F I N A N C I A L F U T U R E S

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INTRODUCTION

This report is on the valuation models and theories of fixed income financial futures contracts. In order to understand these theories a general explanation of the futures market is needed. The first three sections of this report provide this background information by describing the evolution of the futures market, its exchanges and trading practices, and finally its delivery mechanics. The forth section reviews current models and theories.

EVOLUTION OF THE FUTURES MARKET

In the mid-1840s Chicago became the market center for farm products of the states boarding Lake Michigan. Because of the erratic and seasonal supply of farm products, prices would often fluctuate by as much as three hundred percent within a single year. In 1848, to alleviate this feast-to-famine cycle and to attract capital for farm product storage facilities the Board of Trade of the City of Chicago was formed. During this period a practice know as forward contracting developed. Producers agreed to sell grain to buyers on a date following the harvest. Still market price swings could result in defaults on these contract. To solve this problem buyers and sellers began the practice of depositing money with third parties as performance bonds. Over the years this market continued to evolve and by the 1870s the elements of a futures market were established. These elements included: 1. Standard quantity contracts, 2. Quality determined by inspection with price premiums and discounts based on quality above and below standard, 3. Margin/performance bond requirements, 4. Established delivery dates, 5. Ability to offset contracts of the same delivery month, and 6. Negotiated open outcry market prices.

In a fashion similar to farm product prices, in the 1970s government interest rates began experiencing sharp changes in value over short periods of time. This high volatility, the fact that the outstanding dollar value of these instruments was vast, and the fact that a small 1% increase in rates exposes a mortgage holder to a 5 to 6% loss in face value, lead to the development of financial futures. The first of these financial futures contracts began trading in October 1975 on the Chicago Board of Trade (CBOT). The first financial future was the Government National Mortgage Association (GMNA) contract which was designed to hedge mortgage-related debt. The GMNA contract was closely followed by the development of the 90-day Treasury bill contract. The T-Bill contract began trading on the Chicago Mercantile Exchange (International Monetary Market (IMM) or the Merc) in January 1976. Again in September 1977 the CBOT introduced another financial future, the US Treasury bond contract. Finally, several years later in May 1982, the CBOT issued the 10-year Treasury note futures contract. A summary of these contracts and their features can be found on the following page.

Other financial futures currently being traded include: the 90-day certificate-of-deposit, three-month eurodollar time deposit, and stock index contracts.

EXCHANGES AND TRADING PRACTICES

The commodities market has evolved into several market makers with one centralized clearinghouse. The largest market maker of the longer term contracts is the CBOT. Its contracts include the US T-Bond, GMNA, and 10-year T-Note. The CBOT also trades a market index future. The IMM is the dominate market maker for the shorter term maturity contracts. These shorter term contracts include the 90-day T-Bill, 90-day certificate-of-deposit, and 90-day eurodollar contracts. The IMM also trades in a S&P

