriously sluggish periods when the growth rate is positive but not as high as anticipated. Even for the fluctuations it recognizes, it may tend to place peaks too late and the troughs too early, since when a trend is added to a pure cyclic series, the maxima tend to be retarded and the minima advanced in time. To avoid these problems, Ilse Mintz has constructed a "Growth Cycle" chronology, shown in Table 3, page 25. Essentially, the upturns and downturns in this chronology identify peaks and troughs in detrended aggregate economic activity.

The direction of change is in the direction consistent with the misintermediation hypothesis in five out of nine growth contractions and in six out of eight growth expansions, a majority of cases but not an overwhelming majority. However, two of the four contractions with increases in y* and one of the two expansions with decreases in y* have changes that are smaller than 2% in absolute value. Two of the remaining three exceptions are associated with the oil recession of 1973-1975. The remaining exception is the mini-recession of 1966-1967, which on the one hand was not a major recession, and which on the other hand occurred at a time of rising inflationary expectations. Even then, there was a substantial fall in the series during the course of the mini-recession, from September 1966 to February 1967.

In order to test whether the cumulative unanticipated change in interest rates is significantly pro-cyclic, we calculated the mean monthly change in the logarithm of this series, separately for contractions and expansions.

TABLE 3

Cumulative Unanticipated Change in Interest Rates over Growth Cycles

Downturns	Upturns	y*	- 100Δlog y* - Growth Contractions	Growth Expansions
7/48		2.286		
	10/49	1.994	-13.7	
6/51		2.196		+9.6
	6/52	2.102	- 4.4	
3/53		2.290		+8.6
	8/54	1.934	-16.9	
2/57		2.296		+17.2
	5/58	2.081	- 9.8	
2/60		2.634		+23.6
	2/61	2.282	-14.3	
4/62		2.274		-0.4
	3/63	2.286	+ 0.5	
6/66		2.646		+14.6
	10/67	2.962	+11.3	
3/69		3.450		+15.3
	11/70	3.500	+ 1.4	
3/73		3.148		-10.6
	4/75	3.771	+18.1	

Sources for dates: Mintz (1974,60), Moore (1975, 159) and Zarnowitz and Boschan (1976, 26). This deflated series chronology is more widely accepted than Mintz's alternative undeflated series chronology (1974, 59).

These results are shown in Table 4, on page 27. In each case we excluded the changes that occurred during the actual peak and trough months, since it is ambiguous whether they belong to the expansion or to the contraction. The t tests indicate that log y* decreases significantly during reference expansions and increases significantly during reference expansions. It declines during growth contractions, though not significantly, and increases significantly during growth expansions. In both types of cycle the difference in means indicates that the expected change is significantly higher for expansions than for contractions. The normalized von Neumann ratios "NvNR" (which have been normalized to have mean 0, standard deviation approximately 1.0, and to be positive when positive serial correlation is present) throughout indicate no significant serial correlation.

However, the standarized range statistic "SR", defined as the range divided by the estimated standard deviation, is highly significant for all cases, indicating significant leptokurtosis, which violates the normality assumption necessary to use the t test. The statistic

$$x_{med} = \frac{2n_+ - n}{\sqrt{n}} \quad , \tag{29}$$

where n is the number of observations on the change and n_+ is the number of these observations where the change is positive, is asymptotically N(0,1), and enables us to test for the sign of the median change without relying on a normal assumption.[1]

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[1]We do assume here that the distribution of forecasting errors is more or less symmetrical, so that the mean and median have the same sign.

TABLE 4

Mean Month-to-Month Changes, by Phase

	- 100 log y* -		- 100 log y_L -	
	Reference Cycles	Growth Cycles	Reference Cycles	Growth Cycles
<u>Contractions</u>				
Mean change (1)	- .871	- .171	- .498	.053
t	-2.08	- .63	-1.24	.20
NvNR	.92	- .26	1.46	.07
SR	7.38	7.61	6.52	6.56
x_{med}	-1.81	- .86	-1.03	.69
<u>Expansions</u>				
Mean change (2)	.435	.493	.631	.713
t	2.67	2.67	3.76	3.70
NvNR	.43	1.26	.99	1.86
SR	6.85	7.24	6.87	7.19
x_{med}	2.24	2.30	3.64	3.22
<u>Difference</u>				
(2)-(1)	1.305	.664	1.129	.659
t	2.91	2.02	2.60	2.01
χ^2_1	6.87	4.75	6.55	2.70

