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**THE EFFICIENCY OF THE BANKERS'
ACCEPTANCES FUTURE MARKET**

Samar Obaid

A Thesis
In
The Faculty
of
Commerce and Administration

Presented in Partial Fulfilment of the Requirements
for the Degree of Master of Science in Administration at
Concordia University
Montreal, Quebec, Canada

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Abstract:

The Efficiency of the Bankers' Acceptances Futures Market

Samar Obaid

The demand for financial futures to hedge against short-term interest rate risk resulted in the creation of the one-month and the three-month Bankers' Acceptances futures (BAR and BAX, respectively). The effectiveness of these futures as hedging tools depends, in part, on the efficiency of their markets. In this paper, the efficiency of these new futures is examined, extending Rendleman & Carabini's (1979) arbitrage bounds' methodology. The results show that the BAR market is efficient with respect to quasi arbitrage opportunities. On the other hand, the BAX market is inefficient as it contains profitable quasi-arbitrage opportunities. Nevertheless, there is some indication that the BAX market has become more efficient over time, and that contracts with longer maturities are more efficiently priced than near-term contracts. The efficiency of the BAR and BAX contracts just before delivery is also examined. The evidence shows that just before the delivery date, all BAX contracts are efficient. On the other hand, only the nearby BAR contract shows efficiency. In addition, the nature of arbitrage between actual and theoretical futures prices as well as Samuelson's Maturity Hypothesis are examined. The results show that the BAR market contains greater variability as time to maturity approaches. However, only the front month BAX contract shows increased variability as time to maturity approaches. As for the other contracts, there appears to be a larger degree of arbitrage present in the BAX contracts with larger maturities that has helped these contracts become more efficiently priced.

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i. introduction:

Evolving financial markets present new opportunities and risks. One major risk facing money managers today is interest rate risk. To remedy that, financial futures were developed as tools for managing interest rate risk. Treasury-bill futures were the first financial futures created as a hedge for short-term liabilities. However, at times of economic disturbances, when the credit quality of institutions becomes very important, the spread between Treasury-bills and other private money market instruments becomes very volatile¹. This means that hedging private short-term liabilities with Treasury-bill futures might not be very effective. Consequently, demand for the development of futures contracts on private short-term liabilities has increased. In response, in the U.S., Eurodollar futures were developed to become the most widely traded short-term financial futures in the world. In Canada, the one-month and the three-month Bankers' Acceptances futures (BAR and BAX, respectively²), were developed as a parallel to the Eurodollar futures on Canadian short term liabilities. As Bankers' Acceptances are generally considered a benchmark for Canadian money market instruments, BA futures could benefit a large variety of hedgers such as financial institutions, government agencies, pension funds and corporations that borrow or lend money in the cash market.

If the BA futures market was not efficient, then it would have an added attraction

¹ The spread between BA's and Treasury-bills could get as large as one hundred basis points in times of economic upheavals.

² The 1994 trading volume was 12,172 for the BAR and 1.9 million for the BAX.

because of the existence of arbitrage opportunities where profits could be made with zero investment and relatively low risk. However, if that was the case, then hedging interest rate risk with BA futures would become more like speculation because of the larger risk involved.

In this paper, efficiency in the sense of returns predictability (as defined in Fama (1991)) of the Bankers' Acceptances futures market is examined. The study adapts Rendleman & Carabini's (1979) methodology that tested the efficiency of Treasury-bill futures. Also, the efficiency of BA futures contracts just before the last day of trading of the front month is examined to check for a delivery day effect. Then, a GARCH model is used to test if the divergence between the actual and theoretical futures prices decreases as maturity approaches, which is consistent with the idea that there is a greater degree of arbitrage for near-term securities. Finally, Samuelson's Maturity Hypothesis, which states that the variability of the prices increases as the maturity day approaches, is tested.

This paper is organized in the following manner: Section one is an introduction to the Bankers' Acceptances futures market. Section two is a literature review of studies examining interest rate futures markets' efficiency. Section three is a description of the data and the methodology. Section four contains summary statistics related to the efficiency of the BA futures market. Section five contains summary statistics related to the efficiency of the BA futures market just before the last trading day. Section six contains Samuelson's test for the variability of the futures contract as maturity approaches as well as results on the nature of arbitrage between the cash and the futures markets. Section seven contains a summary and conclusion.

1.1 Specifications of BA futures Contracts:

The three-month Canadian Bankers' Acceptances futures (BAX) began trading at the Montreal Exchange in 1988 for delivery in March, June, September, and December. The number of BAX contracts traded at the same time is eight, the latest contract being for delivery twenty-four months in the future. The face value of each contract at maturity is C\$1 million. Thus, the purchase (sale) of a March 1996 contract represents the purchase (sale) of C\$1 million of three-month Bankers' Acceptances to be delivered in March 1996 at an agreed upon price.

The one-month Canadian Bankers' Acceptances futures (BAR) began trading at the Montreal Exchange in 1992 for delivery every month. The number of BAR contracts traded at the same time is six. The face value of each contract at maturity is C\$3 million, so that the purchase (sale) of a March 1996 contract represents the purchase (sale) of C\$3 million of one-month Bankers' Acceptances to be delivered in March 1996 at an agreed upon price.

If held to delivery, a BA futures contract is settled on the business day following the last trading day in the delivery month. The BA futures are cash settled to a final settlement price that is "based on the average of three-month BAX and one-month BAR bid rates quoted on the CDOR page of Reuters' Monitor Service at 10:00 a.m. (EST/EDT) on the last trading day, the two highest and the two lowest being eliminated"³.

When a position is opened in the futures market, the exchange requires an initial margin from the futures trading parties as good faith money to guarantee that the parties will

³ Montreal Exchange, "BAR, BAX Reference Manual on the One-Month and Three-Month Canadian Bankers' Acceptances Futures," P. 26.

abide by the terms of the contract. To open a position in the BA futures market: A speculative trader is required to pay a minimum margin of C\$1,900; A hedge trader pays a minimum of C\$1,000; A spread trader pays a minimum of C\$ 375 for a position in a BAR contract, and C\$ 375 to C\$1,000 for a position in a BAX contract. By offsetting an initial buy or sell order prior to the delivery date, it is possible to trade in the futures market on margin. The commission for executing an order in both the BAX and the BAR markets is C\$ 80 per round trip⁴.

Prices in the Bankers' Acceptances market are quoted on a discount basis, that is at a price lower than the face value. Prices in the BA futures market are also quoted on a discount basis. The interest earned on a BA, if held to maturity, is the difference between the purchase price and the face value. Prices in the BA futures market are quoted in terms of the ME (Montreal Exchange) Index, which represents 100 minus the yield of one-month BAs for BAR contracts and 100 minus the yield of three-month BAs for BAX contracts. The minimum price fluctuation is one basis point which is equal to \$25 ($= \$1,000,000 * 0.0001 * 90/365$) for a BAX contract, and also \$25 ($= \$3,000,000 * 0.0001 * 30/365$) for a BAR contract.

Trading hours for the BA futures contracts are from 8:20 a.m. to 3:00 p.m. (EST/EDT).

1.2 Bankers' Acceptances:

A Bankers' Acceptance (BA) is a widely accepted short-term financing instrument that provides an alternative to other short-term financing methods (e.g. bank loans and

⁴ This rate is based on a survey of investment dealers.

commercial paper). Typically, companies choose the method depending on relative interest costs. A BA is a promissory note drawn for payment by a corporation, with a specific maturity date. The underlying payment is guaranteed by a reputable bank. Since the credit standing of both the bank and the borrower corporation serve to back the BA, it is viewed as a low risk security. Banks typically charge $1/4$ to $3/4$ of one percent of the BA's face value as a stamping or acceptance fee. The actual acceptance fee charged depends on the company's credit worthiness, the instrument's face value, its maturity date, and market conditions. The bank may discount the BA and give the discounted value to the customer/company. Alternatively, the company could deliver the BA to an investment dealer, who would purchase it at a discount from the face value. The bank or the investment dealer could resell the BA in the secondary market for a profit, or they could hold it to maturity in their investment portfolios. The customer has to pay the BA's face value to the bank before the maturity date so that the bank can pay the ultimate holder on the maturity date. BAs usually sell for maturities of 30, 60, 90 or 180 days and are issued in multiples of \$100,000⁵. In addition, "BAs play a key role in letters of credit, as together they achieve the dual goal of the purchaser in assuring the beneficiary's compliance with the trade terms and carrying the transaction on a self-financing basis"⁶.

In Canada, there is a very active secondary market for BAs. This spot market is the underlying market for the Bankers' Acceptances Futures contracts which are the basis of this study. The quoted rate for BAs has been very closely correlated with the T-bill rate for the

⁵ Hatch & Robinson (1989), p. 94.

⁶ Lazar Sarna, "Bankers' Acceptances," p. 50.

past decade. On average, the difference between the BA and the T-bill rates has been less than fifteen basis points⁷. This demonstrates that markets perceive BAs to be very high quality instruments⁸.

1.3 Uses of Bankers' Acceptances futures contracts:

There are four basic transactions that can be carried out in interest rate futures markets:

1. Hedging: "Futures contracts can be used to hedge against interest rate movements in order to protect against actual or expected cash positions of market participants"⁹. A hedger taking a long position in the spot market should, therefore, take a short position in the futures market to reduce his risk. To benefit from hedging, the cash and futures prices should move more or less in the same direction. Because of the way BA futures contracts are designed, futures prices reflect underlying cash market prices throughout the lifetime of the contract. This implies that the correlation between the BA cash market and the BA futures market is high. Taking into consideration that BA futures prices are quoted as 100 minus the BA yield, the correlation between the long (short) cash BA and the short (long) BA futures positions should be negative so that an upward (downward) movement in the cash prices results in a

⁷ Montreal Exchange, "BAR, BAX Reference Manual on the One-Month and Three-Month Canadian Bankers' Acceptances Futures," P. 10.

⁸ The actual cost to the borrower includes the acceptance or stamping fee, and thus is higher than the quoted rates to investors in the secondary market.

⁹ Burger, Lang & Rasche (1977), "The T-Bill Market and Market Expectations of Interest rates," page 2.

downward (upward) movement in the futures prices.

Bankers' Acceptances are also closely related to other short-term corporate and government interest rate financial instruments. For example, the correlation between BAs and R-1 commercial paper is nearly 99 per cent, while the spread between Treasury-bills and BAs is fifteen basis points on average. This implies that BA futures contracts can be used as an effective hedging tool against short-term interest rate risk in other markets.

2. Arbitrage: If two different prices exist for the same security in two different markets, an arbitrage opportunity exists. To explore such opportunities, the arbitrageur should purchase the security in the market where the price is low and then immediately sell it in the market where the price is higher. By doing so, arbitrageurs will drive the prices in the two markets to equilibrium, which will, in turn, increase the effectiveness of hedging in reducing risk. The design of the BA futures allows direct arbitrage between the BAR and the one-month Libor futures contracts as well as between the BAX and the three-month Eurodollar futures contracts.

3. Speculation: A speculator would take a position in the futures market based on his expectations of the price movement of interest-rates. Speculators believe that they can predict price movement better than the market, so they expect to profit from the expected price change. Speculation has a big role in increasing the futures market liquidity as it provides opposite positions for hedgers.

4. Spreading: A spreader would simultaneously buy and sell two contracts with different delivery dates in one market or two contracts in two different markets because he/she expects that the price difference between the two contracts would change in his/her favor.

1.4 The Tax Treatment of Bankers' Acceptances Futures:

There are no specific Canadian income tax rules for the treatment of futures transactions. Nevertheless, the tax treatment depends on the nature of the futures transaction. Speculative transaction usually generate trading income, while hedge transactions should have zero excess loss/profit, in the long-run. Consequently, each transaction is taxed according to the kind of profit it generates.

2. Literature review:

2.1 The Efficiency of Interest Rate Futures Markets:

Market efficiency implies that the prices of securities instantaneously reflect all available information so that abnormal returns cannot be made. There are three categories of market efficiency tests that have been introduced in the literature; First, there are tests of returns predictability, where current prices reflect all available information in past prices and returns, and trading rules cannot be devised to earn abnormal returns (see Fama (1991)). Second, event study tests examine whether current prices reflect all publicly available information. Finally, tests of private information examine whether current prices reflect all information, public or private.

One way of testing the efficient market hypothesis from the returns predictability perspective, is by testing for the existence of arbitrage opportunities. An arbitrage opportunity exists when an investor makes certain transactions that guarantee a profit with zero investment. Arbitrage is defined as "the simultaneous establishment of two opposite positions for the same security in two different markets"¹⁰.

Many researchers have used the Market Expectations Hypothesis framework to test for the presence of arbitrage opportunities. They compared a futures position with a long and short positions in the spot market. If these two positions have identical characteristics, then their prices (yields) should be equal, except for differences in transaction costs. Any

¹⁰ Koblod (1986), p.54

divergence from this equality means that quasi arbitrage¹¹ opportunities exist and that the market is inefficient. To date, all such studies have used U.S. data, and have found evidence of market inefficiency in a quasi arbitrage sense. A brief summary of studies using this approach follows.

Puglisi (1978) tests the efficiency of the T-Bill futures market in the US by comparing the annualized returns of two equivalent investment strategies. The first strategy involves the combination of a long position in a long-term T-Bill and a short position in a futures contract. The second strategy involves a long position in a short-term T-Bill with maturity equal to that of the first strategy. Parametric and sign tests are used to compare the returns of the two strategies.

The data consist of quotes on the Mar, 1976; Jun, 1976; Sep, 1976; Dec, 1976; Mar, 1977; Jun, 1977; Sep, 1977 T-Bill futures rates and the corresponding T-Bill spot rates. Transaction costs are assumed to be a \$60 commission per futures contract.

The results show significant differences between the two strategies, suggesting an inefficient market for T-Bill futures. Puglisi relates this inefficiency to the mispricing of futures contracts and to the small number of institutional investors willing to invest in the futures market at that time.

¹¹ Pure Arbitrage involves financing a position in a portfolio from short-selling an economically equivalent portfolio at a higher price. Quasi Arbitrage involves altering an existing portfolio mix and obtaining an arbitrage profit by selling securities from that portfolio to finance an equivalent position at a lower price.

Poole (1978) and Lang & Rasche (1978), henceforth (L&R), test the hypothesis that T-Bill futures rates are equal to the corresponding implied forward rates.

Poole (1978) uses daily futures and spot rates for the near term contract, from Jan 6, 1976 to Jun 23, 1977. L&R's data consist of thirty randomly selected observations of yields on T-Bill futures contracts and yields on outstanding Treasury securities in all of the following three periods: March 1, 1976 to November 30, 1976; December 1, 1976 to July 31, 1977; August 1, 1977 to March 31, 1978. In both studies, forward rates are calculated to match up with futures rates for each quotation date.

Poole (1978) finds that the differences between the futures and the forward rates are negative and significantly different from zero, indicating that futures rates are lower than forward rates. Poole argues that the negative sign is due to transaction costs, which are significantly larger in the spot market. As for the other factors' effects on the differential, Poole argues that they are the same for both contracts, thus they have no significance. Although the author only tests the near-term contract, he assumes that his results apply to all contracts' maturities.

Similarly, L&R reject the null hypothesis that forward and futures rates are equal. The average differentials, they find, tend to be small and negative for the "nearest to delivery" contracts; in contrast to Poole (1978) who examined only the nearby contract, L&R find large and positive significant differentials for the "further to delivery" contracts.

To specifically test for the existence of profitable arbitrage opportunities (i.e. the returns predictability hypothesis), both studies calculate upper and lower arbitrage boundaries for the futures rates, taking into account transaction costs. Poole finds that profitable

arbitrage opportunities rarely exist, and when they do, they are very small in magnitude and near the lower arbitrage boundary.

I&R find that more profitable arbitrage opportunities exist for the "near delivery" contracts than for the "later dated" ones. When the rates fall outside the arbitrage boundaries, they are usually below the lower boundary for the two contracts nearest to delivery, and above the upper boundary for the further to delivery contracts. This implies that futures rates are usually lower than forward rates for the nearest to delivery contracts, and that they are higher than the forward rates for the further to delivery contracts.

Capozza & Cornell (1978) derive an arbitrage condition relating futures and forward rates. They use weekly quotes of average bid-ask T-Bill spot rates (to compute the forward rates) and closing futures T-Bill rates from January, 1976 to June, 1978.

Their results show a strong differential between the two rates that is small and negative for the near-term contracts (0-13 weeks), and large and positive for the contracts with longer maturities. The authors argue that this is due to several factors including inefficient markets.

Branch (1978) compares futures rates with T-Bill interest rates and Treasury notes. His data consist of quotes for the period starting June 21, 1976 to July 3, 1978. The T-Bill futures rates are collected just before and just after the contracts expired, providing eighteen observations. The matching T-Bill interest rates are collected for maturities of 3, 6 and 9 months. For contracts with longer maturities, Treasury notes replace T-Bills that are not

available.

The results show strong divergences between forward and futures rates especially for contracts with long maturities. Branch argues that this differential is due to the segmentation of the T-Bill futures and spot markets. He explains that if these markets were not segmented, then profit seekers would take advantage of the existing arbitrage opportunities and make them disappear. He also argues that the risk premium attached to the futures interest rates is greater than that attached to the term structure derived rates (forward rates), and that this could affect the forward-futures differential.

Chow & Brophy (1978) test the efficiency of the T-Bill futures market in two ways. First, they compute the term structure implied by the T-Bill futures rates using a pure expectation hypothesis formulation. Then they compare the derived yields with the observed discount yields from the spot market, and test the differences.