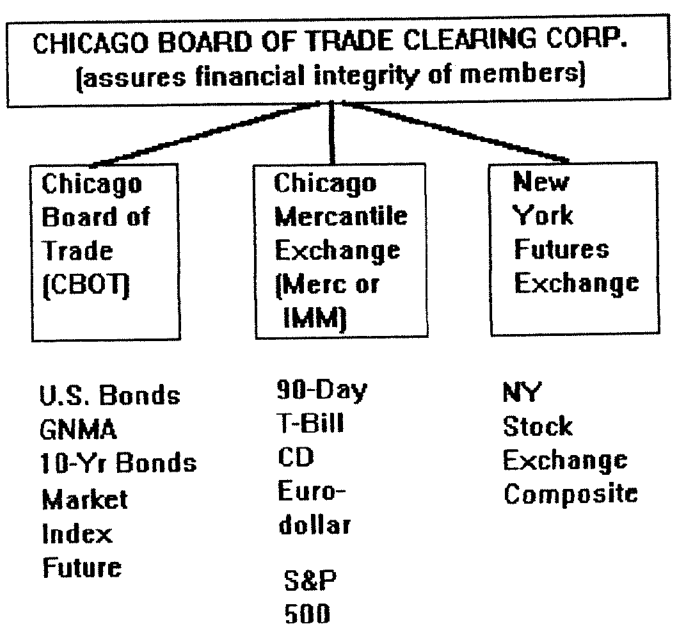
SUMMARY OF FIXED-INCOME FINANCIAL FUTURES CONTRACTS

	U.S. TREASURY BOND	10-YEAR NOTE	GNMA COLLATERAL DEPOSITORY RECEIPT CONTRACT	90-DAY U.S. TREASURY BILL
EXCHANGE	CBOT	CBOT	CBOT	IMM
BEGAN TRADING	Aug-77	May-82	Oct-75	Jan-76
CONTRACT SIZE	$100,000	$100,000	$100,000	$1,000,000
TICKER SYMBOL	US	TY	GM	TB
MIN. PRICE FLUCTUATIONS (POINTS)	1/32	1/32	1/32	.01 (1 BASIS PT)
MIN. PRICE FLUCTUATIONS (DOLLAR)	$31.25	$31.25	$31.25	$25.00
LIMIT MOVE (POINTS)	2	2	2	.60
LAST DAY OF TRADING		Business day prior to last 7 business days of delivery month		2nd day following 1st day of delivery month
ORIGINAL MARGIN	$3,000	$3,000	$3,000	$2,500
MAINTENANCE MARGIN	$2,000	$2,000	$2,000	$2,000

500 composite index future. The New York Stock Exchange Composite Index is traded on the New York Futures Exchange (NYFE). At the center of these market makers is the Chicago Board of Trade Clearing Corporation. This clearinghouse guarantees all transactions and, therefore, eliminates the need for buyers and sellers to know one another. In order for the clearinghouse to make such guarantees it requires all members to meet financial and professional criteria established by its board. The clearinghouse also sets margin requirements and adjusts monetary value of open positions each day to reflect current valuations. This process is termed marking-to-market. The clearinghouse places the required margin calls to its members or allows its members to withdrawal any excess margin funds.

Below is a diagram of the general market structure:

EXCHANGE STRUCTURE



Trading in financial futures is much like trading in any other market. Customers generally work through brokers to place orders. The brokers transmit the instructions to the trading floor of the appropriate exchange. When the order is received on the exchange it is time stamped and rushed to the pit. In the pit, floor brokers execute the buy or sell request. Also like other exchanges the financial futures exchanges allow such order types as a market order, limit order, stop order, straight cancel, or open order. Unlike other markets, however, futures trading requires that the customer put up a specified margin deposit. In commodity trading, there is no tax advantage to holding a position for a specific time period. All profits and losses from contracts on regulated exchanges are treated as 60% long-term and 40% short-term for tax purposes. Additionally, because of price volatility in the futures market a special order type (e.g. limit order) may not be executed when the price ticks at the stated execution price. This is because unlike stock security trading where all orders are channeled to a specialist who records the orders as received and executes them in sequential fashion, futures trading is performed in open market pits. This market pit approach means that a price may be reached and then change before the special order can be executed.

Of course the most unique aspect of the futures market is that unless a contract is offset by another contract in the opposite direction, the holder of the short position, that is the person obligated to deliver the underlying security, will have to deliver the underlying financial instrument to the holder of the long position, that is the person obligated to receive the underlying security. Such deliveries are rare but important.

DELIVERY MECHANICS

Typically less then 2% of all financial futures are offset by the actual underlying security (e.g. T-Bill or GMNA). Most contracts are closed out by the purchase or sell of an opposite trading position then the original position held. Financial futures contracts that are not offset by an opposite trade must be closed by the delivery of an appropriate instrument or by making a cash payment. Although delivery seldom takes place its possibility remains the major factor in keeping the difference between the futures price and underlying spot or security price in proper relationship. In general, the process of delivery on futures contracts is simple. When a short is to be closed through delivery the broker informs the clearinghouse. The clearinghouse then uses an predetermined method for selecting an open long position. The clearinghouse informs the broker who in turn informs the long position that the open position will be satisfied by delivery. The cash instrument used to transfer title may be a T-Bond, Note, Bill, etc. For some futures contracts (i.e. Eurodollar and stock index futures) cash settlement is required. Because the delivery method is a major component of future price determination, the specifics of each of the major fixed-income security instruments is discussed below.