<u>Fractiles of SR Statistic</u>*	.975	.99	.995
Reference Contractions (n = 60)	5.70	5.93	6.09
Reference Expansions (n = 245)	6.67	6.93	7.11
Growth Contractions (n = 134)	6.30	6.55	6.74
Growth Expansions (n = 170)	6.47	6.72	6.92

*Interpolated from David <u>et</u> <u>al</u>. (1954, 491).

We see that this statistic is significantly positive for both types of expansion. It is negative for both types of contraction, though it is not significantly so in either case. Since the median fall during contractions is not significant, it is important to test whether the probability of a rise is significantly higher during an expansion than during a contraction. This hypothesis can be tested with a simple 2 x 2 contingency table test (e.g. Mood et. al. 1974, 454). This test produces a statistic which is asymptotically χ_1^2 if the probability is the same. This statistic is significant at the .95 level if over 3.84, and we see that indeed the probability of y* rising is significantly higher during expansions than contractions for <u>both</u> chronologies.

For comparison, we also perform the same calculations for y_L, the par bond yield for the longest available maturity, which is the series tabulated in Appendix 2. We see that it rises significantly during both types of expansion, by both the t and x_{med} test. It falls during reference contractions, <u>but not significantly even by the t test</u>. During growth contractions, the mean and median are actually positive, though neither is significant. Although the difference between expansion behavior and contraction behavior is significant for reference cycles by both the t and χ^2 tests, this difference just barely passes the t test and actually fails the χ^2 test for growth cycles.

For further comparison, Appendix 5 shows the behavior of the level of the additive cumulative unanticipated change y_a^* tabulated in Appendix 4, along with the level of y_L. The results are qualitatively the same as in Table 4, though the t statistics are uniformly lower, in many cases losing their significance. Note however, that the standardized range indicates stronger leptokurtosis in every expansion case, so that the normal assumption and t test are even less warranted than in Table 4. Taking logarithms apparently removes much of the heteroskedasticity in the changes, since the standard deviation of changes has happened to be almost proportional to the level of interest rates over our period. The non-parametric statistics are of course unaltered.

By every criterion (except the strength of rises during expansions), our synthetic cumulative unanticipated change in interest rates series y^* is actually more reliably pro-cyclic than the long term interest rate y_L. This is true even though a series very similar to the latter is used to date both reference cycles and growth cycles.

We had hoped that the unanticipated change in interest rates would be significantly pro-cyclic, in spite of Kessel's finding that the market has systematically correctly anticipated at least the direction of change in interest rates over business cycles. To find that it is actually more reliably pro-cyclic than the long-term interest rate itself far exceeds our hopes for it. Furthermore, the pro-cyclic nature of our series is significant by many tests even when we include the oil recession of 1973-1975, which our misintermediation theory can excusably be allowed not to explain.[1]

[1] Because of a mathematical identity, rises in forward rates go hand in hand with lower holding period yields for longer term obligations. Therefore, the type of evidence we have looked at here is similar in ultimate nature to that investigated by Kessel and Clark (1976). In their Table 2, Part C, they find unanticipated capital losses on long term bonds during expansions from Nov. 1945 to Nov. 1970, and unanticipated capital gains during contractions. These gains and losses are significant, at least using a t test, so their findings are in conformity with ours.

QUALIFICATION

The misintermediation theory of business fluctuations predicts unanticipated declines in the real interest rate accompanying recessions and unanticipated rises in the real interest rate accompanying disequilibrium booms. What we have shown is that historically, unanticipated changes in the nominal interest rate are in the direction predicted. We have no way of knowing for certain from this evidence the direction of change of the real interest rate. It might be that the entire change has been in the expected inflation rate and that the real interest rate has had no unanticipated change at all. It might even be that the real interest rate actually rises unexpectedly during contractions and falls during expansions, and that the change in inflationary expectations more than compensates for this behavior of the real rate.[1]

It is not implausible that inflationary expectations are pro-cyclic, and therefore contribute to the pro-cyclic nature of the nominal interest rate. However, we have no reliable way of reading peoples' minds to determine actual inflationary expectations, let alone the term structure of inflationary expectations which, strictly speaking, is the necessary consideration.[2] It is difficult to believe that all of the cyclical fluctuation in the nominal interest rate is due to changes in expected inflation, let alone more than one hundred percent of this fluctuation. Fisher in particular would be forced to admit that inflationary expectations change only gradually, and do not vary much over a business cycle lasting a few dozen months. We therefore maintain that there is a good case for our interpretation of the evidence.