Second, they compare a combination of a short-term T-Bill and a futures contract with another T-Bill whose maturity is equal to the maturity of the combination.

Their data consist of biweekly observations of T-Bill spot and futures rates for the period between January 8, 1976 and January 26, 1978.

In both tests, with and without consideration of transaction costs, the differences are significantly different from zero.

Rendleman & Carabini (1979) compare International Monetary Market (IMM) actual and theoretical futures prices. They use daily settlement futures prices for the first three

maturities, and daily bid and ask yields of the T-Bill maturing on the maturity date of each contract and also the bill maturing 91 days after. Their testing period is from Jan 6, 1976 to Mar 31, 1978. Transaction costs are considered to be \$60 for a round trip commission.

To obtain the theoretical prices, the futures contract is treated as a forward contract¹². Then upper and lower arbitrage boundaries are computed using bid-ask cash prices and transaction costs. Finally, using the IMM formula, the equilibrium IMM value corresponding to each contract is computed with and without consideration of transaction costs. The annualized, as well as the non-annualized differentials between the actual and the calculated theoretical IMM prices are computed and summary statistics are obtained. The t-statistics are corrected for serial correlation.

Results for the non-annualized differentials are similar to those of other studies. That is, larger inefficiencies are found for contracts with longer maturities. However, the results for the annualized differentials indicate that the arbitrage opportunities are more significant for the near-term contracts. These contracts appear to become less efficient through time, while the later dated contracts tend to become more efficient through time. The number of arbitrage opportunities decrease when transaction costs are considered. The authors argue that quasi arbitrage opportunities exist in the T-Bill futures market since the investor holding a T-Bill portfolio have lower marginal costs, but doubt that these inefficiencies are large enough to induce portfolio managers to change their investment policies.

¹² Rendleman & Carabini (1979) also use the CIR (1981) model to compute theoretical T-Bill futures and forward prices. The authors find that the differences between the two theoretical prices are 3 to 4 basis points for contracts with 270 days to maturity, and even smaller for contracts with shorter maturities. These differences are insignificant compared to the bid-ask spread in the cash market that is 10 basis points for contracts with 270 days to maturity. The authors conclude that the marking to market effect does not have significant effects on the forward-futures price differential.

Vingola & Dale (1980) compare actual futures prices to the prices implied in the term structure of interest rates (i.e. forward rates) to test for the existence of quasi arbitrage opportunities.

Their testing period is between January, 1976 and December, 1978. The data consist of mean bid-ask T-Bill prices and T-Bill futures prices. The results show that quasi arbitrage opportunities exist especially for the near-term contracts.

Kawaller & Koch (1984) extend Vingola & Dale's work on the efficiency of nearby T-Bill futures contracts. Their data consist of daily T-Bill futures and spot rates for the period of September, 1977 through June, 1982.

In their methodology, the authors test for the equality of futures and forward prices computed from the T-Bill term structure of interest rates. Their results show that the mean differentials for the near-term rates are significantly different from zero.

In contrast, Gruber & Rentzler (1983) apply a direct test of efficiency by examining realistic trading strategies that are more complex than those examined by other studies. Their data consist of daily intra-day bid-ask quotes of T-Bill futures prices as well as T-Bill cash prices noted at hourly intervals on two kinds of T-Bills. The first kind of T-Bills and the futures contracts mature on the same day, whereas the other T-Bills matures 91 days after.

The authors use a portfolio of a T-Bill and a futures contract (i.e. pseudo bill instrument), which they compare with another T-Bill that had the same maturity as the pseudo bill instrument, using three trading strategies: a) A pure arbitrage strategy, where the

cash or pseudo instrument with the lower price is purchased and financed by selling the lower priced one; b) A bill swap strategy, where the holder of the higher priced instrument liquidates his position and buys the lower priced of the two; c) The investor simply buys the lower priced instrument of the two. Gruber & Rentzler (1983) also test for the marking to market effect, and find that while it is present, its magnitude is so small that it most probably of second order importance.

The results, in general, show that profits larger than transaction costs may be obtained using all three strategies. The authors conclude that the market is not perfectly efficient with respect to pure and quasi arbitrage.

To summarize, there exists considerable evidence that U.S. interest rate futures contracts are not efficient, in a quasi arbitrage sense. Recent work adopts an alternative way of testing market efficiency. It examines futures efficiency as a joint test of the unbiased expectations theory using an OLS model. In this approach, spot prices are regressed on futures prices according to the following equation:

$$S_{t+i} = a + b F_{t+i}^t + e_{t+i}$$

where, S_{t+i} is the spot price at time $t+i$, F_{t+i}^t is the price at time t for the futures contract maturing at time $t+i$, and e_{t+i} is the normal random error.

In this context, pricing is considered efficient if the intercept a and the slope b are respectively equal to zero and one.

McDonald & Hein (1993) provide an example of this methodology using daily T-Bill futures and spot rates for the period 1979 to 1989.

Their findings indicate that the constant a and the intercept b are significantly different from zero and one, respectively. This is in agreement with other studies that find that the market for T-Bill futures is inefficient. However, this conclusion may be open to question, in that it is not clear whether the equation above could be used to develop a profitable trading strategy. In addition, Maberly (1985) notes that such results can be misleading because of the application of OLS to censored data.

Elam & Dixon (1988) agree with Maberly's argument. However, they show that the T-bill market inefficiency is not due to the use of censored data. In general, censored data applied to OLS models do not yield consistent estimates. However, after examining Maberly's results, the authors find his estimates to be consistent. They explain that the misleading results are due to the use of an OLS model with a lagged independent variable. The explanatory variable F_{t+i}^t is equal to the expected spot price $E(S_{t+i})$. This, in turn, is equal to the spot price, S_t , which is the lagged value of the dependant variable S_{t+i} . The authors find that the spot price has a unit root (i.e. it is non-stationary), and that the model follows a "Random Walk" process. This implies that $a=0$ & $b=1$, and that the OLS estimates are biased. The authors then conduct Monte Carlo tests to show that the F-statistic should not be used to test the joint hypothesis of $[a=0 \text{ \& } b=1]$, because it often tends to reject the true model.

Shen & Wang (1990) argue that the F-test can be applied to test the joint hypothesis described above. They explain that Phillips (1986,1987) show that by differencing S_t , the series becomes white noise (stationary), thus it should converge to a Wiener process. Phillips & Durlauf (1987) prove that the conventional t and F statistics can also converge to a Wiener process. Shen & Wang (1990) show that by using the Dickey-Fuller (1988) F-statistic on Elam & Dixon's (1988) data, the null hypothesis is accepted. The authors also state that if the variables on both sides of the OLS equality are non-stationary, they might be cointegrated. Cointegration implies that a linear combination of two nonstationary variables can be stationary. It also implies that there is a long-run relationship between the two variables that should have an economic interpretation. Engle & Granger (1987) develop a cointegration technique that can be used to test market efficiency.

Park & Switzer (1995) apply cointegration and forecasting tests on T-Bill, Treasury bond, five-year and ten-year Treasury note futures and forward yields for the period June 1, 1988 to November 30, 1993.

Using the Phillips-Perron (1988) test, unit roots are found in all futures and forward yields and yield spreads, except the implied 10 year and 20 year forward rates and the implied 20 year-5 year and 20 year-10 year forward yield spreads.

The authors then test the long-run relationship between all the forward and futures variables. They find that all the futures and corresponding forward yields are cointegrated. This supports the efficiency hypothesis. In addition, they find long-run equilibrium relationships between all yield spreads, implying few arbitrage opportunities are available

in all segments of the yield curve examined. Finally, the authors show some evidence consistent with Samuelson's ((1965), (1976)) maturity hypothesis¹³.

To conclude, Donald & Hein (1993) argue that forecasting models, of the sort discussed above, are the best methods for examining the efficiency of futures markets. They explain that studies testing the efficiency of futures markets using an OLS model to regress spot prices on futures prices suffer from serious statistical problems. Also, studies testing the significance of the futures-forward differentials often conclude that the futures markets are not efficient. The authors argue that this conclusion could be misleading, because these tests cannot identify which of the two markets (forward or futures) is inefficient.

Many studies of the term structure (e.g. Fama(1976), Friedman(1979), Rowe, Lawler & Cook(1986), McDonald & Hein(1989), Kamara & Lawrence(1985) find evidence supporting the existence of a term premium in the forward yield but not in the futures yield. This implies that the forward market and not the futures market is inefficient.

Donald & Hein, (1993) implement two tests (the Nordhaus and the Arrow test procedures) of weak-form market efficiency based on an evaluation of forecast efficiency and rational expectations. Their data consist of daily closing quotes of T-Bill futures rates for the

¹³ Samuelson (1965) proposes a model defining the behavior of futures prices. In the model, prices are assumed to follow a binomial probability distribution (ergodic probability distribution) for each unit of time and with the central-limit theorem showing that a normal distribution is approached for the prices as time goes to infinity. Samuelson argues that the sequence of futures prices behavior is a fair game or martingale because futures prices cannot just wander around aimlessly. This implies that the expected capital gain should be zero or, in the case of risk-averse traders, a constant mean percentage gain per unit time. As for the variance of futures prices, Samuelson argues that there is no reason why it should stay constant from period to period. He deduces from his (1965) model that if the system is damped stable or has stationary roots, the variability of futures prices should increase as the maturity date approaches.

period January 6, 1976 through December 31, 1988.

Their results show that, after a small starting period, futures rates are independent, and market inefficiencies are not present. This implies that the T-Bill futures market is efficient.

To summarize, the findings to date for interest rate futures markets suggest inefficiency in a quasi arbitrage sense. However, based on forecasting performance and cointegration, recent studies for the U.S. tend to point to efficiency. No studies has been performed for Canada on this score. In subsequent sections, we will provide some new evidence on this issue.

3. Data and Methodology:

3.1 Theoretical BA Futures Prices:

In equilibrium, there should be no arbitrage opportunities between the spot and futures markets. In turn, this implies that forward and futures prices should be very close. Based on this premise, we price a futures contract as if it were a forward contract¹⁴.

Time t ----- m ----- n

t : is the current date.

m : is the maturity date of the futures contract.

n : is the maturity date of the BA delivered according to the futures contract.

P : is the BA spot price per \$100 of par value.

FP : is the theoretical no arbitrage futures price per \$100 of par value.

Y : is the yield on a BA.

D : is the time to maturity.

In an efficient market, the price of a combination of a futures contract and a BA maturing m days from now (BA_m) should be equal to the price of a BA maturing n days from now (BA_n).

$$P_m(FP/100) = P_n, \text{ which means that } FP = 100P_n/P_m. \quad (1)$$

If actual and theoretical prices are not equal, the differences in bid-ask prices and transaction costs in the futures market, which are assumed to be \$80 on a round trip basis

¹⁴ In the analysis above, it was shown that many studies found that the marking to market effect in futures contracts had an insignificant effect on the forward-futures spread.

(\$0.008 per \$100), should eliminate much of the potential arbitrage profit available to portfolio investors. This suggests that there exists a range of prices above/below which arbitrage is possible. These arbitrage boundaries can be defined by considering the following situations: First, if the desired investment horizon is **n**, an investor has two options:

(a) To take long positions in a **BA_m** and a futures contract, in which case the proceeds from **BA_m** should fund the long position in the futures contract plus the commission. Given this, the amount paid for **BA_m** should be:

$$P_m^{ask} \frac{(FP+0.008)}{100}$$

(b) To take a long position in **BA_n**.

In an efficient market, if the amount paid for **BA_m** is greater or equal to **BA_n**'s bid price,

$$P_m^{ask} \frac{(FP+0.008)}{100} \geq P_n^{bid}$$

then profitable arbitrage opportunities should not be present.

This means that the lower arbitrage boundary should be:

$$FP \geq 100P_n^{bid}/P_m^{ask} - 0.008 \quad (2)$$

Second, if the desired investment horizon is **m**, the investor also has two options:

(a) To take a long position in

BA_n and a short one in the

$$P_n^{ask} \left(\frac{100}{FP-0.008} \right)$$

futures contract. Here, the amount paid should be:

(b) To take a long position in BA_m .

In an efficient market, if the amount paid for BA_n is less or equal to BA_m 's bid price,

$$P_n^{ask} \left(\frac{100}{FP - 0.008} \right) \leq P_m^{bid}$$

then profitable arbitrage opportunities should not be present.

This means that the upper arbitrage boundary should be:

$$FP \leq 100 P_n^{ask} / P_m^{bid} - 0.008 \quad (3)$$

3.2 Montreal Exchange BA Index Equilibrium Values:

The BA futures are quoted on the Montreal Exchange (ME) Index basis, which is related to yield in the following manner: $ME = 100 - Yield$

The ME Index value corresponds to an actual contract price of :

$$\$100 - \$ (100 - ME) (D/365)$$

To compare actual and theoretical prices, the calculated theoretical FP price should be converted to the Index value.

$$\$100 - \$ (100 - FP) \left(\frac{365}{90} \right) = ME \quad \text{for BAX contracts.}$$

$$\$100 - \$ (100 - FP) \left(\frac{365}{30} \right) = ME \quad \text{for BAR contracts.}$$

In the presence of transaction costs, the arbitrage boundaries for the ME Index equilibrium values are: (a) For BAX contracts:

$$100 - 405.56(1 - P_n^{bid}/P_m^{ask}) - 0.0324 \leq ME \leq 100 - 405.56(1 - P_n^{ask}/P_m^{bid}) + 0.0324 \quad (4)$$

(b) For BAR contracts:

$$100 - 1216.67(1 - P_n^{bid}/P_m^{ask}) - 0.0973 \leq ME \leq 100 - 1216.57(1 - P_n^{ask}/P_m^{bid}) + 0.0973 \quad (5)$$

Without transaction costs the ME Index value becomes:

(a) For BAX contracts:

$$ME = 100 - 405.56(1 - P_n/P_m) \quad (6)$$

(b) For BAR contracts:

$$ME = 100 - 1216.67(1 - P_n/P_m) \quad (7)$$

If the market is efficient, the actual Index values should fall within the boundaries of (4) & (5) for the BAX & BAR contracts, respectively. The prices might also converge to the no transaction cost price of (6) & (7) for the BAX & BAR contracts, respectively.

3.3 The Nature of Arbitrage in The BA Futures Market and Samuelson's Maturity

Hypothesis:

To test the hypothesis of whether or not the price differences between actual and theoretical BA futures as well as the variability increase as the futures contracts' maturity approaches, price differences as well as absolute price differences are regressed on days to maturity. The absolute price difference is used as a proxy for the variance of price change.

$$Diff_t = a_0 + b_0 DTM_t + E_t \quad (8)$$

$$AbDiff_t = a_1 + b_1 DTM_t + E_t \quad (9)$$

where $Diff_t$ and $AbDiff_t$ are the differences and the absolute differences between actual and theoretical BA futures prices, respectively. a is a constant, DTM_t is the number of days to maturity and E_t is an error term.

The null hypothesis are: 1) $H_0: b_0 = 0$ 2) $H_0: b_1 = 0$

$H_1: b_0 > 0$ $H_1: b_1 > 0$

The White test, Engle (1982) ARCH/GARCH tests (for lags of 1, 2, 4 and 10) and the Durbin Watson test were performed to test for significant heteroskedasticity, ARCH effects and autocorrelation, respectively. The presence of such disturbances would result in inefficient OLS estimations and invalid inference procedures which implies that the test results would be misleading. To remedy this, Bollerslev's (1986) Generalized Autoregressive Conditional Heteroskedasticity or GARCH (1,1) model is used. In this model, the variance term depends upon the lagged variances as well as the lagged residuals.

$$Diff_t = b_{0a} + b_{1a} DTM_t + b_{2a} DUM_t + E_t \quad (10)$$

$$AbDiff_t = b_{0b} + b_{1b} DTM_t + b_{2b} DUM_t + E_t \quad (11)$$

Where, the error term

$$E_t \sim N(0, h_t)$$

with $h_t = a_0 + a_1 E_{t-1}^2 + a_2 h_{t-1}$

DUM_t is a dummy variable that is equal to 1 in the first half of the sample and zero in the second half of the sample. The dummy variable measures if the intercept in the second half is different from that in the first half. If it is negative and significant, evidence of increased efficiency of the market through time is provided.

3.4 Description of the Data:

Daily average settlement prices for the one-month & three month Canadian Bankers' acceptance futures (i.e. BAR and BAX) were obtained from the Montreal Exchange (ME). The period examined is from January 8, 1990 to December 9, 1994 for the BAX contracts and from April 16, 1992 to December 16, 1994 for the BAR contracts.

Corresponding daily average settlement spot yields for the 1, 2, 3, 6 & 12 month maturities of bankers' acceptances were provided by the Caisse de Dépôt et Placement du Québec. The yield of Bankers' acceptances maturing on the maturity date of the futures contracts as well as those maturing 90 days after were needed to compute the theoretical futures prices. However, in many cases these yields were not available, which meant that the yield curve had to be estimated. Two approaches were used. First, we used the simple interpolation approach by Rendleman & Carabini (1979). In addition, we used a method of cubic approximation, to capture potential curvature effects. In the latter approach for each

day, the following model is fitted to the five BA yields available:

$$Y_t(k) = a_t + b_t k + c_t k^3 + e_t$$

where $k = 30/365, 60/365, 90/365, 180/365$ and $365/365$, t = the date and e_t = a random error term. Then, the estimated coefficients, a' , b' and c' for each day, are used to compute an implied spot rate with a maturity corresponding to the maturity of the futures contract, as well as for subsequent dates t' , where $t' = 1/365, 2/365, \dots, 365/365$.

$$Y_t(t') = a'_t + b'_t (t') + c'_t (t')^3$$

Both the Rendleman & Carabini's (1979) interpolation approach as well as the cubic approximation approach yielded very similar results. Since the conclusions of the study do not depend on the method, to conserve space, we only report the results for the latter approach.