The delivery of a T-Bond contract can be initiated during any business day of the expiration month or it can commence on the second to the last business day of the month just before the delivery month. This period is known as the delivery window. When the yield curve is steep, deliveries usually take place on the last permissible day because overnight financing costs are less than the bond coupon income. When the yield curve is inverted, most deliveries are made on the first permissible day since the overnight financing cost exceed coupon income. To be deliverable, a contract grade T-Bond must have a minimum of 15 years to maturity remaining on the date it is delivered against the futures position. If the bond is callable, it must have 15 years to the call date remaining. The price quotes in the T-Bond futures market are based on a bond with an 8% coupon rate and a 20-year maturity. The actual amount paid or received for the particular bond being delivered must, therefore, be adjusted by applying a conversion factor and adding any accrued interest. The conversion factors are provided by the CBOT. These factors assume that the bonds have semiannual coupons with semiannual compounding. Premiums or discounts are amortized over the life of the issue. Bonds may sell in the cash bond market at prices above or below the converted price of the futures contract (i.e. futures price times conversion factor). The bond that is "cheapest to deliver" (i.e. for which the difference between the invoice price and the market price is the most positive) is the bond that T-Bond futures traders focus on in making transaction decisions. Generally the cheapest bonds are those with the highest coupon and longest maturates. Although, it is possible for lower coupon bonds with shorter maturities to become the more desirable. The delivery procedures and invoicing routines for 10-Year Note futures are identical to those described for the long-term T-Bond contracts. The remaining maturity of notes eligible for delivery must be not less than 6 l/2 years or more than 10 years.

The delivery subtleties for a GNMA CDR contract are materially different from the T-bond contract. GNMA contract delivery can only be made with a collateralized depository receipt (CDR). The CDR is a bank document certifying that the bank has received on deposit the equivalent of $100,000 principal balance GNMA 8% certificates. This instrument is unique in the marketplace and suffers from a lack of liquidity. The actual CDR delivery procedure is similar to the T-Bond contract. The invoice amount is the settlement price multiplied by $100,000 converted into an equivalent GNMA at 8% (conversion factors are supplied by the CBOT and are based on an average 12 year prepayment period and 30 year mortgage term), plus accrued interest. The delivery rules also permit a short to deliver a principal balance equivalent to $100,000 plus or minus 2 1/2 percent. The over or under amount is called the tail. The complexities of these calculations make profitable deliveries difficult and rare. Most speculators would find it unwise to take delivery of a CDR.

The 90-Day T-Bill delivery procedures is simple and invoicing calculations are fundamental. The IMM delivery regulation requires that deliveries to be cleared by 1:45 P.M., EDT. If this deadline is missed, the short is charged one or more days of interest. The first delivery day in a nearby contract is variable and relates to outstanding one-year T-Bills. The actual date is determined by the first day of the month on which an outstanding one-year T-Bill has 13 weeks remaining to maturity. Delivery can be made during the three business days following the last day of trading. Interest calculations are unnecessary since Treasury bills are discount instruments.

FIXED-INCOME FINANCIAL FUTURES VALUATION THEORIES

In its simplest form, a futures price is the price set today to be paid in the future for a security. The price of a futures contract thus depends (in part) on an assessment of the future price of the underlying instrument at delivery, based on information currently available. In valuing financial futures the starting point is the carry cost model. This model was originally developed for storable physical commodities such as grains, metals, etc. The model's name reflects the fact that these types of commodities can be stored and carried from one contract month to another if that is advantageous. The price for the future according to this model is a function of the cash market and the cost of carrying or storing the commodity over the time to delivery. The carrying cost concept links current prices of futures to current cash prices and the cost of carrying. When prices in either the cash or futures market are cheap relative to the other market after considering carrying cost, marginal purchasing will occur in the market with the lowest price. If we assume that any such arbitrage opportunities will quickly eliminate differentials in the cash and futures markets then the following relationship should exist:

$$FP_t = CP(1+r)^t$$

or ignoring interest compounding, $FP_t \approx CP + (CP \times r \times t)$; where:

FP_t = current price of a futures contract calling for delivery in t months

CP = current price of a cash security deliverable into the futures contract

r = rate of interest per month (considered financing cost)

t = number of months until delivery (note that a one month period and rate are being used in these equations)

Thus the FP_t will equal the price of the deliverable security, CP, plus the cost of financing the purchase of that security for t months until delivery, at a monthly interest rate of r. Another way of seeing this is that the FP_t equals the amount that would be accumulated if the purchase of the security is delayed until the delivery date and the CP amount were deposited in the bank earning r interest for t months. Both these statements are true as long as the cost of financing equals the interest earned which may or may not be the actual case.

In order to understand how the cost of carrying effects financial futures it is necessary to incorporate the term structure of interest rates. One theory of the term structure of interest rates is the unbiased expectations theory developed by Lutz (1940). This theory states that if investors are indifferent among investment combinations reflecting desired maturity then the yields of bonds maturing one period apart would be entirely based on the rate of a single period security today as well as the expected rates that are anticipated to be available in the future. The price of any two securities differing only in time to maturity are linked by what is termed the forward (expected) rate. The basic formula relating spot (currently observable rates) and forward rates is:

$$r_{0,t} = [(1+r_{0,1})(1+R_{1,2})\ldots(1+R_{t-1,t})] - 1.0$$

That is, the rate on a security maturing in period t is related to the spot rate on a security maturing in one period ($r_{0,1}$) and forward rates, R, prevailing between the end of period one and time t. Simplifying this equation into a two period example and rearranging the terms provides the following equation for the forward rate:

$$R_{1,2} = [(1+r_{0,2}) / (1+r_{0,1})] - 1.0$$

In its simplest form the CP is equal to the present value of the securities face value which is, using a two period example, equal to:

$$CP = \text{Face Value} / (1+r_{0,2})$$

Because forward rates are implicit in current rates, this formula can be restated as:

$$CP = \text{Face Value} / (1+r_{0,1})(1+R_{1,2})$$

where $r_{0,1}$and $r_{0,2}$ are spot rates, and $R_{1,2}$ is the forward interest rate. Since $r_{0,1}$ is also the carrying or financing cost over the first period, the FP_t formula can be restated, again using a two period example, as

$$FP_2 = [\text{Face value} / (1+r_{0,1})(1+R_{1,2})] \times (1+r_{0,1})$$

or

$$FP_2 = \text{Face value} / (1+R_{1,2})$$

Thus, the futures price is equal to the face value of the security (e.g. treasury bill) divided by the second (e.g. 90 day) period. Any difference between these cash and futures prices is referred to as the "basis". For financial futures this basis is primarily a function of the financing cost of the cash security which implies that the difference should equal the carrying cost as a percentage of the face value. Also, the difference between the rate implied by the futures price and the rate on the security (e.g. treasury bill) deliverable into the future (e.g. 180 day) should equal the financing rate for the period prior to the futures delivery. Finally, the sum of the rate, $r_{0,1}$ (e.g. on a 90-day bill) and a future calling for delivery in the future (e.g. 90 days) $R_{1,2}$ should approximate (not exactly because it ignores monthly compounding) the rate of the security extending to the second period, $r_{0,2}$. (e.g. 180-day treasury bill). If there is any differences between these rates arbitrageurs should enter the market with the highest forward rate (lowest price) and seek to take advantage of the discrepancies. For example, if an arbitrageur in T-Bills feels that the carrying cost implied in the futures price is attractive relative to rates available on financing using a repurchase agreement (repo). He can borrow cash at the repo rates to finance a cash position in bonds, which can be delivered into a short position.