[1]Indeed, the monetary business cycle theorists Irving Fisher and Ludwig von Mises argue that this is in fact the case.

[2]William Gibson has done some exploratory work in this direction.

CONCLUSION

The series we have constructed on the cumulative unanticipated change in interest rates provides strong evidence in support of the hypothesis that many business fluctuations of the type that have occurred in the United States since World War II are caused by the mis-matching of intertemporal consumption and production plans. We lay the ultimate blame for this problem on "misintermediation", the traditional failure by financial intermediaries to match the maturity structures of their assets and liabilities.

Our synthetic interest rate series turns out to be actually more reliably pro-cyclic than the simple long-term interest rate, this in spite of the fact that the latter is used to help construct the standard business cycle chronologies. It is hoped that this series will be of use to other researchers in macroeconomics, whether or not they accept its interpretation in terms of the misintermediation hypothesis.

APPENDIX 1

Longest Maturity Available (years)

Beginning of:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1947	20	20	20	20	20	20	20	20	20	20	20	20
1948	19	19	19	19	19	19	19	19	19	19	19	19
1949	18	18	18	18	18	18	18	18	18	18	18	18
1950	17	17	17	17	17	17	17	17	17	17	17	17
1951	16	16	16	21	21	21	21	21	21	21	21	21
1952	20	20	20	20	20	20	20	20	20	20	20	20
1953	19	19	19	19	30	30	29	24	24	24	24	24
1954	24	24	24	24	24	24	23	23	23	23	23	23
1955	23	40	35	35	35	35	35	35	35	35	35	35
1956	35	35	35	35	35	35	35	35	35	35	26	26
1957	26	26	26	26	26	26	25	25	25	25	25	25
1958	20	32	31	31	31	31	31	31	31	31	31	31
1959	31	31	30	30	30	30	30	30	30	30	30	30
1960	30	20	29	29	29	29	29	29	29	35	35	35
1961	35	35	35	35	35	35	35	35	28	28	28	28
1962	28	28	27	35	35	35	35	27	27	27	27	27
1963	27	27	29	29	29	29	29	29	29	30	30	30
1964	30	30	30	34	30	29	29	29	29	29	29	29
1965	29	29	29	29	29	28	28	28	28	28	28	28
1966	28	28	28	28	28	27	27	27	27	27	27	27
1967	27	27	27	27	27	26	26	26	26	26	26	24
1968	26	26	24	24	26	25	25	25	25	25	25	25
1969	23	23	23	25	25	23	23	23	22	23	22	22
1970	22	22	22	15	22	14	14	14	14	14	14	21
1971	23	21	21	23	14	13	13	13	13	13	15	14
1972	14	14	14	14	14	14	14	14	14	14	14	13
1973	13	20	19	19	19	24	24	24	24	24	24	24
1974	24	24	24	24	24	23	23	23	24	24	23	23
1975	23	25	24	24	24	29	24	29	29	29	24	29
1976	24	24	24	24	24	23	23	23	23	23	23	23
1977	23	23	29	29	29	29						

APPENDIX 2

Longest Term Available Par Bond Yield (y_L)