BA prices are computed from BA yields using the following formula:

$$P_t = 100 - Y_t * D/365$$

Finally, due to the difficulty of obtaining BA bid and ask prices, BA bid and ask prices are assumed to be one tick below and one tick above BA prices:

$$P_t^{bid} = P_t - 1/32, \quad P_t^{ask} = P_t + 1/32.$$

4. Empirical Results:

4.1 The Efficiency of the BA Futures Market:

The following tables provide summary statistics for the differences between actual and theoretical futures prices. The first contract is the front or nearby month contract, while the second and the third contracts are the two contracts maturing on the two subsequent maturity dates. Only the first three contracts are examined since markets for longer maturities are very thin, making the data unreliable.

Efficiency of the BA futures market implies that the average difference between actual and theoretical prices should be zero. A positive average difference between the two prices would suggest that the futures are over-priced. On the other hand, a negative difference between the two prices would indicate that the futures are under-priced.

4.1.1 Non-Annualized Differentials (without Considering Transaction Costs):

A non-zero difference between actual and theoretical futures prices would not necessarily imply market efficiency at this stage because of the existence of transaction costs. We need to take account of transaction costs in establishing whether or not there are deviations from the arbitrage bounds.

4.1.1.1 BAX Data:

In Table 1, the results show that, for all three contracts, the futures are over-priced during the sample period. The differentials of the three contracts are lower in the second half

of the sample, when compared to the first half, suggesting that these contracts became more efficiently priced over time. The differential of the first contract is fourteen basis points lower, the differential of the second contract is thirty-seven basis points lower, and that of the third contract is sixty-seven points lower. The average differentials of all three contracts are roughly equivalent to their absolute values implying that these contracts are over-priced during the whole sample period as well as during the two sub-periods.

The t-values¹⁵ for all average deviations in Table 1 are high which implies that these average deviations are significantly different from zero. The average deviation for all the contracts for the entire sample is sixty-nine basis points. This suggests that in the absence of transaction costs, excess profits in the BAX futures market could be earned.

The standard deviations of the differentials increase as time to maturity increases. This implies that the contracts with larger maturities are less predictable. The standard deviations are not constant through time. The first contract's standard deviation is considerably lower in the second half implying that its pricing is more predictable. In contrast, the standard deviation of the third contract is triple its value in the first half.

Figure 1 provides more support for the above conclusions. In general, the contracts

¹⁵ The t-statistics are adjusted to reflect the autocorrelated differentials using Rendleman & Carabini's (1979) methodology. Let Diff_t represent the differential observed at time t . The following autoregressive model was fit to the data presented in Tables 1 through 10.

$$\text{Diff}_t = \phi_0 + \phi_1 \text{Diff}_{t-1} + \phi_2 \text{Diff}_{t-2} + \epsilon_t$$

The coefficients and the standard error of the estimates are presented in the tables. Also, the Ljung-Box (1978) Q statistic was used to test for higher order autocorrelation (i.e. to test the residuals as well as the squared residuals for significant departures from white noise). In many cases, the hypothesis of zero autocorrelation in the residuals could be rejected at the 5% level. The t-statistic for testing the null hypothesis of a zero mean differential is:

$t = [\mu (1 - \phi_1 - \phi_2)] / [\sigma \epsilon / N^{1/2}]$, where μ and N represent the sample mean and size, respectively. If there was zero first and second order autocorrelation then the first and second coefficients of the autoregressive model should be zero and we obtain the usual t-statistic.

are over-priced during the entire period and very few contracts are under-priced during the same time period. Consequently, excess returns could be earned in the magnitude of the differential which implies that higher profits could be earned by trading a long-term contract. In the last fifty days, the differentials seem to be closer to zero, but there is no convergence towards zero.

The differentials for the whole sample, as well as for the two subperiods, are leptokurtic and skewed.

4.1.1.2 BAR Data:

Table 2 provides summary statistics for the differences between actual and theoretical BAR prices for the non-annualized data without considering transaction costs.

The positive average differentials for all three contracts in the entire sample, as well as in the two sub-periods, suggest that the futures are over-priced. The average differentials are very close to their absolute values, suggesting that very few contracts are under-priced during the whole sample and the two sub-periods. The largest differentials are those of the third contract, which means that the largest arbitrage profit potential is present in this contract.

In the second half of the sample, the average differentials are lower than their values in the first half, implying that the market became more efficiently priced through time. All average deviations in Table 2 are significantly different from zero and the t-values are somewhat high. This suggests that the BAR market is not efficient. The average differential for all contracts over the entire sample is seventeen basis points implying that, in the absence

of transaction costs, excess profits can be earned.

The standard deviations increase as time to maturity increases throughout the sample, as well as during the two sub-periods. In the second period, the standard deviations of the first two contracts are lower than their values in the first half. However, the standard deviation of the third contract is higher in the second half.

Figure 2 presents a plot the differentials versus days to maturity. We can observe that few BAR contracts are under-priced and that the price differentials do not converge to zero. It can also be observed that the largest excess profits can be made by trading the third contract.

The differentials are leptokurtic and skewed over the entire sample and in the first half. However, only the first contract's differentials are leptokurtic and skewed.

4.1.2 Annualized Differentials (without Considering Transaction Costs):

The arbitrage profits in the shorter term contracts can be earned in a shorter period of time which means that these contracts can be traded more frequently and can earn higher profits in the long-run than those earned by trading in the long-term contracts. This suggests that the conclusions from Tables 1 and 2 could be misleading. Therefore, we use annualized differences between actual and theoretical prices instead of the non-annualized differentials in the analysis since they take into consideration the time period in which the arbitrage profit is earned. The method of annualization is:

Annualized BAX differential = BAX Differential * (90/365) * (365/DTM),

Annualized BAR differential = BAR Differential * (30/365) * (365/DTM), where the first

brackets convert the differential from an ME index value units to dollar units. The second brackets annualize the return by multiplying it by the number of times it can be earned per year.

4.1.2.1 BAX Data:

Table 3 presents summary statistics for the annualized differentials without consideration of transaction costs. Figure 3 presents a graphical representation of the annualized differentials without considering transaction costs versus days to maturity.

When compared to the non-annualized statistics, we can see that the average annualized differentials as well as the absolute average annualized differentials of the second and the third contracts are considerably lower. Conversely, the average annualized differentials of the first contract is nearly double its non-annualized value. This implies that trading in the shortest term contracts has a higher potential of arbitrage profits than trading in the longer term contracts. The standard deviations of the differentials, as well as the standard deviations of the estimates, show that the dispersion of the annualized arbitrage profit is highest in the shortest term contracts. Contrary to the non-annualized data, the above observations imply that the efficiency in the pricing of the longer term contracts increase in the second half of the sample, while that of the shortest term contract becomes less efficient.

The average differentials for all three contracts decrease through time, which implies that the efficiency of the market on the whole increased. Nevertheless, all average differentials in the entire sample, as well as in the two sub-periods, are significantly different from zero.

The differentials for the entire sample, as well as for the two subperiods, are also skewed and highly leptokurtic.

4.1.2.2 BAR Data:

Table 4 shows that the average annualized BAR differentials, as well as the absolute annualized BAR differentials, are higher for all contracts during the entire sample period, as well as during the two sub-periods, when compared to the non-annualized data. The most considerable difference is in the first two contracts. The annualized differentials of the second and the third contracts are very close to their absolute values suggesting that these contracts are over-priced on the whole. Conversely, the annualized differential of the first contract is nearly half of its absolute value, which means that many of the nearest to term BAR contracts are under-priced.

The standard deviations of the differentials and the standard deviations of the estimate of the first and second contracts are considerably higher, when compared to those of the non-annualized data. These observations suggest that pricing efficiency of the first and second contracts is considerably lower when compared to that of the non-annualized differentials. This also implies that the arbitrage profit potential may be highest by trading the first two contracts.

The statistics also suggest that the differentials for the whole sample as well as for the two subperiods are skewed. In addition, the differentials of the entire sample and the first half are leptokurtic, while in the second half, only the first contract's differentials are leptokurtic.

4.1.3 BA Futures Price Differentials Considering Transaction Costs:

To reach firmer conclusions about the efficiency of the BA futures market, transaction costs should be considered. Tables 5 and 6 provide summary statistics for BAX and BAR differentials, respectively, when transaction costs are considered.

Following the methodology in Rendleman & Carabini (1979), transaction costs are considered in the following way. Whenever the ME index value of a contract falls between the lower and the upper arbitrage boundaries, the differential calculated is the difference between the actual index value and the no transaction cost value of equation (6) for the BAX. For the BAR, it is the difference between the actual index value and the no transaction costs value of equation (7) for the BAR. If the ME index value falls below the lower theoretical arbitrage bound of equation (4) for BAX data or below the lower theoretical arbitrage bound of equation (5) for the BAR data, the differential calculated is the difference between the actual index value and the lower bound. Similarly, if the index value climbs above the upper theoretical arbitrage bound of equation (4) in the BAX data or above the upper theoretical bound of equation (5) in the BAR data, then the differential calculated is the difference between the actual index value and the upper bound.

Figures 5 through 8 contain plots of the differentials when transaction costs are considered versus days to maturity.

4.1.3.1 BAX: Non-Annualized and Annualized Price Differentials When Transaction Costs are Considered:

Table 5 shows that sixty percent of the observations in the entire sample are outside the upper and the lower arbitrage boundaries. This implies that sixty percent of the

observations may provide arbitrage profits as large as thirty-nine basis points on a non-annualized basis and twenty-eight basis points on an annualized basis for all contracts. This also suggests market inefficiency in the returns predictability sense. The first half of the sample shows the same scenario with sixty-five percent of the observations being outside the no arbitrage boundaries. Nevertheless, the percentage of observations outside the no arbitrage boundaries, in the second half, went down to fifty-four percent. Also the potential arbitrage profits, for all contracts, went down from forty-two basis points to thirty-four basis points on a non-annualized basis and from thirty-six basis points to eighteen basis points on an annualized basis. This implies that the BAX market became more efficiently priced in the second half of the sample period.

Figure 5 shows that, on a non-annualized basis, the shorter term contracts are more efficiently priced, as it is apparent that average price differentials of contracts with less than fifty days to maturity are closer to zero, thus making them the most efficiently priced contracts. On the other hand, Figure 6 shows that, on an annualized basis, the longer term contracts are more efficiently priced, as it is apparent that average returns of the contracts with two-hundred to two-hundred and seventy days to maturity are closer to zero, making them the most efficiently priced contracts.

4.1.3.2 BAR Data: Non-Annualized and Annualized Price Differentials When Transaction Costs are Considered:

It can be seen in Table 6 that the percentage of observations outside the no-arbitrage boundaries for all contracts during the entire sample period ranges from zero to two percent.

This means that arbitrage returns cannot be earned in the BAR market which, in turn, implies that the BAR contracts are efficiently priced.

4.2 Delivery Day Effect:

On the final day of trading, an investor has two alternatives to get a BA: he/she could either buy a BA or buy a BA futures contract. This means that on the final trading day, simple arbitrage between the BA cash and the BA futures markets should ensure that the two prices are the same. To check for a delivery day effect in the BAX and BAR markets, observations one day prior to the nearby contract's delivery date are separated from the sample and summary statistics are obtained for both the one day prior to delivery sample and the sample without the one day prior to delivery date observations.

4.2.1 BAX Data:

Tables 7 and 8 provide summary statistics for the annualized differences between actual and theoretical BAX futures prices with and without consideration of transaction costs, respectively, for the sample without the one day prior to delivery date observations. The results from the two tables are similar to previous results for the entire sample, the differentials being positive, implying that the futures contracts are overpriced, and all average deviations are significantly different from zero.

Tables 7 and 8 also provide summary statistics for the annualized differences between actual and theoretical BAX futures prices with and without consideration of transaction costs, respectively, for the sample constituting the one day prior to delivery date observations.

Table 7 contains somewhat high differentials and standard deviations for all three contracts. The highest differentials and dispersion is that of the first contract, which means that it was the least efficiently priced. Also, the t-values are high implying that the differentials are significantly different from zero and that one day prior to delivery of the nearby contract, all three BAX contracts are not efficiently priced. The differentials for the entire sample, as well as for the two subperiods, are skewed and highly leptokurtic.

Table 8 shows that, when transaction costs are considered, the average differentials as well as the dispersion in all three contracts decrease considerably. The least efficiently priced observations are still those of the first contract. The t-values for all contracts are considerably small and not significant which suggests that the average deviations of all three contracts are not significantly different from zero. This means that, one day prior to delivery of the nearby contract, investors have a good consensus about the price of the maturing BAX contract, as well as the prices of the two further to term contracts. This implies that there is sufficient arbitrage around the delivery dates to make the BAX futures prices equal to the cash BA prices for all three maturities. Also, the statistics show that there is no significant kurtosis for these differentials, although there is some skewness.

4.2.2 BAR Data:

Tables 9 and 10 contain summary statistics for the annualized differences between actual and theoretical BAR futures prices with and without consideration of transaction costs, respectively, for the sample without the one day prior to delivery date observations. As in the

case of the BAX market, these tables are similar to the previous results for the entire sample, the differentials being positive, implying that the futures are overpriced, and all average deviations are significantly different from zero.

Tables 9 and 10 also contain summary statistics for the annualized differences between actual and theoretical BAR futures prices with and without consideration of transaction costs, respectively, for the sample of observations one day prior to delivery date of the first contract. As discussed above, very few observations for this sample for all dates fall outside the no arbitrage boundaries. Hence, not surprisingly, Tables 9 and 10 are very similar. The t-value for the first contract is not significant in contrast to the second and third contracts. This implies that the first contract's differential is not significantly different from zero while the second and third contracts' differentials are significantly different from zero. The results imply that, just before the delivery day of the nearby contract, arbitrage in the BAR market causes only the first contract to become efficiently priced, which means that investors are more in agreement about the first contract's pricing as maturity approaches. The results could also explain the larger variability present in the contracts further from maturity.

4.3 The Nature of Arbitrage in the BA Futures Market and Samuelson's Maturity Hypothesis:

Tables 11 through 18 provide the results of the OLS regressions of the price differentials as well as the absolute price differentials on days to maturity for the BAX and the BAR, respectively. The tables also provide the results of the White test for heteroskedasticity, the Durbin Watson test for autocorrelation, and Engle (1982)

ARCH/GARCH tests for lags of 1, 2, 4 and 10.

Tables 19 and 21 provide the results of the GARCH regression of the price differentials on days to maturity for the BAX and the BAR, respectively. Tables 20 and 22 contain the results of the GARCH regression of the absolute price differentials on days to maturity for the BAX and the BAR, respectively.

4.3.1 BAX Data:

Tables 11 and 12 show that for the non-annualized differentials, with and without consideration of transaction costs, there are significant ARCH effects in the first contract and significant autocorrelation in the first and second contracts over the entire sample. On the other hand, the first half provides significant heteroskedasticity in the first contract, significant ARCH effects in the first and the third contracts, and significant autocorrelation in all of the contracts' differentials. As for the second half, there seem to be significant ARCH effects and autocorrelation in the first contract and significant heteroskedasticity in the first and third contracts.

Tables 13 and 14 provide the following results for the annualized data with and without consideration of transaction costs. In the first half of the sample, significant ARCH effects are present in the third contract. It also seems that there is significant autocorrelation in the second and third contracts. On the other hand, the second half shows that there is significant heteroskedasticity, ARCH effects and autocorrelation in the first contract. As for the entire sample, there seem to be significant ARCH effects present in the first contract and significant autocorrelation in the first and second contracts.

Table 29 contains the results of the GARCH model where the differences between actual and theoretical BAX prices are regressed on the number of days to maturity. It can be seen from the table that the coefficients b_{0a} , b_{1a} and b_{2a} are all significant for the non-annualized and the annualized price differentials with and without consideration of transaction costs. The significance of b_{0a} and b_{2a} mean, respectively, that the intercept is significant and that the intercept in the second half of the sample is different from that in the first half. Also, in many instances b_{2a} is negative which implies that the contracts became more efficiently priced over time.

In the non-annualized data b_{1a} is positive in all three contracts, which implies that the differential between actual and theoretical BAX prices gets smaller as maturity approaches. This implies that there is a greater degree of arbitrage as maturity approaches that brings the prices closer together. This result is in accordance with the previous results as it suggests that investors are more in agreement about prices as maturity approaches. On the other hand, b_{1a} is positive only in the second contract for the annualized differentials without consideration of transaction costs, and it is positive for the second and the third contracts in the annualized differentials with consideration of transaction costs. These results are also in accordance with previous results as the differences are largest for the first contract which means that there is more room for arbitrage and spread profits by trading the nearby contract.