To summaries the simple case, buying a future allows the buyer to avoid tying up funds by purchasing the security prior to the futures delivery date. Forward rates can be thought of as the market's current price for tying up funds over the future period to which the forward rate applies. Thus, futures are directly influenced by forward rates that are implied in the yield of securities that are equivalent to those that can be purchased with a futures contract. Thus, all futures prices will respond to any change in carrying cost. That is, any information that changes the markets assessment of forward rates will result in changes in futures prices (i.e. the spread will widen as forward rates (carrying cost) rise and will narrow as rates fall).

Income producing securities modify the simple case. When an instrument is income producing (e.g. coupon interest payments) this income is a disincentive to purchasing the futures contract as an alternative to the cash security and its impact must be netted against any carrying charges to determine the theoretical futures price. The greater the income the lower the futures price because purchase of the future as an alternative to the cash security means foregoing such income. Additionally, the earlier the income flows are received, the greater the "reinvestment income" that can be earned on those flows. To account for the impact of the income flows, the pure carrying cost model is modified as follows:

$$FP_t = CP(1+r)^t + \Sigma_t\, I_t \,/\, (1+r)_t + \lambda$$

where I_t is the cash flows accruing to the holder of the deliverable security during month t (note that the coupon income of fixed-income securities is constant over time, r is not) and λ is the difference between the cash received by the seller of the futures at settlement and the proceeds that would be realized if those same securities were sold in the cash market. λ is generally the result of time delays and transaction costs. Indeed in an empirical study conducted by Theodore M. Barnhill (1990), he was able to concluded that estimates of the forward prices explain the majority of observed fluctuations in futures prices for all maturity categories (note that this study was limited to T-Bond futures). This study also noted that, on occasion, higher than estimated forward prices were observed indicating the existence of an additional factor, or factors, affecting futures prices[1]. Other factors causing deviations from the theoretical price may result from:

- Futures contracts offering additional liquidity because they can be readily closed out.

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[1]Barnhill, Theodore M., "Quality Option Profits, Switching Option Profits, and Variation Margin Costs: An Evaluation of Their Size and Impact on Trasury Bond Futures Prices," Journal of Fiancial and Quantitative Analysis, Vol 25, No. 1, March 1990, pp 65-85

- Sellers having discretion as to the actual securities delivered causing the buyer to suffer delivery risk and the seller to gain a quality option.
- The fact that T-Bond and Note futures have elements of timing risk, that is, the futures seller may choose any day in the delivery month to deliver including after the futures contract ceases trading.
- The fact that price controls exist in the futures markets and present liquidity risks.
- Errors in the estimations of forward rates.
- The requirement of futures trading initial margins.
- The immediate posting of variation margins (marking-to-market) providing immediate access to profits if they occur

Using a theoretical approach Dr. Martin Leibowitz (1982) examines the implications of the theoretical advantage of the futures contracts relative to the cash security. To do this he divides the basis into a "carry basis" reflecting the direct effect of debt market factors, and a "value basis" representing the theoretical advantages of the futures contract relative to the outright purchase of the underlying security. This value basis is, therefore, equal to the total basis minus the carry basis. Although no empirical evidence is presented, the analysis demonstrates that the value basis should exists and that it will cause futures prices to move in the fashion that is usually associated with fixed income securities during parallel term structure market shifts, but to move with greater sensitivity to yield curve reshaping even when the cash security's yield remains unchanged[2].

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[2]Leibowitz, Martin L., "The Analysis of Value and Volatility in Financial Futures," Salomon Brothers Center for the Study of Financial Institutions, 1982