Beginning of:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1947	2.241	2.241	2.231	2.210	2.226	2.225	2.263	2.270	2.243	2.253	2.324	2.377
1948	2.454	2.455	2.455	2.440	2.440	2.396	2.440	2.455	2.457	2.459	2.459	2.442
1949	2.421	2.402	2.380	2.378	2.386	2.387	2.313	2.273	2.235	2.223	2.221	2.210
1950	2.164	2.217	2.239	2.269	2.298	2.306	2.342	2.337	2.333	2.369	2.390	2.386
1951	2.398	2.393	2.410	2.446	2.641	2.690	2.664	2.636	2.565	2.622	2.665	2.700
1952	2.709	2.698	2.769	2.771	2.617	2.627	2.656	2.647	2.725	2.816	2.715	2.733
1953	2.802	2.818	2.905	2.932	3.100	3.250	3.167	3.154	3.174	3.031	2.999	3.014
1954	2.887	2.855	2.690	2.688	2.651	2.716	2.590	2.549	2.571	2.584	2.616	2.677
1955	2.666	2.799	2.917	2.887	2.873	2.867	2.879	2.943	2.968	2.948	2.916	2.960
1956	2.914	2.899	2.914	2.974	3.076	2.991	2.957	3.066	3.190	3.122	3.245	3.317
1957	3.471	3.208	3.254	3.255	3.397	3.430	3.506	3.531	3.560	3.624	3.685	3.547
1958	3.218	3.271	3.325	3.335	3.219	3.165	3.265	3.549	3.746	3.828	3.768	3.738
1959	3.847	3.974	3.987	3.995	4.029	4.067	4.103	4.075	4.139	4.128	4.097	4.174
1960	4.356	4.376	4.238	4.033	4.235	4.130	3.919	3.731	3.838	3.852	3.895	3.946
1961	3.833	3.921	3.804	3.794	3.736	3.730	3.888	3.912	4.024	4.021	3.995	4.028
1962	4.066	4.085	4.110	3.965	3.957	3.966	4.008	4.153	4.011	3.978	3,940	3.947
1963	3.944	3.985	4.001	4.029	4.067	4.042	4.042	4.007	4.012	4.096	4.142	4.146
1964	4.177	4.156	4.165	4.196	4.190	4.148	4.137	4.181	4.183	4.180	4.159	4.177
1965	4.189	4.181	4.189	4.190	4.190	4.197	4.187	4.206	4.245	4.306	4.313	4.390
1966	4.490	4.561	4.790	4.626	4.662	4.728	4.802	4.817	5.089	4.843	4.734	4.859
1967	4.619	4.506	4.708	4.589	4.811	4.890	5.117	5.128	5.224	5.280	5.534	5.737
1968	5.725	5.492	5.602	5.861	5.687	5.659	5.531	5.400	5.387	5.535	5.715	5.829
1969	6.376	6.486	6.412	6.403	6.194	6.569	6.411	6.314	6.278	6.602	6.530	6.805
1970	6.909	6.826	6.437	6.803	7.553	7.697	7.409	7.337	7.393	7.177	7.159	6.442
1971	6.349	5.979	6.174	5.801	6.009	6.387	6.712	6.848	6.252	6.002	5.911	5.904
1972	5.988	6.336	6.221	6.185	6.178	6.109	6.172	6.317	6.396	6.526	6.361	6.283
1973	6.342	6.479	6.683	6.674	6.679	6.849	7.006	7.451	7.194	6.938	7.281	7.081
1974	7.206	7.303	7.400	7.728	8.025	7.987	7.917	8.067	8.305	8.296	7.977	7.855
1975	7.797	7.642	7.644	8.119	8.257	8.029	8.004	8.129	8.306	8.507	8.060	8.244
1976	7.957	7.924	7.957	7.815	7.850	8.030	7.919	7.924	7.772	7.713	7.669	7.367
1977	7.165	7.556	7.688	7.649	7.635	7.594						

APPENDIX 3

Cumulative Sum of $\Delta_y(t)$

Beginning of:

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1947	2.241	2.229	2.206	2.173	2.177	2.162	2.188	2.183	2.144	2.143	2.205	2.248
1948	2.319	2.311	2.302	2.279	2.270	2.217	2.253	2.260	2.253	2.247	2.239	2.215
1949	2.189	2.161	2.131	2.121	2.121	2.114	2.031	1.982	1.934	1.914	1.903	1.883
1950	1.842	1.885	1.899	1.920	1.939	1.939	1.966	1.952	1.940	1.968	1.981	1.969
1951	1.967	1.951	1.957	1.981	2.082	2.123	2.090	2.053	1.974	2.025	2.064	2.091
1952	2.081	2.063	2.125	2.118	1.955	1.958	1.980	1.964	2.037	2.121	2.010	2.019
1953	2.091	2.100	2.180	2.200	2.362	2.391	2.317	2.398	2.410	2.256	2.213	2.217
1954	2.080	2.038	1.861	1.848	1.801	1.855	1.737	1.686	1.696	1.701	1.723	1.774
1955	1.755	1.880	1.932	1.894	1.874	1.862	1.866	1.922	1.941	1.916	1.880	1.921
1956	1.870	1.852	1.863	1.919	2.017	1.930	1.893	1.998	2.118	2.044	2.175	2.241
1957	2.394	2.126	2.171	2.167	2.304	2.334	2.428	2.447	2.469	2.527	2.584	2.448
1958	1.985	2.035	1.944	1.944	1.818	1.755	1.840	2.115	2.299	2.369	2.293	2.251
1959	2.346	2.465	2.460	2.458	2.485	2.516	2.546	2.511	2.564	2.546	2.511	2.577
1960	2.749	2.685	2.541	2.329	2.524	2.414	2.190	1.989	2.085	2.087	2.083	2.122
1961	1.997	2.075	1.950	1.934	1.868	1.852	2.003	2.018	2.116	2.100	2.062	2.081
1962	2.107	2.117	2.146	1.991	1.962	1.965	1.998	2.177	2.027	1.986	1.941	1.939
1963	1.926	1.961	1.972	1.989	2.016	1.985	1.980	1.939	1.939	2.017	2.044	2.043
1964	2.068	2.043	2.047	2.076	2.067	2.018	2.001	2.040	2.037	2.029	2.005	2.019
1965	2.026	2.013	2.020	2.018	2.015	2.019	2.007	2.024	2.060	2.119	2.124	2.199
1966	2.296	2.366	2.592	2.425	2.459	2.524	2.596	2.608	2.877	2.627	2.519	2.642
1967	2.395	2.282	2.484	2.361	2.580	2.634	2.850	2.851	2.935	2.980	3.229	3.427
1968	3.404	3.224	3.284	3.539	3.357	3.346	3.216	3.085	3.069	3.215	3.395	3.511
1969	3.941	4.050	3.975	3.960	3.812	4.156	3.994	3.895	3.830	4.159	4.094	4.370
1970	4.471	4.380	3.993	4.140	4.894	4.971	4.673	4.592	4.626	4.400	4.367	3.629
1971	3.625	3.237	3.418	3.022	3.307	3.623	3.930	4.048	3.432	3.162	3.058	3.007
1972	3.068	3.393	3.242	3.181	3.149	3.053	3.093	3.216	3.273	3.386	3.207	3.080
1973	3.127	3.246	3.240	3.220	3.214	3.378	3.455	3.898	3.645	3.398	3.746	3.543
1974	3.675	3.772	3.870	4.194	4.491	4.493	4.418	4.563	4.789	4.714	4.410	4.276
1975	4.218	4.050	3.996	4.448	4.559	4.304	4.251	4.357	4.465	4.645	4.206	4.369
1976	4.052	3.996	4.002	3.831	3.843	4.003	3.866	3.849	3.674	3.592	3.527	3.203
1977	2.978	3.347	3.455	3.354	3.317	3.253						