Table 20 contains the results of the GARCH model where the absolute differences between actual and theoretical BAX prices are regressed on the number of days to maturity. It can be seen from the table that b_{0b} , b_{1b} and b_{2b} are all significant for the non-annualized and the annualized series, with and without consideration of transaction costs. The significance

of b_{2b} coupled with the fact that in many instances its sign is negative, is in accordance with the hypothesis that deviations from efficiency decreases in the second half of the sample. The significance of b_{1b} suggests that the null hypothesis of a constant variance is rejected at the five percent level, for all contracts in the non-annualized series, as well as in the annualized series, with and without consideration of transaction costs. In the non-annualized series, b_{1b} is positive in all three contracts. This means that the variability of the price differences gets smaller as maturity approaches, which could be caused by a larger degree of arbitrage as maturity approaches. This is in accordance with the previous results as it suggests that investors are more in agreement about prices as maturity approaches. This also suggests that Samuelson's Maturity Hypothesis does not have any support in the non-annualized data. On the other hand, b_{1b} for the annualized data, with and without consideration of transaction costs, is positive for the second and the third contracts. Therefore, Samuelson's maturity hypothesis seem to have support only in the first contract. This means that the first contract contains more variability as maturity approaches, which implies that there may be more room for arbitrage. The results also suggest that investors are more in agreement about the pricing of the second and the third contracts.

4.3.2 BAR Data:

Tables 15 and 16 show that for the non-annualized differentials, with as well as without consideration of transaction costs, there are significant ARCH effects and significant autocorrelation for all three contracts over the entire sample, as well as in the two subsamples. Also there seems to be significant heteroskedasticity in the first contract, in the

entire sample and also in the second and the third contracts in the second half of the sample.

In addition, Tables 17 and 18 provide the following results for the annualized data, with and without consideration of transaction costs: In the first half of the series, there are significant ARCH effects in all three contracts, significant heteroskedasticity in the first and second contracts, and significant autocorrelation in all three contracts. The second half of the series contains significant ARCH effects and significant autocorrelation in all three contracts as well as significant heteroskedasticity in the first and third contracts. Finally, over the entire sample, there seem to be significant ARCH effects and significant autocorrelation in all three contracts and also significant heteroskedasticity in the first contract.

Table 21 lists the results of the GARCH model where the differences between actual and theoretical BAR prices were regressed on the number of days to maturity. It can be seen from the table that b_{0a} , b_{1a} and b_{2a} are all significant for the non-annualized differences, as well as for the annualized differences, with and without consideration of transaction costs. The significance as well as the negative sign of b_{2a} , again, imply an increase in market efficiency in the second half of the sample. This is logical since the differentials in the second half are smaller than the differentials in the first half. In the non-annualized data, b_{1a} is positive in all three contracts, which means that the divergence between actual and theoretical BAR prices gets smaller as maturity approaches. This could be a result of a larger degree of arbitrage as maturity approaches. This result is in accordance with the results from Table 2 as it suggests that investors are more in agreement about prices as maturity approaches. On the other hand, b_{1a} is positive only in the first and third contracts for the annualized differences, with and without consideration of transaction costs. These results

suggest that, in general, the price differences get smaller as maturity approaches, except in the second contract where the differences seem to get larger. This means that investors are in better agreement about the prices of the first and the second contracts, and that there is room for arbitrage in the second contract.

Table 22 contains the results of the GARCH model where the absolute differences between actual and theoretical BAR prices are regressed on the number of days to maturity. It can be seen from the table that b_{0b} , b_{1b} and b_{2b} are all significant for the non-annualized series as well as for the annualized series with and without consideration of transaction costs. Here again, the significance and the negative sign of b_{2a} imply greater efficiency in the latter half of the sample. The significance of b_{1b} suggests that the null hypothesis of a constant variance is rejected at the five percent level for all contracts in the non-annualized, differentials as well as for the annualized differentials, with and without consideration of transaction costs. In the non-annualized data, b_{1b} is positive in all three contracts, which means that the variability of the price differences gets smaller as maturity approaches. This is in accordance with the results from Table 2, as it suggests that investors are in general agreement about prices as maturity approaches. This also means that Samuelson's Maturity Hypothesis is not supported by the non-annualized data. On the other hand, b_{1b} for the annualized differentials, with and without consideration of transaction costs, is positive only for the third contract. This implies that these contracts seem to support Samuelson's Maturity Hypothesis, as they provide larger variability as the maturity date approaches.

5. Summary and Conclusions:

This paper examines the efficiency of a new financial futures market, the Bankers Acceptances futures market, which is becoming increasingly popular in Canada. The results of the tests show that the BAR and the BAX futures contracts were overpriced during the entire sample period. The results also suggest that, when transaction costs are considered, the BAR market is efficient with respect to quasi arbitrage opportunities. On the other hand, the BAX market is inefficient with respect to quasi-arbitrage opportunities, because of the large number of observations outside the no arbitrage boundaries. Nevertheless, the BAX market has become more efficiently priced over time. On an annualized basis, the pricing of the first contract has become less efficient, while the pricing of the third contract has become more efficient over time. The evidence suggests that the potential arbitrage return for all BAX contracts during the entire sample period was around thirty basis points on an annualized basis and around thirty-nine basis points on a non-annualized basis. This suggests that the potential arbitrage returns in this market may be worth exploiting. The inefficiency of the BAX market can be attributed to a number of reasons, such as the reluctance of institutions and investors to enter this market and take advantage of the present arbitrage opportunities. An alternative explanation is that there may be a risk premium embodied in the cash market implied rates.

Just before the maturity date of a contract, the BAX market becomes efficient as the differences between actual and theoretical BAX prices converge to zero. This implies, that there is a greater degree of arbitrage for all maturities around the delivery date that brings actual and theoretical prices together for all three contracts. On the other hand, only the front

month BAR contract converges to zero just before the maturity date.

The evidence from the GARCH models suggests that there is a larger variability as the maturity date approaches in the BAR market. It also seems that there is more arbitrage taking place in the largest maturity contract that is bringing the actual and theoretical futures prices (i.e. cash and futures prices) into alignment. On the other hand, the BAX market contains a larger variability for nearest to maturity contracts. Also, more arbitrage is taking place in larger maturities which results in traders being more in agreement about the pricing of these contracts.

In conclusion, our findings of the existence of quasi arbitrage opportunities as well as of the overpricing of futures contracts suggest that the BAX markets may provide profitable opportunities for arbitrage, spread traders and short hedgers. Also, as tools for hedging short-term interest rate risk, the BAR and the BAX markets seem to become more effective over time as the arbitrage opportunities get exploited and the pricing of the contracts become more efficient. The BAR market seems to contain less risk for hedgers and speculators in general, because of its efficiency. Finally, given the evidence on Samuelson's Maturity Hypothesis, it may be prudent for brokers and dealers to increase margin requirements on the first two BAR contracts as they approach maturity.

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Appendix 1

Tables

Table 1 Summary Statistics for the Non-Annualized BAX Differentials Between Actual and No-Transaction Cost Values of ME Index					
First Half of Sample: 8/1/1990 - 9/6/1992					
	1 st contract	2 nd contract	3 rd contract	all contracts	
μ	0.32888	0.84241	1.37758	0.849616	
$ \mu $	0.359655	0.894665	1.389283	0.881201	
σ	0.362488	0.761372	0.686258	0.759611	
N	607	607	607	1821	
σ_e	0.331147	0.711819	0.396442	0.533686	
ϕ_1	0.274760	0.237524	0.432776	0.407034	
ϕ_2	0.224263	0.209634	0.438468	0.376504	
t	12.25739 ^a	16.11938 ^a	11.02290 ^a	14.70527 ^a	
Q(21,n)	157.1609 ^b	100.7749 ^b	56.4793 ^b	276.968 ^b	
Q(21,n) ²	93.9383 ^b	9.2724	55.097 ^b	110.4914 ^b	
skewness	-8.70874	-1022114	0.46749	-3.2137	
kurtosis	131.4814	199.6842	5.89368	71.40405	
Entire Sample Period: 8/1/1990 - 16/12/1994					
	1 st contract	2 nd contract	3 rd contract	all contracts	
μ	0.257602	0.773987	1.046668	0.692753	
$ \mu $	0.277559	0.805217	1.057284	0.713353	
σ	0.301905	1.272915	1.783015	1.296335	
N	1233	1170	1104	3507	
σ_e	0.264036	1.112180	1.768090	1.225825	
ϕ_1	0.295678	0.457875	0.111672	0.259271	
ϕ_2	0.282292	0.058144	0.073933	0.135916	
t	14.45807 ^a	11.52071 ^a	16.01858 ^a	20.24128 ^a	
Q(21,n)	221.6633 ^b	36.8775 ^b	122.9861 ^b	270.066 ^b	
Q(21,n) ²	181.0816 ^b	81.0694 ^b	1.1446	20.0904	
skewness	-6.22023	6.30488	25.09731	23.03648	
kurtosis	134.4162	91.71794	752.3250	898.2384	

Legend:

μ = Sample mean.

$|\mu|$ = Sample mean of absolute values

σ = Sample standard deviation

N = Sample size.

σ_e = Standard error of estimate of second order autoregressive process

ϕ_1 = First order autocorrelation coefficient.

ϕ_2 = First order autocorrelation coefficient

t = $\mu (1 - \phi_1 - \phi_2) / (\sigma_e / N^{1/2})$

Q(21,n) = Box-Pierce Q statistic using 21 residual autocorrelations with sample size N

Q(21,n)² = Box-Pierce Q statistic using 21 squared residual autocorrelations with sample size N

^a Significantly different from zero at 5% level

^b Null hypothesis that residuals follow a white noise process is rejected at the 5% level

Table 2 Summary Statistics for Non-Annualized BAR Differentials Between Actual and No-Transaction Cost Values of ME Index									
First Half of Sample: 16/4/1992 - 28/7/1993					Second Half of Sample: 29/7/1993 - 16/12/1994				
	1 st contract	2 nd contract	3 rd contract	all contracts		1 st contract	2 nd contract	3 rd contract	all contracts
μ	0.0948854	0.2391192	0.3212227	0.2184091	μ	0.0480983	0.1441258	0.2138428	0.1353556
$ \mu $	0.1086148	0.2391453	0.3213896	0.2230499	$ \mu $	0.0803426	0.1691290	0.2665380	0.1720032
σ	0.1245041	0.1435593	0.1750308	0.1759651	σ	0.1008688	0.1385751	0.2378387	0.1794766
N	317	317	317	951	N	344	319	300	963
σ_e	0.0984087	0.1090310	0.1457880	0.1226565	σ_e	0.6842887	0.0961455	0.1745864	0.1203253
ϕ_1	0.5259631	0.5176596	0.4415502	0.5359175	ϕ_1	0.7117406	0.5111843	0.5315531	0.5689754
ϕ_2	0.1310863	0.1893902	0.1807642	0.2324833	ϕ_2	0.0583817	0.2676310	0.2024934	0.2185371
t	5.8874470 ^a	11.438990 ^a	14.816455 ^a	12.717651 ^a	t	0.2996860	5.9219243 ^a	5.6422250 ^a	7.4176398 ^a
Q(21,n)	62.472 ^b	24.5128	23.2265	62.9526 ^b	Q(21,n)	16.895	16.3985	19.5611	47.7574 ^b
Q(21,n) ²	26.4699	37.7908 ^b	49.5921 ^b	126.7559 ^b	Q(21,n) ²	31.4247	99.7599 ^b	105.4713 ^b	361.6906 ^b
skewness	1.77355	2.04478	1.68636	1.37667	skewness	-0.68919	-0.26789	-0.01657	0.53403
kurtosis	12.00593	6.14754	4.97558	4.30131	kurtosis	4.74529	2.71882	3.22099	4.78214
Entire Sample Period: 16/4/1992 - 16/12/1994					Legend:				
μ	0.0704604	0.1913546	0.2689235	0.1769128	μ = Sample mean				
$ \mu $	0.0937901	0.2038888	0.2945894	0.1974228	$ \mu $ = Sample mean of absolute values.				
σ	0.1150670	0.1486816	0.2144486	0.1828257	σ = Sample standard deviation.				
N	662	637	618	1917	N = Sample size.				
σ_e	0.0844367	0.1031437	0.1609495	0.1212387	σ_e = Standard error of estimate of second order autoregressive process				
ϕ_1	0.5982796	0.5314445	0.5085604	0.5599670	ϕ_1 = First order autocorrelation coefficient.				
ϕ_2	0.1208573	0.2411625	0.2098209	0.2348686	ϕ_2 = First order autocorrelation coefficient				
t	6.0302753 ^a	10.647383 ^a	11.697543 ^a	13.107829 ^a	t = $\mu (1 - \phi_1 - \phi_2) / (\sigma_e / N^{1/2})$				
Q(21,n)	55.1289 ^b	35.4475 ^b	29.611	81.3129 ^b	Q(21,n) = Box-Pierce Q statistic using 21 residual autocorrelations with sample size N.				
Q(21,n) ²	63.168 ^b	84.5168 ^b	149.9117 ^b	413.4145 ^b	Q(21,n) ² = Box-Pierce Q statistic using 21 squared residual autocorrelations with sample size N.				
skewness	0.94608	0.83442	0.24705	0.84954	^a Significantly different from zero at 5% level.				
kurtosis	10.41927	4.9107	4.16694	4.38372	^b Null hypothesis that residuals follow a white noise process is rejected at the 5% level.				

Table 3 Summary Statistics for the Annualized BAX Differentials Between Actual and No-Transaction Cost Values of ME Index									
First Half of Sample: 8/1/1990 - 9/6/1992					Second Half of Sample: 10/6/1992 - 16/12/1994				
	1 st contract	2 nd contract	3 rd contract	all contracts		1 st contract	2 nd contract	3 rd contract	all contracts
μ	0.5406461	0.4342482	0.4104292	0.4617745	μ	0.6601879	0.5502479	0.5421024	0.5841794
$ \mu $	0.6344647	0.4591976	0.4147541	0.5028055	$ \mu $	0.7965785	0.5929022	0.5473472	0.6456093
σ	1.0343067	0.5168862	0.6113520	0.7654102	σ	1.3323291	0.5624868	0.2613249	0.8497280
N	1233	1170	1104	3507	N	607	607	607	1821
σ_e	1.0351097	0.5009997	0.6029581	0.7542129	σ_e	1.3360990	0.5530183	0.1620815	0.8470597
ϕ_1	0.1021756	0.1651925	0.1333772	0.1225396	ϕ_1	0.0233934	0.1380635	0.4053735	0.0651573
ϕ_2	0.0915915	0.1593691	0.0949962	0.1070186	ϕ_2	0.0196513	0.1221149	0.4426997	0.0601699
t	14.786612	20.025302	17.451905	27.934675	t	11.649704	18.135946	12.519193	25.741437
Q(21,n)	125.7328	141.7725	182.6838	339.3704	Q(21,n)	60.8108	84.6924	83.5167	196.3808
Q(21,n) ²	19.949	5.288	3.4565	43.5714	Q(21,n) ²	9.9958	2.7644	56.0248	28.8016
skewness	-19.53495	-5.082	22.71695	-13.67674	skewness	-19.26295	-14.58853	0.03064	-25.89192
kurtosis	558.03216	283.87751	653.73272	748.63064	kurtosis	417.79846	304.69041	7.5743	850.23964
Entire Sample Period: 8/1/1990 - 16/12/1994					Legend:				
μ	1 st contract	2 nd contract	3 rd contract	all contracts	μ	Sample mean			
$ \mu $	0.4247326	0.3091827	0.2496130	0.3278428	$ \mu $	Sample mean of absolute values.			
σ	0.4772714	0.3150435	0.2528144	0.3483765	σ	Sample standard deviation			
N	0.6002474	0.4293841	0.8370047	0.6377478	N	Sample size			
σ_e	626	563	497	1686	σ_e	Standard error of estimate of second order autoregressive process			
ϕ_1	0.5088400	0.4230306	0.8400405	0.6175375	ϕ_1	First order autocorrelation coefficient.			
ϕ_2	0.3240944	0.1200167	0.0218510	0.1640995	ϕ_2	First order autocorrelation coefficient.			
t	0.2625054	0.1320535	-0.1091046	0.1281097	t	$t = \mu (1 - \phi_1 - \phi_2) / (\sigma_e / N^{1/2})$			
Q(21,n)	8.6336027	12.970551	7.2023813	15.428935	Q(21,n)	Box-Pierce Q statistic using 21 residual autocorrelations with sample size N			
Q(21,n) ²	42.1783	29.6779	25.6523	122.1538	Q(21,n) ²	Box-Pierce Q statistic using 21 squared residual autocorrelations with sample size N			
skewness	9.0099	0.7399	1.4623	5.8174	skewness	Significantly different from zero at 5% level.			
kurtosis	4.79074	16.26472	20.23672	16.60216	kurtosis	Null hypothesis that residuals follow a white noise process is rejected at the 5% level			
	51.22745	333.86912	430.14733	409.3719					