T-Bond and Note futures contracts grant the short futures position two valuable delivery options: the right to choose the optimal bond for delivery and the right to choose the optimal time for delivery. The first option is generally known as the quality option and the second the timing option. Combining the timing option with the quality option (i.e., placing specific exercise and delivery time restrictions on the quality option) produces an additional option dubbed the wild card. There exists conflicting evidence on the value of the delivery options. Benninga and Smirlock (1985) and others argue that the quality option is valuable because the Board of Trade uses a conversion factor that prices all eligible bonds to yield 8%, regardless of the prevailing market rates. They contend that the equilibrium futures price must be bid down by the value of the implicit quality option, otherwise the short would benefit at the expense of the long position[3]. These theories were supported by empirical evidence provided by Barnhill (1990). He found that T-Bond futures prices generally are lower than the estimated forward price, with the size of the deviation starting at relatively small levels and increasing with the maturity of the futures contract. This is consistent with the theory that observed T-Bond futures prices reflect the value of the delivery options, which also increase with the length of the holding period[4]. In contrast to this theory, Livingston (1987) argues that a continuously adjusted hedge will drive the value of the quality option implicit in the futures contract towards zero in perfect and frictionless markets, and that the quality option derives its value from market imperfections[5].

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[3]Hegde, Shantaram P., "An Ex Post Valuation of the Quality Option Implicit in the Treasury Bond Futures Contract," Journal of Banking and Finance, 1990, pp 741-760
[4]Barnhill, Theodore M., "Quality Option Profits, Switching Option Profits, and Variation Margin Costs: An Evaluation of Their Size and Impact on Trasury Bond Futures Prices," Journal of Fiancial and Quantitative Analysis, Vol 25, No. 1, March 1990, pp 65-85
[5]Hegde

Another type of option which is available to arbitrageurs is the switching option. This switching profit comes about because the differences between the forward prices of the potentially deliverable bonds fluctuate in a constrained range and tend to be mean reverting. This pattern of changes in relative prices appears to result from both shifts in the term structure of interest rates and by temporary disequilibrium in bond prices or so-called "noise." Under such circumstances, traders encountering an opportunity to lock in a moderate-sized switching profit due to fluctuations in the relative levels of forward prices[6].

Price controls present a liquidity risk for the traders in the futures markets and may be reflected in futures prices. There are three forms of price control. First is the price limit, second is trading suspension (Hopewell and Schwartz (1976, 1978) provide detailed descriptions of the conditions which justify trading suspensions), and minimum price change stipulations. Daily price movement in futures prices is limited to a specified amount. When the limit is reached traders lose liquity in the price range that they may prefer to trade. Trading suspension halts all liquidity. In regards to minimum price changes, Osborne (1960) and Neiderhoffer (1966) found that prices ending in even eighths occurred more frequently than price ending in odd eighths. Traders may be unwilling to transact if the price change is within the minimum range because of rounding[7].

Another cost associated with futures is the required maintenance margin. The maintenance margin is determined by each member firm, with the minimum set by each exchange. In general, the initial margins are quite minimal, about 2%, and can

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[6]Barnhill

[7]Ma, Christopher K., Rao, Ramesh P., Sears, R. Stephen, "Limit Moves and Price Resolution: The Case of the Treasury Bond Futures Market," The Journal of Futures Markets, 1989, Vol. 9, No. 4 321-335

be put up in the form of U.S. T-Bills; therefore, interest can continue to be earned on margin amounts.[8] It is generally assumed that the maintenance margins have little impact of futures prices.

Another component of futures prices may be the systematic risk premium described by the Capital Asset Pricing Model (CAPM). The CAPM was applied to futures contracts in an effort to discover, and measure the size of, a risk premium for these assets by Joan C. Junkus (1991). No systematic risk premium in futures returns was found[9].

An important aspect of futures prices is the well known "price convergence" or "pull-to-parity" effect. This effect is related to the passage of time, shortening the pre-delivery time, which reduces the carry cost and thus causes the futures price to converge to the underlying security price[10]. A positive and statistically significant relationship exists between the futures market and the underlying security because of the "pull-to-parity" principal. The "pull-to-parity" principle is evidenced in the cash market, when the 91-day T-Bills auctioned each week has the same maturity as the six-month T-Bills that were auctioned three months earlier. At auction time, the rate on the six-month bill that has 91 days remaining to maturity converges with the rate on the 91-day bill being auctioned. Occasionally, basis differences do not converge between the cash market and the futures market as expected because of unusual circumstances. For example, on June 16, 1980, the basis point difference between the June 1980 T-Bill futures contract and the when-issued, September 18, 1980, maturity T-bill was relatively large. This rarity was caused by concern that there were more shorts outstanding in the June