APPENDIX 4

Additively Cumulative Unanticipated Change in Interest Rates (y_a^*)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1947	2.241	2.230	2.210	2.178	2.184	2.171	2.198	2.195	2.158	2.159	2.223	2.268
1948	2.340	2.334	2.327	2.306	2.299	2.247	2.285	2.294	2.289	2.285	2.279	2.257
1949	2.232	2.207	2.178	2.171	2.172	2.167	2.086	2.039	1.993	1.975	1.966	1.948
1950	1.909	1.954	1.970	1.993	2.014	2.016	2.045	2.033	2.023	2.053	2.068	2.058
1951	2.058	2.045	2.053	2.078	2.181	2.224	2.193	2.158	2.081	2.133	2.174	2.203
1952	2.194	2.179	2.243	2.237	2.076	2.080	2.104	2.090	2.165	2.251	2.142	2.153
1953	2.226	2.238	2.320	2.341	2.505	2.536	2.463	2.546	2.559	2.407	2.366	2.371
1954	2.236	2.196	2.020	2.010	1.963	2.020	1.903	1.853	1.865	1.872	1.895	1.948
1955	1.931	2.057	2.111	2.074	2.055	2.044	2.050	2.107	2.127	2.103	2.069	2.111
1956	2.062	2.045	2.058	2.114	2.214	2.128	2.092	2.199	2.320	2.248	2.380	2.448
1957	2.602	2.336	2.383	2.380	2.519	2.551	2.646	2.667	2.691	2.750	2.809	2.675
1958	2.214	2.265	2.176	2.178	2.053	1.991	2.078	2.355	2.540	2.611	2.537	2.496
1959	2.592	2.714	2.710	2.710	2.738	2.771	2.803	2.769	2.823	2.808	2.774	2.842
1960	3.016	2.953	2.812	2.602	2.799	2.690	2.467	2.268	2.365	2.369	2.367	2.407
1961	2.283	2.363	2.240	2.225	2.160	2.146	2.298	2.314	2.414	2.400	2.364	2.385
1962	2.413	2.424	2.454	2.301	2.274	2.279	2.313	2.494	2.345	2.306	2.263	2.263
1963	2.251	2.287	2.300	2.319	2.348	2.319	2.315	2.276	2.277	2.357	2.386	2.386
1964	2.413	2.390	2.396	2.426	2.419	2.372	2.356	2.397	2.395	2.389	2.366	2.382
1965	2.392	2.380	2.388	2.388	2.387	2.392	2.382	2.401	2.439	2.499	2.506	2.583
1966	2.681	2.753	2.981	2.816	2.852	2.919	2.993	3.006	3.277	3.029	2.923	3.048
1967	2.803	2.692	2.895	2.774	2.996	3.051	3.269	3.272	3.358	3.405	3.656	3.856
1968	3.835	3.657	3.720	3.976	3.797	3.787	3.660	3.531	3.517	3.665	3.847	3.966
1969	4.398	4.509	4.436	4.424	4.278	4.624	4.465	4.368	4.306	4.637	4.574	4.852
1970	4.956	4.868	4.483	4.633	5.390	5.471	5.176	5.098	5.135	4.912	4.882	4.147
1971	4.146	3.760	3.943	3.550	3.837	4.158	4.467	4.589	3.976	3.709	3.608	3.560
1972	3.624	3.952	3.804	3.746	3.716	3.624	3.667	3.793	3.853	3.969	3.793	3.669
1973	3.719	3.842	3.838	3.821	3.818	3.984	4.063	4.510	4.259	4.014	4.365	4.164
1974	4.299	4.398	4.499	4.825	5.124	5.129	5.057	5.205	5.433	5.361	5.060	4.928
1975	4.873	4.708	4.656	5.111	5.224	4.972	4.922	5.030	5.141	5.324	4.887	5.052
1976	4.739	4.685	4.693	4.525	4.540	4.702	4.568	4.554	4.382	4.302	4.240	3.918
1977	3.695	4.067	4.178	4.079	4.044	3.983						

APPENDIX 5

Mean Month-to-Month Changes, by Phase

	- 100 y^*_a -		- 100 y_L -	
	Reference Cycles	Growth Cycles	Reference Cycles	Growth Cycles
<u>Contractions</u>				
Mean Change (1)	- 2.32	0.36	- .75	1.28
t	- 1.03	.26	- .33	.89
NvNR	1.62	- .25	1.97	.19
SR	6.96	7.37	6.49	6.85
x_{med}	- 1.81	- .86	- 1.03	.69
<u>Expansions</u>				
Mean Change (2)	1.85	1.79	2.62	2.67
t	2.27	1.95	3.13	2.82
NvNR	.14	1.16	.69	1.87
SR	8.31	8.73	8.73	9.25
x_{med}	2.24	2.30	3.64	3.22
<u>Difference</u>				
(2)-(1)	4.17	1.42	3.37	1.39
t	1.74	.84	1.39	.81
χ^2_1	6.87	4.75	6.55	2.70

Note: Since the percentage rates have been multiplied by 100, the mean monthly changes are in basis points.

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