Table 4 Summary Statistics for Annualized BAR Differentials Between Actual and No-Transaction Cost Values of ME Index									
First Half of Sample: 16/4/1992 - 28/7/1993					Second Half of Sample: 29/7/1993 - 16/12/1994				
	1 st contract	2 nd contract	3 rd contract	all contracts		1 st contract	2 nd contract	3 rd contract	all contracts
μ	0.374004	0.463850	0.376774	0.404876	μ	0.281673	0.271103	0.245651	0.266143
$ \mu $	0.665503	0.463926	0.376941	0.502123	$ \mu $	0.506318	0.318328	0.308673	0.377773
σ	1.171265	0.289527	0.210758	0.707619	σ	0.885677	0.244092	0.268692	0.567490
N	317	317	317	951	N	344	319	300	963
σ_e	1.070613	0.213282	0.176126	0.636975	σ_e	0.697742	0.169247	0.196839	0.478845
ϕ_1	0.376017	0.573218	0.460398	0.390344	ϕ_1	0.760321	0.534311	0.548683	0.583818
ϕ_2	0.079369	0.147506	0.150216	0.089683	ϕ_2	-0.014732	0.241646	0.183011	-0.094343
t	3.387363 ^a	10.81394 ^a	14.83081 ^a	10.19225 ^a	t	1.904874 ^a	6.409695 ^a	5.799564 ^a	8.805425 ^a
Q(21,n)	25.4188	25.8697	21.8064	61.0299 ^b	Q(21,n)	5.0983	23.7189	21.6004	20.4155
Q(21,n) ²	38.9068 ^b	44.6523 ^b	39.705 ^b	135.9647 ^b	Q(21,n) ²	19.0925	100.9462 ^b	76.5182 ^b	266.6702 ^b
skewness	-7.85547	2.33683	1.81775	-11.85188	skewness	5.55472	-0.88771	-0.36454	7.53409
kurtosis	102.1080	7.63597	5.66175	258.9019	kurtosis	55.16	3.58103	3.36481	119.8876
Entire Sample Period: 16/4/1992 - 16/12/1994					Legend:				
μ	1 st contract	2 nd contract	3 rd contract	all contracts	μ	= Sample mean.			
$ \mu $	0.325606	0.366946	0.312893	0.335148	$ \mu $	= Sample mean of absolute values.			
σ	0.581924	0.390633	0.343572	0.438710	σ	= Sample standard deviation.			
N	1.032032	0.284184	0.249078	0.644018	N	= Sample size			
σ_e	662	637	618	1917	σ_e	= Standard error of estimate of second order autoregressive process.			
ϕ_1	0.906884	0.193345	0.187184	0.564950	ϕ_1	= First order autocorrelation coefficient.			
ϕ_2	0.490944	0.575057	0.525738	0.464700	ϕ_2	= First order autocorrelation coefficient.			
t	0.053920	0.202552	0.186754	0.032892	t	$= \mu (1 - \phi_1 - \phi_2) / (\sigma_e / N^{1/2})$			
Q(21,n)	4.204460 ^a	10.65252 ^a	11.94732 ^a	13.04950 ^a	Q(21,n)	= Box-Pierce Q statistic using 21 residual autocorrelations with sample size N.			
Q(21,n) ²	27.5935	38.4166 ^b	32.6989	60.3957 ^b	Q(21,n) ²	= Box-Pierce Q statistic using 21 squared residual autocorrelations with sample size N.			
skewness	133.9427 ^b	92.4822 ^b	104.7252 ^b	373.4144 ^b	skewness	Significantly different from zero at 5% level.			
kurtosis	-3.61258	1.09987	0.16618	-5.12369	kurtosis	Null hypothesis that residuals follow a white noise process is rejected at the 5% level.			
	94.41603	7.12051	4.62454	218.0409					

Table 5 Summary Statistics for BAX Differentials When Transaction Costs are Considered																
Trading Period	First Contract				Second Contract				Third Contract				All Contracts			
	N	%	μ	μ_a	N	%	μ	μ_a	N	%	μ	μ_a	N	%	μ	μ_a
First Half																
8/1/1990 - 9/6/1992																
A	168	28	0.11	0.479	422	70	0.287	0.29	583	96	0.56	0.385	1173	65	0.417	0.364
W	437	72	0.322	0.776	183	30	1.07	0.744	23	4	1.187	0.512	643	35	0.59	0.751
B	2	0	-	-	2	0	-	-	1	0	-	-0.86	5	0	-	-
Sum	607	100			607	100			607	100			607	100		
Second Half																
10/6/1992 - 16/12/1994																
A	128	20	0.156	0.221	377	67	0.337	0.204	407	82	0.417	0.155	912	54	0.347	0.185
W	498	80	0.123	0.353	185	33	0.165	0.119	88	18	0.346	0.129	771	46	0.15	0.277
B	0	0	0	0	1	0	-	-	2	0	-	-	3	0	-	-
Sum	626	100			563	100			497	100			1686	100		
Entire Sample																
8/1/1990 - 16/12/1994																
A	296	24	0.131	0.358	799	68	0.31	0.248	990	90	0.525	0.286	2085	60	0.387	0.282
W	935	76	0.218	0.557	368	32	0.647	0.455	111	10	0.684	0.28	1414	40	0.364	0.509
B	2	0	-3.13	-	3	0	-	-	3	0	-	-	8	0	-	-
Sum	1233	100			1170	100			1104	100			3507	100		
Legend:																
N = Number of Observations																
% = % of total observations within cell																
μ = Non-annualized sample mean																
μ_a = Annualized sample mean																
B = Below Lower index bound (Means are differences between actual ME Index values and the lower Index bound).																
W = Within index bounds (Means are differences between actual and no-transaction cost index values).																
A = Above upper index bound (Means are differences between actual ME Index values and the upper Index bound)																

Table 6 Summary Statistics for BAR Differentials When Transaction Costs are Considered																
Trading Period	First Contract				Second Contract				Third Contract				All Contracts			
	N	%	μ	μ_a	N	%	μ	μ_a	N	%	μ	μ_a	N	%	μ	μ_a
First Half																
8/1/1990 - 9/6/1992																
A	7	2	0.149	0.138	10	3	0.072	0.184	2	0.6	0.186	0.279	19	2	0.211	0.177
W	310	98	0.091	0.365	307	97	0.233	0.462	315	99.4	0.313	0.374	932	98	0.149	0.496
B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum	317	100			317	100			317	100			951	100		
Second Half																
10/6/1992 - 16/12/1994																
A	0	0	0	0	0	0	0	0	0	2	0.132	0.132	6	0.6	0.127	0.132
W	344	100	0.048	0.281	319	100	0.144	0.318	294	98	0.201	0.292	957	99.4	0.132	0.377
B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum	344	100			319	100			300	100			963	100		
Entire Sample																
8/1/1990 - 16/12/1994																
A	7	1	0.149	0.138	10	2	0.072	0.184	8	1	0.159	0.169	25	1	0.168	0.166
W	655	99	0.069	0.321	627	98	0.188	0.389	610	99	0.258	0.335	1892	99	0.142	0.456
B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sum	662	100			637	100			618	100			1917	100		
Legend:																
N = Number of Observations																
% = % of total observations within cell																
μ = Non-annualized sample mean																
μ_a = Annualized sample mean																
B = Below Lower index bound (Means are differences between actual ME Index values and the lower Index bound).																
W = Within index bounds (Means are differences between actual and no-transaction cost index values).																
A = Above upper index bound (Means are differences between actual ME Index values and the upper Index bound).																

Table 7
Summary Statistics for the Annualized BAX Differentials Between Actual and No-Transaction Cost Values of ME Index

<u>Entire Sample without the One Day before Delivery Dates</u>					<u>One Day Before the 1st Contract's Delivery Date</u>				
	1 st contract	2 nd contract	3 rd contract	all contracts		1 st contract	2 nd contract	3 rd contract	all contracts
μ	0.5420923	0.4347284	0.4114105	0.4627437	μ	0.450320	0.403514	0.347685	0.400506
$ \mu $	0.6373793	0.4600676	0.4158030	0.5044167	$ \mu $	0.486121	0.414293	0.347685	0.416033
σ	1.0418628	0.5199951	0.6149514	0.7706202	σ	0.244262	0.252229	0.305398	0.265418
N	1214	1152	1087	3453	N	20	18	17	55
σ_e	1.0325534	0.5043822	0.6069387	0.7595172	σ_e	0.173726	0.113602	0.098834	0.200679
ϕ_1	0.1019332	0.1632967	0.1310839	0.121571 ^a	ϕ_1	0.154354	0.135362	0.386749	0.565268
ϕ_2	0.0919902	0.1581886	0.0924385	0.1065210	ϕ_2	0.327724	0.331683	0.352286	0.041153
t	14.745054 ^a	19.849231 ^a	17.352984 ^a	27.635453 ^a	t	6.003920 ^a	8.031488 ^a	3.785163 ^a	5.825324 ^a
Q(21,n)	126.6415 ^b	143.7881 ^b	174.8201 ^b	335.5708 ^b	Q(21,n)	18.4672	13.4038	4.508	17.1691
Q(21,n) ²	19.6415	5.2898	3.3506	42.8783 ^b	Q(21,n) ²	15.2727	6.2307	8.7407	34.1077 ^b
skewness	-19.41677	-5.07715	22.665264	-13.61478	skewness	0.75636	1.89995	1.06004	0.77586
kurtosis	550.61088	281.49276	648.43171	740.03709	kurtosis	1.53726	4.87867	0.74248	0.42131

Legend:

μ = Sample mean.

$|\mu|$ = Sample mean of absolute values

σ = Sample standard deviation.

N = Sample size.

σ_e = Standard error of estimate of second order autoregressive process.

ϕ_1 = First order autocorrelation coefficient.

ϕ_2 = First order autocorrelation coefficient.

$t = \mu (1 - \phi_1 - \phi_2) / (\sigma_e / N^{1/2})$

Q(21,n) = Box-Pierce Q statistic using 21 residual autocorrelations with sample size N

Q(21,n)² = Box-Pierce Q statistic using 21 squared residual autocorrelations with sample size N

^a Significantly different from zero at 5% level.

^b Null hypothesis that residuals follow a white noise process is rejected at the 5% level!

Table 8

Summary Statistics for the Annualized BAX Differentials When Transaction Costs are Considered

Entire Sample without the One Day before Delivery Dates				One Day Before the 1 st Contract's Delivery Date				
	1 st contract	2 nd contract	3 rd contract	all contracts	1 st contract	2 nd contract	3 rd contract	all contracts
μ	0.4430158	0.2676955	0.2070088	0.3059067	0.290310	0.214713	0.172157	0.225727
$ \mu $	0.5192738	0.2889199	0.2102637	0.3394858	0.280402	0.214713	0.172157	0.222424
σ	0.8162296	0.4856635	0.5806899	0.6546734	0.289192	0.175441	0.145727	0.218828
N	1212	1151	1087	3450	20	18	17	55
σ_e	0.7937996	0.4730113	0.5809999	0.6399098	0.487954	0.309471	0.200679	0.158520
ϕ_1	0.1648069	0.1436488	0.0481289	0.1496296	0.781429	0.615426	0.565268	0.292872
ϕ_2	0.1400266	0.1544594	0.0124647	0.1282615	-0.128863	-0.156418	0.041153	0.146809
t	13.506675 ^a	13.476506 ^a	11.035221 ^a	20.276007 ^a	0.924421	1.592449	1.392127	5.917187 ^a
Q(21,n)	101.5875 ^b	133.6877 ^b	54.3401 ^b	419.8764 ^b	20.4231	15.8735	17.1691	37.1338 ^b
Q(21,n) ²	11.2868	3.4988	3.0037	688.4991 ^b	13.2166	16.9927	34.1077 ^b	38.2243 ^b
skewness	-16.37634	-2.3489	27.43506	16.2578	1.66406	1.20655	0.77586	1.82819
kurtosis	442.22934	260.2501	837.5001	330.32131	2.79508	0.60878	0.42131	4.40389

Legend:

μ = Sample mean.

$|\mu|$ = Sample mean of absolute values.

σ = Sample standard deviation.

N = Sample size.

σ_e = Standard error of estimate of second order autoregressive process.

ϕ_1 = First order autocorrelation coefficient.

ϕ_2 = First order autocorrelation coefficient.

$t = \mu (1 - \phi_1 - \phi_2) / (\sigma_e / N^{1/2})$

Q(21,n) = Box-Pierce Q statistic using 21 residual autocorrelations with sample size N.

Q(21,n)² = Box-Pierce Q statistic using 21 squared residual autocorrelations with sample size N.

^a Significantly different from zero at 5% level.

^b Null hypothesis that residuals follow a white noise process is rejected at the 5% level.

Legend:

μ = Sample mean.

$|\mu|$ = Sample mean of absolute values.

σ = Sample standard deviation.

N = Sample size.

σ_e = Standard error of estimate of second order autoregressive process.

ϕ_1 = First order autocorrelation coefficient.

ϕ_2 = First order autocorrelation coefficient.

$t = \mu (1 - \phi_1 - \phi_2) / (\sigma_e / N^{1/2})$

Q(21,n) = Box-Pierce Q statistic using 21 residual autocorrelations with sample size N.

Q(21,n)² = Box-Pierce Q statistic using 21 squared residual autocorrelations with sample size N.

^a Significantly different from zero at 5% level.

^b Null hypothesis that residuals follow a white noise process is rejected at the 5% level.

Table 9 Summary Statistics for Annualized BAR Differentials Between Actual and No-Transaction Cost Values of ME Index									
Entire Sample without the One Day before Delivery Dates					One Day Before the 1 st Contract's Delivery Date				
	1 st contract	2 nd contract	3 rd contract	all contracts		1 st contract	2 nd contract	3 rd contract	all contracts
μ	0.3220502	0.3682115	0.3182896	0.3361838	μ	0.6850227	0.3377413	0.2008530	0.4078724
$ \mu $	0.5885050	0.3920383	0.3485348	0.4430260	$ \mu $	0.7334568	0.3593973	0.2413821	0.4447454
σ	1.0550915	0.2883051	0.2478888	0.6571886	σ	1.6486092	0.1891771	0.2550505	1.0053003
N	631	606	588	1825	N	32	30	29	91
σ_e	0.9222136	0.1949284	0.1877492	0.5739088	σ_e	1.7510097	0.1889054	0.2703614	1.0258370
ϕ_1	0.5190045	0.6177681	0.5093455	0.4896608	ϕ_1	0.4956006	0.3012161	-0.0808133	0.0326037
ϕ_2	0.0110252	0.1544355	0.2001086	-0.0021564	ϕ_2	0.2637759	-0.2181512	0.1252424	0.0341711
t	4.1226562 ^a	10.592665 ^a	11.943934 ^a	12.824942 ^a	t	0.5325117	8.9792274 ^a	3.8229240 ^a	3.5395907 ^a
Q(21,n)	23.4724	35.3359 ^b	22.3913	51.4546 ^b	Q(21,n)	1.6574	16.0544	14.6776	2.1568
Q(21,n) ²	118.1178 ^b	74.5362 ^b	92.427 ^b	326.7134 ^b	Q(21,n) ²	0.3698	21.4	18.0712	0.4123
skewness	-3.53618	1.10801	0.18747	-5.06054	skewness	5.29637	-0.62225	-0.02342	8.54081
kurtosis	90.54745	6.98729	4.91025	210.94609	kurtosis	29.03522	2.70752	0.80071	78.34187

Legend:

μ = Sample mean.

$|\mu|$ = Sample mean of absolute values

σ = Sample standard deviation

N = Sample size

σ_e = Standard error of estimate of second order autoregressive process

ϕ_1 = First order autocorrelation coefficient.

ϕ_2 = First order autocorrelation coefficient

t = $\mu (1 - \phi_1 - \phi_2) / (\sigma_e / N^{1/2})$

Q(21,n) = Box-Pierce Q statistic using 21 residual autocorrelations with sample size N

Q(21,n)² = Box-Pierce Q statistic using 21 squared residual autocorrelations with sample size N

^a Significantly different from zero at 5% level

^b Null hypothesis that residuals follow a white noise process is rejected at the 5% level

Table 10 Summary Statistics for Annualized BAR Differentials When Transaction Costs are Considered									
Entire Sample without the One Day before Delivery Dates					One Day Before the 1 st Contract's Delivery Date				
	1 st contract	2 nd contract	3 rd contract	all contracts		1 st contract	2 nd contract	3 rd contract	all contracts
μ	0.3159972	0.3655704	0.3072538	0.3296071	μ	0.6857396	0.3377413	0.2008530	0.4081113
$ \mu $	0.5824520	0.3893971	0.3374991	0.4364494	$ \mu $	0.7341736	0.3593973	0.2413821	0.4449843
σ	1.0420148	0.2817910	0.2319014	0.6472111	σ	1.6486567	0.1891771	0.2550505	1.0053953
N	631	606	588	1825	N	32	30	29	91
σ_e	0.9067883	0.1809734	0.1621343	0.5616203	σ_e	1.7572400	0.1889054	0.2703614	1.0259337
ϕ_1	0.5303984	0.6762734	0.6608758	0.5051607	ϕ_1	0.4931640	0.3012161	-0.0808133	0.0326999
ϕ_2	0.0031345	0.1149676	0.0754540	-0.0140299	ϕ_2	0.2573742	-0.2181512	0.1252424	0.0341434
t	4.0833155 ^a	10.380959 ^a	12.116353 ^a	12.758258 ^a	t	0.5506898	8.9792274 ^a	3.8229240 ^a	3.5410704 ^a
Q(21,n)	21.7962	37.702 ^b	25.4017	46.4316 ^b	Q(21,n)	1.6602	16.0544	14.6776	2.1587
Q(21,n) ²	123.1211 ^b	160.5686 ^b	78.2813 ^b	342.9924 ^b	Q(21,n) ²	0.3699	21.4	18.0712	0.4125
skewness	-3.75551	0.96388	-0.20473	-5.42841	skewness	5.29451	-0.62225	-0.02342	8.53771
kurtosis	94.83862	6.63528	4.9796	223.27527	kurtosis	29.02087	2.70752	0.80071	78.30192
Legend: μ = Sample mean. $ \mu $ = Sample mean of absolute values. σ = Sample standard deviation. N = Sample size. σ_e = Standard error of estimate of second order autoregressive process ϕ_1 = First order autocorrelation coefficient. ϕ_2 = First order autocorrelation coefficient $t = \mu (1 - \phi_1 - \phi_2) / (\sigma_e / N^{1/2})$ Q(21,n) = Box-Pierce Q statistic using 21 residual autocorrelations with sample size N Q(21,n) ² = Box-Pierce Q statistic using 21 squared residual autocorrelations with sample size N. ^a Significantly different from zero at 5% level. ^b Null hypothesis that residuals follow a white noise process is rejected at the 5% level.									