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[8]Baker, James V. Jr., "A beginner's guide to proper use of interest rate futures," ABA Banking Journal, February 1982, pp 129
[9]Junkus, Joan C., "Systematice Skewness in Futures Contracts," The Journal of Futures Markets, Vol. 11, No. 9-24, 1991, pp 9-24
[10]Leibowitz

1980 T-bill futures contract than there were deliverable bills outstanding. Convergence occurred quickly, however, when fears began to fade[11]. The peculiarities associated with the bond and note futures contracts deliver methods and the associated delivery options may also prevent full cash security to futures price convergence.[12].

The unbiased expectations theory is not the only theory for the term structure of interest rates. In fact, Dua found evidence that forward rates are not unbiased estimates of future expected interest rates. The liquidity preference theory (Hicks 1946) asserts that the presence of risk-averse investors ensures that forward rates are positively biased estimates of expected future rates, because investors have to be offered a premium to compensate them for the risk of leading long[13]. The basic formula relating spot and forward rates can be modified to include a liquidity premium as follows:

$$r_{0,t} = [(1+r_{0,1})(1+R_{1,2}+L_{1,2})\ldots(1+R_{t-1,t}+L_{t-1,t})] - 1.0$$

where $L_{t-1,,t}\ldots > L_{1,2}$

$L_{1,2}$ is the premium required for holding a two-period security instead of two, one-period securities. This expression assumes the liquidity premium is additive and increases in value with the number of periods. This formula cause the yield to raise above the straight implied forward rate yield as it requires additional yield for longer maturities, which would tend to lower computed forward rates used in calculations of futures prices.

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[11]Baker, James V. Jr., "A beginner's guide to proper use of interest rate futures," ABA Banking Journal, February 1982, pp 129
[12]Labuszewski, John and Kamradt, Michael, "Cash Factors that make Treasury Futures Tick," Futures (Cedar Falls, Iowa) V14, Aug. 1985 and Sep. 1985
[13]Dua, Pami, "Survey Evidence on the Term Structure of Interest Rates," Journal of Economics and Business, 1991; 43, pp 133-142

Modigliani and Sutch (1966) propose an alternative to the liquidity preference theory, the preferred habitat theory, which states that the supply and demand for funds in each habitat give rise to any pattern of the term premium. This implies that changes in the relative supplies of debt instruments of different maturities would affect the term structure of interest rates. For instance, an increase in the supply of short-term relative to long-term securities would increase short-term rates relative to long-term rates. Empirical evidence concerning the relevance of this hypothesis is mixed[14] and this theory should be less important in setting rates to the extent that economic units use futures to adjust mismatches between their assets and liabilities.

In regards to estimating forward rates, it should be noted that additional and perhaps better models do exist then those presented here. One simple and versatile model in which all security prices and rates depend on only one factor - the short rate - was developed by Black and others. In this model the current structure of long rates and their estimated volatilities are used to construct a tree of possible future short rates. This tree can then be used to value interest-rate-sensitive securities[15]. Another model developed by Hillard and others is autoregressive and uses a covariance matrix of unexpected changes in forward rates and of spot interest rates[16]. Any modifications to the calculation of expected forward rates provided by such models will of course directly impact the futures price calculations

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[14]Dua

[15]Black, Fischer, Dermam, Emanuel, and Toy, William, "A One-Factor Model of Interest Rates and Its Application to Treasury Options," Financial Analysts Journal, January - February 1990, pp 33

[16]Hilliard, Jimmy E. and Jordan, Susan D., "Hedging Interest Rate Risk with Futures Portfolios under Full-Rand Assumptions," Journal of Financial and Quantitative Analysis, Vol. 24 No. 2, June 1989.

CONCLUSION

In conclusion futures pricing is generally tied to the underlying securities price and the current term structure of interest rates. The determination of the relationships involved in the term structure will have a direct impact on the carrying cost impact on futures price determination. In addition to the standard carrying cost impact on futures prices several peculiarities in the delivery processes may also impact price determination.