Table 11													
Non-Annualized BAX Differences (Absolute Differences) Between Actual and Theoretical Futures Prices as a Function of Days to Maturity													
Without Considering Transaction Costs: OLS Estimates: $DIFF = a_0 + b_0 DTM_t + e_t$, $(ABDIFF = a_1 + b_1 DTM_t + e_t)$													
First Half of Sample: 8/1/1990 - 9/6/1992													
contract	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat		
contract1	-0.002775	-0.1079	0.00724	14.78346	218.5506	0.9393	0.00641	0.013709	0.028403	85.84085 ^b	1.705492		
contract2	-0.089155	-0.54616	0.0068	5.80127	33.6547	0.771457	0.000634	0.001674	0.002238	1.454008	1.478419 ^c		
contract3	-0.234810	-0.97623	0.007072	6.74343	45.4738	2.239254	9.6657 ^b	15.93022 ^b	22.95401	48.47115 ^b	0.508666 ^c		
Absolute Differences:													
contract1	0.075749	3.14536	0.006197	13.51684	182.7051	0.876017	0.007226	0.014968	0.032109	67.50100 ^b	1.584113 ^c		
contract2	0.247782	1.63365	0.004722	4.33445	18.7875	0.618492	0.000439	0.001032	1.01E-02	0.106429	1.171613 ^c		
contract3	-0.114512	-0.49216	0.006596	6.50147	42.2691	7.898 ^a	20.77972 ^b	33.90416 ^b	44.65219 ^b	52.00885	0.303397 ^c		
Second Half of Sample: 10/6/1992 - 16/12/1994													
contract	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat		
contract1	0.0256	1.71624	0.003495	12.55236	157.5619	7.550824 ^a	0.018462	0.495063	0.648013	0.794717	1.342882 ^c		
contract2	-0.182264	-1.01079	0.004785	3.73565	13.9551	4.290907	0.002153	0.004609	0.008414	0.022167	1.85405		
contract3	-0.2323	-0.37369	0.003893	1.42709	2.0366	3.329497 ^a	0.001804	0.002879	0.007901	0.021047	1.968388 ^c		
Absolute Differences:													
contract1	0.038665	2.72719	0.003417	12.91365	166.7623	6.201524	0.20124	0.511087	0.678885	0.856242	1.269262		
contract2	-0.167527	-0.935	0.004742	3.72547	13.8791	4.333352	0.002494	0.004447	0.00808	0.021208	1.87518		
contract3	-0.269426	-0.43393	0.004100	1.50483	2.2645	3.319315	0.001793	0.004039	0.008172	0.022101	1.969435		
Entire Sample: 8/1/1990 - 16/12/1994													
contract	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat		
contract1	0.015449	0.995	0.005241	17.90234	320.4936	0.245171	0.000481	0.0012	0.003508	156.8755 ^b	1.445228 ^c		
contract2	-0.104846	-0.84248	0.005614	6.31249	39.8475	2.855305	5.17E-06	9.51E-04	0.000194	0.166174	1.58145 ^c		
contract3	-0.205655	-0.56358	0.005529	3.46437	12.0018	3.553912	0.000816	0.000911	0.002248	0.007803	1.775266		
Absolute Differences:													
contract1	0.060489	4.09853	0.004697	16.88131	284.9787	0.216026	0.000194	0.000588	0.003612	128.6679 ^b	1.318572 ^c		
contract2	0.075948	0.62812	0.004527	5.23889	27.446	3.287174	0.000074	0.000431	0.000916	0.014954	1.450181 ^c		
contract3	-0.192323	-0.52891	0.005517	3.46911	12.0347	3.552124	0.000789	0.001436	0.002727	0.008295	1.767427		

^a ^b ^c indicate significant Heteroskedasticity, Arch effect and autocorrelation at the 5% level, respectively

Table 12												
Non-Announced BAX Differences (Absolute Differences) Between Actual and Theoretical Futures Prices as a Function of Days to Maturity												
Considering Transaction Costs: OLS Estimates: $DIFF = a_0 + b_0 DTM_t + e_t$, $(ABDIFF = a_1 + b_1 DTM_t + e_t)$												
1 st 8/1/1990 - 9/6/1992												
	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat	
contract1	1.62776	0.004742	10.45647	109.3379	0.149347	0.000144	0.001387	0.009292	48.10495 ^b	1.105426 ^c		
contract2	2.12768	0.001430	1.31283	1.7235	1.082801	0.006265	0.015352	0.031579	0.017997	1.496776 ^c		
contract3	-2.14352	0.004315	6.30963	39.8115	0.523375	2.921452	4.076716	5.193469	11.31487	0.98365 ^c		
Absolute Differences:												
contract1	0.094346	4.14755	0.004001	9.23689	85.3201	0.347516	0.000512	5.15E-03	0.004897	31.30216 ^b	0.945751 ^c	
contract2	0.607072	4.20529	-0.000333	-0.32173	0.1035	1.014362	0.002409	0.006582	0.0139	0.039189	1.174418 ^c	
contract3	-0.260959	-1.70488	0.004020	0.000667	36.2864	1.157257	3.934759 ^b	5.439948	7.021759	10.83513	0.929363 ^c	
Second Half of Sample: 10/6/1992 - 16/12/1994												
	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat	
contract1	0.047811	4.01929	0.001746	7.86651	61.882	4.79782	0.005314	0.047184	0.05018	0.078723	1.613982 ^c	
contract2	-0.199396	-1.1327	0.003469	2.77442	7.6974	4.53435	0.002189	0.003939	0.007158	0.019038	1.93201	
contract3	-0.374859	-0.60421	0.003408	1.25169	1.5667	3.315102	0.00178	0.003538	0.007986	0.022341	1.973919	
Absolute Differences:												
contract1	0.062604	5.52394	0.001614	7.6311	58.2336	4.380752	0.003769	0.049806	0.052033	0.078093	1.63714 ^c	
contract2	-0.185935	-1.06007	0.003431	2.7536	7.5823	4.376756	0.002113	0.003838	0.006953	0.018547	1.94455	
contract3	-0.403944	-0.65153	0.003573	1.31328	1.7247	3.310226	0.001775	0.003997	0.008384	0.022723	1.97477	
Entire Sample: 8/1/1990 - 16/12/1994												
	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat	
contract1	0.046594	3.36896	0.003139	12.03918	144.9418	1.907351	0.117054	0.200499	0.330996	76.05699 ^b	1.100012 ^c	
contract2	0.083051	0.70965	0.002331	2.78792	7.7725	3.05617	3.76E-04	4.51E-04	0.000224	0.002886	1.686483	
contract3	-0.353955	-1.01343	0.003911	2.56045	6.5559	3.40847	0.000662	0.001042	0.002935	0.009311	1.92835	
Absolute Differences:												
contract1	0.081289	6.10993	0.002713	10.81732	117.0144	2.563	0.18889	0.329237	0.538195	53.25202 ^b	0.976645 ^c	
contract2	0.235894	2.05173	0.001409	1.71577	2.9439	3.287323	0.000339	0.000563	9.00E-03	0.004208	1.547471 ^c	
contract3	-0.349666	-1.00266	0.003927	2.57511	6.6312	3.4059	0.000652	0.001529	0.003393	0.009786	1.929093	

^{a,b,c} indicate significant Heteroskedasticity, Arch effect and autocorrelation at the 5% level, respectively.

Table 13 Annualized BAX Differences (Absolute Differences) Between Actual and Theoretical Futures Prices as a Function of Days to Maturity Without Considering Transaction Costs: OLS Estimates: $DIFF = a_0 + b_0 DTM_t + e_t$, $(ABDIFF = a_1 + b_1 DTM_t + e_t)$												
First Half of Sample: 8/1/1990 - 9/6/1992												
contract	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat	
contract1	0.706891	6.40605	-0.001023	-0.48728	0.2374	1.631144	0.002183	0.004865	0.010388	9.622799	1.950285	
contract2	0.489617	3.95106	0.000440	0.49501	0.245	1.235357	0.000274	0.000949	0.001842	0.9164	1.68654	
contract3	0.447499	4.71481	0.000414	1.00163	1.0033	0.258881	7.283712 ^b	12.21025 ^b	19.49809	59.31443 ^b	2.00428	
Absolute Differences:												
contract1	1.082298	10.4936	-0.006243	-3.1793	10.1079	1.564899	0.002058	0.005039	0.010773	6.546017	1.892242	
contract2	0.767313	6.7455	-0.001276	-1.56252	2.4415	1.16069	5.46E-05	4.47E-04	1.08E-03	0.073163	1.358584 ^c	
contract3	0.501974	5.52191	0.000198	0.5009	0.2509	0.947008	21.95851 ^b	37.44342 ^b	52.10926 ^b	71.05847 ^b	0.284239 ^c	
Second Half of Sample: 10/6/1992 - 16/12/1994												
contract	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat	
contract1	0.604581	12.74145	-0.003930	-4.43735	19.6901	33.31459 ^a	1.246728	1.369538	1.56578	1.617678	1.097112 ^c	
contract2	0.231981	2.40812	0.000558	0.81662	0.6669	3.993936	0.003238	0.005762	0.010922	0.028593	1.727121	
contract3	0.027876	0.13328	0.000989	1.07812	1.1623	3.245294	0.001948	0.003061	0.007716	0.023155	1.9602	
Absolute Differences:												
contract1	0.769373	17.99316	-0.006339	-7.94269	63.0863	20.76091 ^a	0.503143	0.414705	0.501667	0.554415	1.158271 ^c	
contract2	0.242889	2.54663	0.000522	0.77105	0.5945	4.069033	0.003108	0.00556	0.10448	0.027037	1.75818	
contract3	0.015223	0.07288	0.001060	1.15675	1.3381	3.234401	0.001932	0.004364	0.008961	0.024418	1.961473	
Entire Sample: 8/1/1990 - 16/12/1994												
contract	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat	
contract1	0.664696	11.15047	-0.002692	-2.39587	5.7402	2.618773	0.000816	0.002349	0.006055	19.23695 ^b	1.778159	
contract2	0.381715	4.71001	0.000380	0.511751	0.4307	1.067238	0.003343	0.007632	0.015532	0.917105	1.607862 ^c	
contract3	0.173378	1.38097	0.001047	1.90716	3.6373	3.35807	0.000954	0.001087	0.002306	0.007831	1.710306	
Absolute Differences:												
contract1	0.932328	16.72746	-0.006459	-6.14655	37.7801	2.2841	0.004174	0.414705	0.501667	0.554415	1.725872	
contract2	0.530194	6.83485	-0.000518	-0.93496	0.8741	1.223674	0.001133	0.00556	0.010448	0.027037	1.390268 ^c	
contract3	0.182284	1.45882	0.001027	1.87922	3.5315	3.39528	0.00093	0.004364	0.008961	0.024418	1.693668	

^a ^b ^c indicate significant Heteroskedasticity. Arch effect and autocorrelation at the 5% level, respectively.

Table 14 Annualized BAX Differences (Absolute Differences) Between Actual and Theoretical Futures Prices as a Function of Days to Maturity Considering Transaction Costs: OLS Estimates: $DIFF = a_0 + b_0 DTM_t + e_t$, $(ABDIFF = a_1 + b_1 DTM_t + e_t)$												
First Half of Sample: 8/1/1990 - 9/6/1992												
contract	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat	
contract1	0.755810	8.86756	-0.004207	-2.59272	6.7222	1.66093	0.001782	0.004467	0.010349	4.724377	1.824167	
contract2	0.570188	4.92902	-0.001625	-1.95547	3.8238	1.6076	0.10009	0.023186	0.045989	0.188456	1.631186	
contract3	0.127904	2.05112	0.000553	2.03472	4.1401	0.737074	5.526601 ^b	7.551262	9.416142	22.27543	0.996545	
Absolute Differences:												
contract1	1.032226	13.09467	-0.008084	-5.38633	29.0126	1.537439	0.002533	0.005242	0.012071	2.507554	1.718644	
contract2	0.805960	7.38542	-0.003090	-3.94257	15.5439	1.625234	0.005353	0.013169	0.026386	0.062862	1.259351	
contract3	0.161849	2.6757	0.000419	159.216	2.535	0.2479	9.202538 ^b	12.29608	15.29526	22.51774	0.928107	
Second Half of Sample: 10/6/1992 - 16/12/1994												
contract	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat	
contract1	0.534475	14.55648	-0.004642	-6.77306	45.8743	109.9224 ^a	66.66929 ^b	79.62848 ^b	105.4992 ^b	111.5510	0.942204 ^c	
contract2	0.081296	0.88093	0.000706	1.07722	1.1604	4.159199	0.00268	0.004846	0.009072	0.024446	1.86083	
contract3	-0.067027	-0.32134	0.000963	1.05274	1.1083	3.230481	0.001902	0.003805	0.008839	0.024849	1.968577	
Absolute Differences:												
contract1	0.770088	22.37867	-0.007102	-12.37867	147.6097	64.03466 ^a	39.22069 ^b	42.99529 ^b	67.19661 ^b	75.68145	0.984285 ^c	
contract2	0.091464	0.99689	0.000672	1.03136	1.0637	4.199916	0.002568	0.00469	0.08742	0.023649	1.880318	
contract3	-0.076876	-0.36883	0.001020	1.1151	1.2435	3.225361	0.001896	0.004316	0.009296	0.025309	1.969554	
Entire Sample: 8/1/1990 - 16/12/1994												
contract	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat	
contract1	0.652280	14.09091	-0.004590	-5.25983	27.6658	2.87818	1.24E-04	0.000253	0.001845	9.325606	1.632264 ^c	
contract2	0.340769	4.50939	-0.000541	-1.0023	1.0046	1.397523	0.019671	0.043579	0.088151	0.248223	1.655831	
contract3	-0.001045	-0.00883	0.000918	1.77263	3.1422	3.281442	0.000738	0.001164	0.00353	0.011044	1.906133	
Absolute Differences:												
contract1	0.872231	20.4741	-0.007732	-9.62672	92.6738	2.251924	0.000326	0.001145	0.004217	5.645646	1.543452 ^c	
contract2	0.467151	6.35581	-0.001308	-2.49134	6.2068	1.53499	0.012392	0.028252	0.057945	0.130903	1.416645 ^c	
contract3	0.003145	0.02661	0.000913	1.76778	3.1251	3.282702	0.000723	0.001707	0.004021	0.011521	1.90611	

^a ^b ^c indicate significant Heteroskedasticity, Arch effect and autocorrelation at the 5% level, respectively.

Table 15												
Non-Annualized BAR Differences (Absolute Differences) Between Actual and Theoretical Futures Prices as a Function of Days to Maturity												
Without Considering Transaction Costs: OLS Estimates: $DIFF = a_0 + b_0 DTM_t + e_t$, $(ABDIFF = a_1 + b_1 DTM_t + e_t)$												
First Half of Sample: 16/4/1992 - 28/7/1993												
contract	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat	
contract1	-0.010100	-0.76145	0.006141	8.9012	79.2327	2.6529	9.278631 ^b	10.93122	14.06407	18.86859	0.831186 ^c	
contract2	0.1199	2.8737	0.002503	2.888	8.3414	0.00966	79.2032 ^b	80.51778 ^b	85.50946 ^b	94.88578	0.724801 ^c	
contract3	0.109688	2.0513	0.002778	4.0105	16.0845	0.366938	29.1919 ^b	29.06382	33.45972	46.59258	0.90079 ^c	
Absolute Differences:												
contract1	0.030519	2.44257	0.004556	7.01036	49.1451	3.106101	8.104455 ^b	9.423663	10.58282	12.29762	0.755104 ^c	
contract2	0.120177	2.88	0.002498	2.883	8.3122	0.008543	79.16413 ^b	80.45620 ^b	85.40103 ^b	94.74198	0.723578 ^c	
contract3	0.108935	2.0414	0.002790	4.03638	16.2924	0.386406	28.93192 ^b	28.80477	33.17108	46.49641	0.903053 ^c	
Second Half of Sample: 29/7/1993 - 16/12/1994												
contract	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat	
contract1	-0.003224	-0.29285	0.003039	5.3039	28.1314	3.113759	235.1078 ^b	234.5840 ^b	234.7385 ^b	238.6986	0.497509 ^c	
contract2	-0.035493	-0.91683	0.003800	4.73202	22.392	12.48966 ^a	194.6427 ^b	197.1418 ^b	198.7431 ^b	198.8015	0.615841 ^c	
contract3	-0.077709	-0.93913	0.003815	3.57214	12.7602	6.147616 ^a	108.2035 ^b	119.3738 ^b	118.9232 ^b	142.3989	0.684567 ^c	
Absolute Differences:												
contract1	0.020616	2.5767	0.003542	8.50638	72.3584	0.631485	162.5047 ^b	162.0533 ^b	161.6130 ^b	162.5669	0.526857 ^c	
contract2	0.026709	-0.93192	0.004145	6.97162	48.6036	19.53061 ^a	87.80397 ^b	96.04191 ^b	99.92089 ^b	103.0446	0.743653 ^c	
contract3	-0.001954	-0.0322	0.003516	4.48839	20.1456	16.32588 ^a	38.02174 ^b	51.53687 ^b	55.31190 ^b	78.39845	0.904691 ^c	
Entire Sample: 16/4/1992 - 16/12/1994												
contract	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat	
contract1	-0.006352	-0.72068	0.004520	9.85384	97.0981	5.645668	90.43788 ^b	103.4367 ^b	112.3443 ^b	117.5482	0.646015 ^c	
contract2	0.041681	1.3889	0.003159	5.07155	25.7206	2.272004	238.1369 ^b	244.5789 ^b	248.6049 ^b	258.0914 ^b	0.601635 ^c	
contract3	0.028453	0.5765	0.003154	4.94173	24.4207	3.053616	188.6464 ^b	198.8237 ^b	199.4879 ^b	201.6386	0.708878 ^c	
Absolute Differences:												
contract1	0.025333	3.4416	0.004028	10.5166	110.599	3.318094	31.70573 ^b	35.72523 ^b	38.60773 ^b	42.07091	0.660299 ^c	
contract2	0.045905	1.7531	0.003336	6.13622	37.6532	1.141166	175.8684 ^b	180.5898 ^b	190.2835 ^b	207.2468 ^b	0.672746 ^c	
contract3	0.060917	1.5026	0.003065	5.84697	34.1871	6.392026 ^a	66.96114 ^b	71.14465 ^b	80.85298 ^b	84.50103	0.877665 ^c	

^{a, b, c} indicate significant Heteroskedasticity. Arch effect and autocorrelation at the 5% level, respectively.

Table 16												
Non-Annualized BAR Differences (Absolute Differences) Between Actual and Theoretical Futures Prices as a Function of Days to Maturity												
Considering Transaction Costs: OLS Estimates: $DIFF = a_0 + b_0 DTM_t + e_t$, $(ABDIFF = a_1 + b_1 DTM_t + e_t)$												
First Half of Sample: 16/4/1992 - 28/7/1993												
contract	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat	
contract1	-0.011092	-0.9359	0.006042	9.80087	96.057	2.837547	100.2833 ^b	100.5788 ^b	104.1658 ^b	130.9045	0.619154 ^c	
contract2	0.143934	3.8619	0.001824	2.3559	5.5503	2.222504	193.4019 ^b	194.5010 ^b	198.0291 ^b	195.3767	0.685789 ^c	
contract3	0.090885	2.0904	0.002812	4.99261	24.9262	1.060623	48.48385 ^b	52.96687 ^b	72.25907 ^b	90.99945 ^b	0.865531 ^c	
Absolute Differences:												
contract1	0.029527	2.68	0.004457	7.778	60.5091	4.009374	110.4712 ^b	110.1195 ^b	112.2938 ^b	140.11152	0.481688 ^c	
contract2	0.144197	3.87	0.001819	2.35	5.5234	2.190929	193.2931 ^b	194.3431 ^b	197.7446 ^b	195.1225	0.684182 ^c	
contract3	0.090132	2.0793	0.002824	5.02916	25.2925	0.979267	47.41152 ^b	52.17293 ^b	71.38602 ^b	89.66718 ^b	0.868497 ^c	
Second Half of Sample: 29/7/1993 - 16/12/1994												
contract	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat	
contract1	-0.003224	-0.2928	0.003039	5.3039	28.1314	3.11375	235.1078 ^b	234.5845 ^b	234.7385 ^b	238.6986	0.4975 ^c	
contract2	-0.035493	-0.91683	0.003800	4.73202	22.392	12.48966 ^a	194.6427 ^b	197.1418 ^b	198.7431 ^b	198.8015	0.615841 ^c	
contract3	-0.018828	-0.25532	0.002820	2.96248	8.7763	2.828689	144.4294 ^b	147.4625 ^b	148.1345 ^b	146.4566	0.527267 ^c	
Absolute Differences:												
contract1	0.020616	2.5767	0.003542	8.50638	72.3584	0.631485	162.5047 ^b	162.0533 ^b	161.6130 ^b	162.5669	0.526857 ^c	
contract2	-0.026709	-0.93192	0.004145	6.97162	48.6036	19.53061 ^a	87.80597 ^b	96.04191 ^b	99.92089 ^b	103.0446	0.743653 ^c	
contract3	0.056926	1.1403	0.002520	3.9118	15.3026	21.39851 ^a	58.26655 ^b	58.01617 ^b	58.09651	63.19943	0.858831 ^c	
Entire Sample: 16/4/1992 - 16/12/1994												
contract	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat	
contract1	-0.006829	-0.8211	0.004472	10.33259	106.7625	6.353005 ^a	353.3987 ^b	352.9498 ^b	354.4538 ^b	370.9208	0.531559 ^c	
contract2	0.053320	1.8835	0.002828	4.8119	23.1547	0.905037	396.3304 ^b	399.8505 ^b	402.9292 ^b	402.3151 ^b	0.581324 ^c	
contract3	0.043662	1.0128	0.002735	4.90688	24.0775	2.62232	298.4820 ^b	305.8598 ^b	306.0925 ^b	312.7799 ^b	0.58079 ^c	
Absolute Differences:												
contract1	0.024856	3.6631	0.003980	11.273	127.081	3.953636	259.55 ^b	259.1705 ^b	262.2537 ^b	301.0013	0.485047 ^c	
contract2	0.057544	2.3665	0.003004	5.95113	35.416	0.102154	353.1188 ^b	358.6194 ^b	367.5677 ^b	366.0903 ^b	0.651298 ^c	
contract3	0.076125	2.2823	0.002646	6.13614	37.6522	13.76445 ^a	103.2451 ^b	106.3157 ^b	122.0276 ^b	141.2050 ^b	0.831665 ^c	

^{a, b, c} indicate significant Heteroskedasticity, Arch effect and autocorrelation at the 5% level, respectively.

Table 17 Annualized BAR Differences (Absolute Differences) Between Actual and Theoretical Futures Prices as a Function of Days to Maturity Without Considering Transaction Costs: OLS Estimates: $DIFF = a_0 + b_0 DTM_t + e_t$, $(ABDIFF = a_t + b_t DTM_t + e_t)$													
First Half of Sample: 16/4/1992 - 28/7/1993													
contract	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat		
contract1	-0.076515	-0.55845	0.026418	3.70679	13.7403	7.931082 ^a	4.213324 ^b	4.22949	4.211233	4.276032	1.159497 ^c		
contract2	0.681322	8.06536	-0.004628	-2.63713	6.9544	5.732803	112.8467 ^b	115.8156 ^b	119.0554 ^b	123.6784	0.671311 ^c		
contract3	0.275862	4.1934	0.001322	1.55105	2.4058	2.197095	23.18501 ^b	23.29087	24.80532	33.72856	0.896855 ^c		
Absolute Differences:													
contract1	0.983423	8.06987	-0.018884	-2.97914	8.8753	6.58722 ^a	2.414	2.405098	2.39494	2.45908	1.24046 ^c		
contract2	0.682087	8.078	-0.004642	-2.64676	7.0054	5.702482	112.9317 ^b	115.7598 ^b	118.8992 ^b	123.4917	0.669533 ^c		
contract3	0.275108	4.188	0.001334	1.5676	2.4575	2.263973	23.05278 ^b	23.16026	24.63744	33.60994	0.89843 ^c		
Second Half of Sample: 29/7/1993 - 16/12/1994													
contract	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat		
contract1	0.376579	3.75046	-0.005611	-1.0737	1.1528	14.673 ^a	208.8216 ^b	209.2459	208.0308	204.4993	0.65793 ^c		
contract2	0.195409	2.7743	0.001603	1.09719	1.2038	0.802152	161.1269 ^b	165.4710	167.0988 ^b	172.4555	0.592423 ^c		
contract3	0.028372	0.2999	0.002844	2.32893	5.4239	0.678333	90.47323 ^b	105.1142	104.5594 ^b	149.9191	0.657791 ^c		
Absolute Differences:													
contract1	0.816095	9.4478	-0.018297	-4.06948	16.5607	11.74775 ^a	214.0956 ^b	213.4752	212.2260	208.6317	0.533855 ^c		
contract2	0.262384	5.1124	0.001188	1.116	1.2463	5.911843	79.23086 ^b	89.22560 ^b	94.45234 ^b	96.90571	0.807034 ^c		
contract3	0.152542	2.2488	0.002046	2.3376	5.4648	5.412172	11.56940 ^b	18.78283 ^b	21.85753	55.82854	0.951095 ^c		
Entire Sample: 16/4/1992 - 16/12/1994													
contract	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat		
contract1	0.162 ^a	1.921	0.009592	2.1795	4.7505	17.16055 ^a	25.45422 ^b	25.41622	25.36945	25.47081	0.96922 ^c		
contract2	0.43 ^a	4.4276	-0.001456	-1.19943	1.4386	3.884294	267.6274 ^b	273.1994 ^b	273.7888 ^b	282.5082 ^b	0.559946 ^c		
contract3	0.168 ^a	2.8967	0.001893	2.5178	6.3395	1.475134	158.0534 ^b	172.7030 ^b	173.3530 ^b	174.8442	0.696014 ^c		
Absolute Difference:													
contract1	0.895393	12.1437	-0.018546	-4.83346	23.3623	14.03692 ^a	18.45665 ^b	18.44275	18.39567	18.49992	0.967128 ^c		
contract2	0.469283	9.10467	-0.001671	-1.56166	2.4388	4.096339	243.3776 ^b	249.1260 ^b	254.6675 ^b	264.7080 ^b	0.639055 ^c		
contract3	0.222094	4.6493	0.001593	2.5792	6.6527	0.056919	41.17615 ^b	44.41338 ^b	48.77490 ^b	55.85345	0.894063 ^c		

^{a, b, c} indicate significant Heteroskedasticity, Arch effect and autocorrelation at the 5% level, respectively.

Table 18													
Annualized BAR Differences (Absolute Differences) Between Actual and Theoretical Futures Prices as a Function of Days to Maturity													
Considering Transaction Costs: OLS Estimates: $DIFF = a_0 + b_0 DTM_i + e_i$, $(ABDIFF = a_1 + b_1 DTM_i + e_i)$													
First Half of Sample: 16/4/1992 - 28/7/1993													
contract	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat		
contract1	-0.081178	-0.60448	0.025987	3.72011	13.8392	8.315068 ^a	4.276841 ^b	4.295088	4.276648	4.350384	1.141961 ^c		
contract2	0.678395	8.3522	-0.004673	-2.76932	7.6691	7.801815 ^a	175.6349 ^b	175.0505 ^b	177.0121 ^b	188.4162	0.541606 ^c		
contract3	0.272750	4.3198	0.001320	1.61447	2.6065	2.651287	39.30349 ^b	39.30679 ^b	40.35637	50.14328	0.754715 ^c		
Absolute Differences:													
contract1	0.978760	8.223	-0.019315	-3.119	9.733	6.956302 ^a	2.484839	2.475816	2.464238	2.541405	1.215342 ^c		
contract2	0.679161	8.366	-0.004687	-2.77945	7.7253	7.729449 ^a	175.8238 ^b	175.2340 ^b	177.1276 ^b	188.3275	0.539536 ^c		
contract3	0.271997	4.3148	0.001332	1.6319	2.6632	2.73035	39.1168 ^b	39.12451 ^b	40.1298	49.93671	0.755941 ^c		
Second Half of Sample: 29/7/1993 - 16/12/1994													
contract	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat		
contract1	0.376579	3.7504	-0.005611	-1.0737	1.1528	14.67302 ^a	208.8216 ^b	209.2459	208.0308	204.4993	0.6579 ^c		
contract2	0.195409	2.7743	0.001603	1.09719	1.2038	0.802152	161.1269 ^b	165.4710 ^b	167.0988 ^b	172.4555	0.592423 ^c		
contract3	0.081113	0.9491	0.001914	1.73553	3.0121	0.729495	165.2558 ^b	170.6210 ^b	173.5789 ^b	171.9973	49.3722 ^c		
Absolute Differences:													
contract1	0.816095	9.4478	-0.018297	-4.06948	16.5607	11.74775 ^a	214.0956 ^b	213.4752	212.2260	208.6317	0.533855 ^c		
contract2	0.262384	5.1124	0.001188	1.1163	1.2463	5.911843 ^a	79.23086 ^b	89.22560 ^b	94.45234 ^b	96.90571	0.807034 ^c		
contract3	0.205282	3.619	0.011173	1.52616	2.3292	10.07736	53.47304 ^b	55.41985 ^b	55.58481	57.41785	0.835074 ^c		
Entire Sample: 16/4/1992 - 16/12/1994													
contract	a	t-stat	b	t-stat	F	white test	Arch 1	Arch 2	Arch 4	Arch 10	Durb/Wat		
contract1	0.160217	1.918	0.009385	2.15897	4.6612	17.71375 ^a	25.75215 ^b	25.71413	25.66828	25.77602	0.955195 ^c		
contract2	0.433934	7.58616	-0.001478	-1.24492	1.5498	4.798857	358.279 ^b	357.9434 ^b	357.2876 ^b	371.2207 ^b	0.495242 ^c		
contract3	0.189918	3.4742	0.001474	2.08549	4.3492	2.587916	235.8418 ^b	242.8676 ^b	242.1327 ^b	243.7314	0.545514 ^c		
Absolute Differences:													
contract1	0.893153	12.2965	-0.018753	-4.96132	246147	14.56936 ^a	18.73403 ^b	18.71862	18.67136	18.78855	0.945243 ^c		
contract2	0.467786	9.33531	-0.001692	-1.62707	2.6474	5.141262	354.6896 ^b	354.1150 ^b	358.3717 ^b	376.7896 ^b	0.558188 ^c		
contract3	0.243532	5.5571	0.001173	2.07127	4.2902	0.992518	91.22979 ^b	91.88517 ^b	94.58206	111.0830 ^b	0.74846 ^c		

^{a, b, c} indicate significant Heteroskedasticity, Arch effect and autocorrelation at the 5% level, respectively.

<p align="center">Table 19 BAX Differences Between Actual and Theoretical Futures Prices as a Function of Contract Maturity: Garch Estimation; DIFF = $b_{0a} - b_{1a} \text{DTM} - b_{2a} \text{DUM}$</p>						
<u>Non-Annualized Differentials Without Consideration of Transaction Costs.</u>						
	b_{0a}	t-stat	b_{1a}	t-stat	b_{2a}	t-stat
contract1	-0.0009079	-17.04969 [*]	0.0054192	762.178 [*]	-0.0564138	-60.28437 [*]
contract2	-0.5676923	-282.9 [*]	0.0093640	878.55 [*]	-0.0683111	-63.3248 [*]
contract3	-0.84048	-271.466 [*]	0.0086798	596.2 [*]	-0.0656964	-67.04 [*]
<u>Non-Annualized Differentials With Transaction Costs</u>						
	b_{0a}	t-stat	b_{1a}	t-stat	b_{2a}	t-stat
contract1	-0.0125403	-18.146 [*]	0.0046149	406.42256 [*]	-0.020853	-24.23477 [*]
contract2	-0.7733674	-323.0190 [*]	0.0082388	576.0468 [*]	0.047389	41.367 [*]
contract3	-0.2670190	-128.6297 [*]	0.0036769	445.19718 [*]	-0.0168500	-18.23602 [*]
<u>Annualized Differentials Without Consideration of Transaction Costs.</u>						
	b_{0a}	t-stat	b_{1a}	t-stat	b_{2a}	t-stat
contract1	0.6762173	1340.541 [*]	-0.003531	-533.8321 [*]	-0.0031437	-4.76 [*]
contract2	-0.0697895	-24.347 [*]	0.0039425	261.27192 [*]	-0.0420663	-32.6056 [*]
contract3	1.4606050	669.229 [*]	-0.0040389	-379.3742 [*]	-0.1860152	-252.4750 [*]
<u>Annualized Differentials Considering Transaction Costs.</u>						
	b_{0a}	t-stat	b_{1a}	t-stat	b_{2a}	t-stat
contract1	0.3988864	253.4411 [*]	-0.0005864	-31.85448 [*]	0.0051135	3.47905 [*]
contract2	-0.1757078	-163.4537 [*]	0.0028565	457.428 [*]	0.0828041	139.672 [*]
contract3	0.1103777	165.86823 [*]	0.0004967	196.447 [*]	-0.0077308	-21.492 [*]

^{*} indicates significant at the 5% level.

Table 20

BAX Absolute Differences Between Actual and Theoretical Futures Prices as a Function of Futures Contract Maturity: GARCH Estimates;

$$ABDIFF = b_{0b} - b_{1b} \text{ DTM} - b_{2b} \text{ DUM}$$

Non-Annualized Absolute Differentials Without Consideration of Transaction Costs

	b_{0b}	t-stat	b_{1b}	t-stat	b_{2b}	t-stat
contract1	-0.0300026	-0.23377 ^a	0.0061499	1210.7406 ^a	-0.0431046	-103.4361 ^a
contract2	-0.5286776	-230.7283 ^a	0.0098078	763.15375 ^a	-0.1313165	-108.9498 ^a
contract3	-0.8499108	-279.663 ^a	0.0087264	607.49496 ^a	-0.0588162	-59.51963 ^a

Non-Annualized Absolute Differentials Considering Transaction Costs

	b_{0b}	t-stat	b_{1b}	t-stat	b_{2b}	t-stat
contract1	-0.0058	-10.40732 ^a	0.0046668	419.2346 ^a	-0.0341133	-72.06973 ^a
contract2	-0.7609245	-323.7837 ^a	0.0081701	579.23841 ^a	0.0421736	37.26296 ^a
contract3	0.0165002	10.59974 ^a	0.0025463	427.618 ^a	-0.0629900	-61.20451 ^a

Annualized Absolute Differentials Without Consideration of Transaction Costs

	b_{0b}	t-stat	b_{1b}	t-stat	b_{2b}	t-stat
contract1	0.6914256	1242.623 ^a	-0.0036778	-550.8017 ^a	0.0263573	35.576 ^a
contract2	-0.1051246	-67.96192 ^a	0.0042868	533.938 ^a	-0.0582498	-68.8326 ^a
contract3	0.1142163	111.697 ^a	0.0014375	326.18367 ^a	-0.0438481	-93.9567 ^a

Annualized Absolute Differentials Considering of Transaction Costs

	b_{0b}	t-stat	b_{1b}	t-stat	b_{2b}	t-stat
contract1	0.7232190	677.58299 ^a	-0.0071737	-555.8064 ^a	-0.0947711	-81.99754 ^a
contract2	-0.1642984	-156.5715 ^a	0.0027896	454.78935 ^a	0.0802237	138.23132 ^a
contract3	0.1497504	163.9731 ^a	0.0002983	86.42878 ^a	0.0340404	59.90375 ^a

^a indicates significant at the 5% level.

^a indicates significant at the 5% level.

<p>Table 21</p> <p>BAR Differences Between Actual and Theoretical Futures Prices as a Function of Futures Contract Maturity: GARCH Estimates;</p> <p>DIFF = $b_{0a} - b_{1a}$ DTM - b_{2a} DUM</p>						
Non-Annualized Differentials Without Consideration of Transaction Costs						
	b_{0a}	t-stat	b_{1a}	t-stat	b_{2a}	t-stat
contract1	-8.04E-02	-18.301 ^a	5.49E-02	266.2168 ^a	-3.21E-01	-933.0323 ^a
contract2	0.1343901	109.913 ^a	0.0021922	84.0119 ^a	-0.0907063	-171.027 ^a
contract3	0.1109446	22.92599 ^a	0.0023641	36.517 ^a	-0.068098	-59.108 ^a
Non-Annualized Differentials Considering Transaction Costs						
	b_{0a}	t-stat	b_{1a}	t-stat	b_{2a}	t-stat
contract1	-0.0126743	-23.25 ^a	0.0052221	193.21149 ^a	-0.0269442	-65.091 ^a
contract2	0.1275678	94.873 ^a	0.0022228	76.98997 ^a	-0.0845561	-142.9625 ^a
contract3	0.0633271	34.4902 ^a	0.0026883	118.14226 ^a	-0.0476619	-80.2729 ^a
Annualized Differentials Without Consideration of Transaction Costs						
	b_{0a}	t-stat	b_{1a}	t-stat	b_{2a}	t-stat
contract1	0.2327839	61.276 ^a	0.0082179	35.77907 ^a	-0.1652611	-41.25186 ^a
contract2	0.6278	334.251 ^a	-0.0034164	-82.774 ^a	-0.1829629	-187.6325 ^a
contract3	0.2637012	56.11836 ^a	0.0010961	17.777 ^a	-0.0837489	-49.5877 ^a
Annualized Differentials Considering of Transaction Costs						
	b_{0a}	t-stat	b_{1a}	t-stat	b_{2a}	t-stat
contract1	0.183428	91.31929 ^a	0.0105234	82.7315 ^a	0.16366	-86.43 ^a
contract2	0.6275466	277.2048 ^a	-0.0036151	-70.60724 ^a	-0.1733276	-168.0362 ^a
contract3	0.2482278	67.05335 ^a	0.0012040	25.7668 ^a	-0.0762490	-52.567 ^a

^a indicates significant at the 5% level.

<p style="text-align: center;">Table 22</p> <p style="text-align: center;">BAR Absolute Differences Between Actual and Theoretical Futures Prices as a Function of Futures Contract Maturity: GARCH Estimates; ABDIFF = $b_{0b} - b_{1b}$ DTM - b_{2b} DUM</p>						
<u>Non-Annualized Absolute Differentials Without Consideration of Transaction</u>						
	b_{0b}	t-stat	b_{1b}	t-stat	b_{2b}	t-stat
contract1	0.017788	14.44747*	0.003972	77.81*	-0.016695	-18.281*
contract2	0.121349	109.6*	0.002505	102.073*	-0.090122	-176.2542*
contract3	0.120688	26.3046*	0.002264	36.832*	-0.055747	-42.28763*
<u>Non-Annualized Absolute Differentials Considering Transaction Costs</u>						
	b_{0b}	t-stat	b_{1b}	t-stat	b_{2b}	t-stat
contract1	9.16E-02	22.29912*	4.35E-02	267.687*	-1.30E-01	-36.241*
contract2	0.124310	98.011*	0.002378	84.219*	-0.08684	-156.854*
contract3	0.067451	39.34561*	0.002636	124.3519*	-0.038664	-60.22756*
<u>Annualized Absolute Differentials Without Consideration of Transaction Costs</u>						
	b_{0b}	t-stat	b_{1b}	t-stat	b_{2b}	t-stat
contract1	0.832697	832.8447*	-0.005420	-93.095*	-0.417380	-192.8559*
contract2	0.618977	318.9398*	-0.003195	-73.69*	-0.184892	-186.3050*
contract3	0.281823	65.31027*	0.000897	15.88445*	-0.070611	-40.37589*
<u>Annualized Absolute Differentials Considering of Transaction Costs</u>						
	b_{0b}	t-stat	b_{1b}	t-stat	b_{2b}	t-stat
contract1	0.662079	383.4112*	-0.006214	-56.79349*	-0.260770	-152.1566*
contract2	0.621442	258.4671*	-0.003455	-62.42818*	-0.174769	-165.7494*
contract3	0.266998	79.45339*	0.001001	23.54902*	-0.070094	-48.6611*
* indicates significant at the 5% level.						

Appendix 2
Figures

Figure 1: Non-Annualized BAX Differentials without Considering Transaction Costs Versus Days to Maturity.

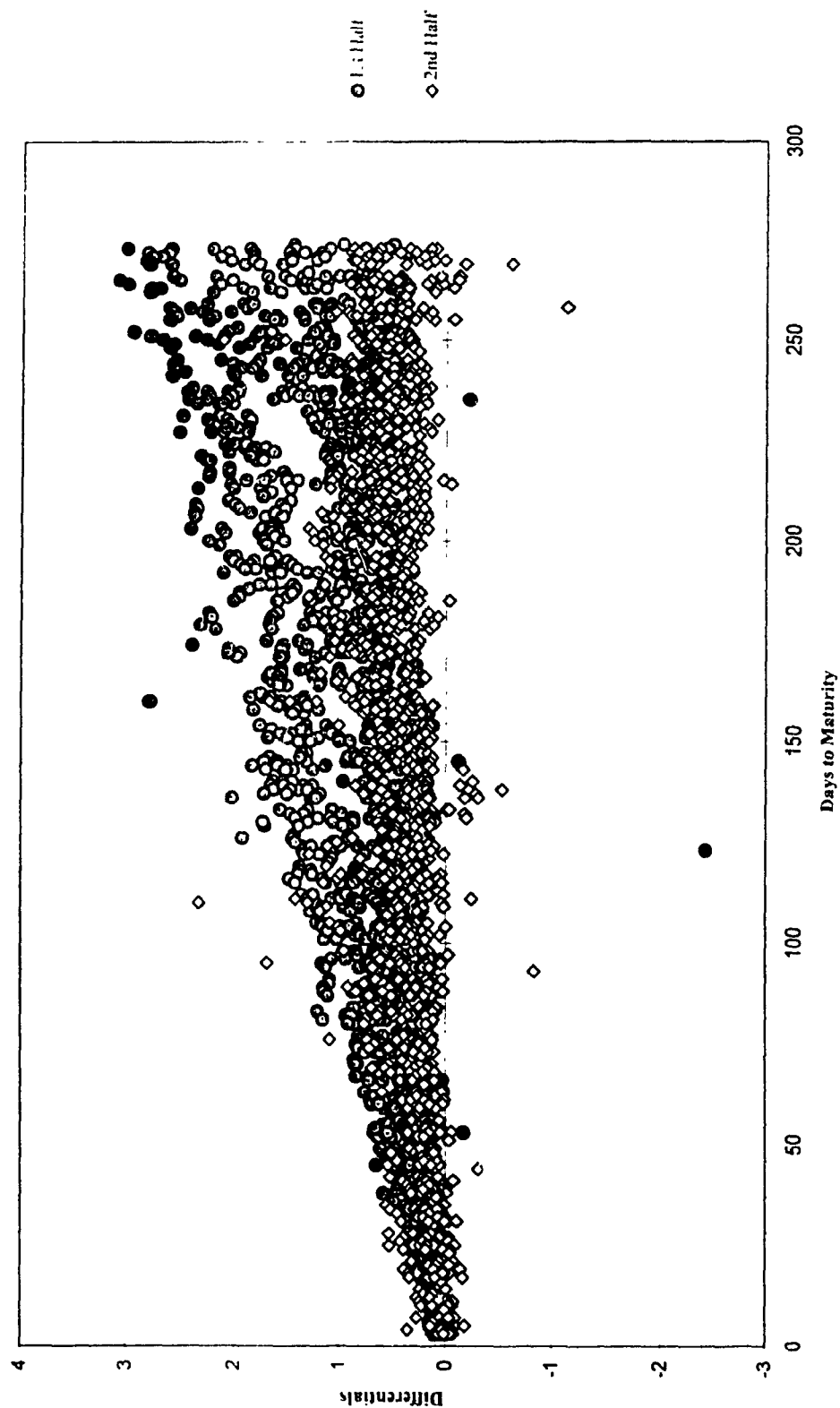


Figure 2: Non-Annualized BAR Differentials without Considering Transaction Costs Versus Days to Maturity

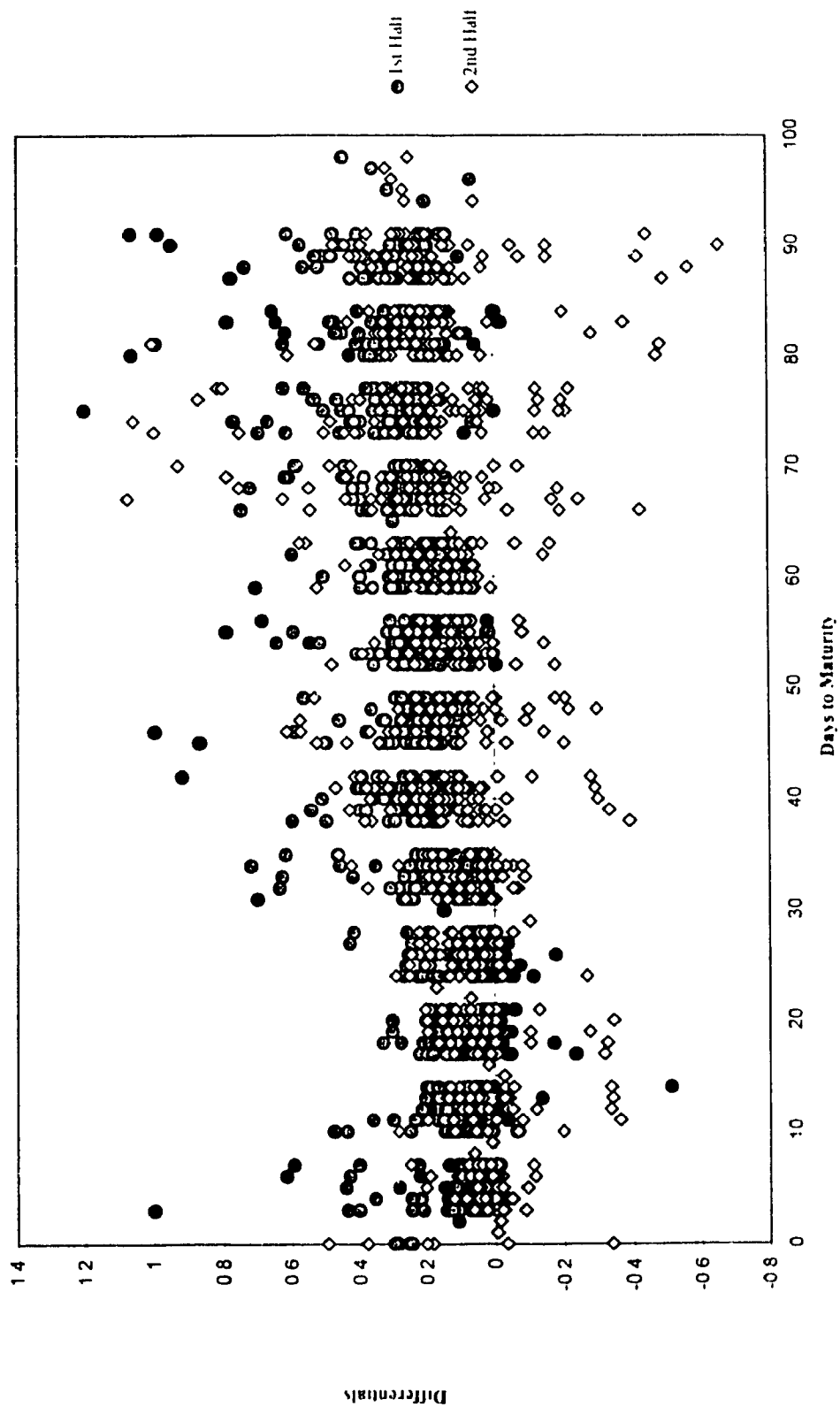


Figure 3: Annualized BAX Differentials without Considering Transaction Costs Versus Days to Maturity.

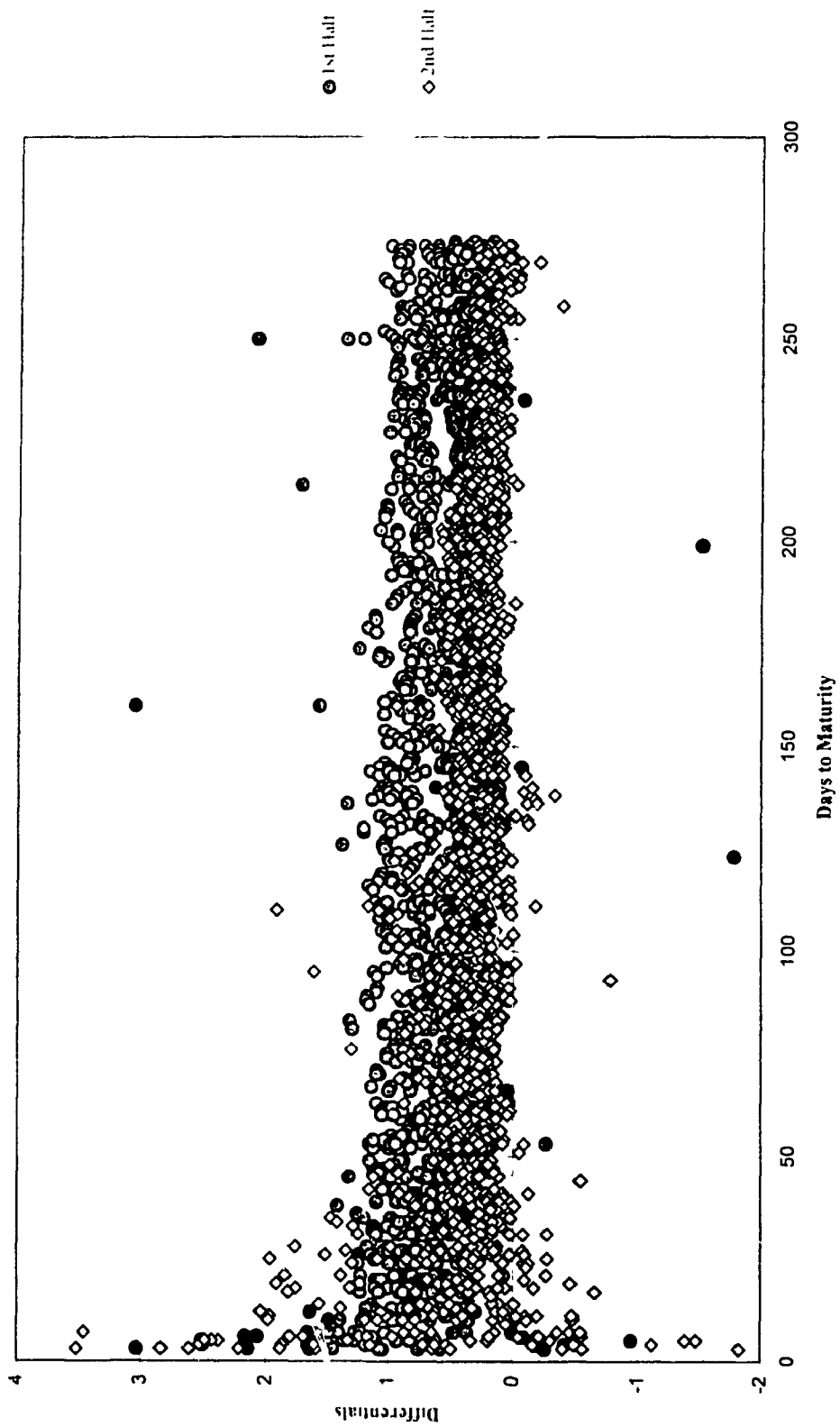


Figure 4: Annualized Bar Differentials without Considering Transaction Costs Versus Days to Maturity.

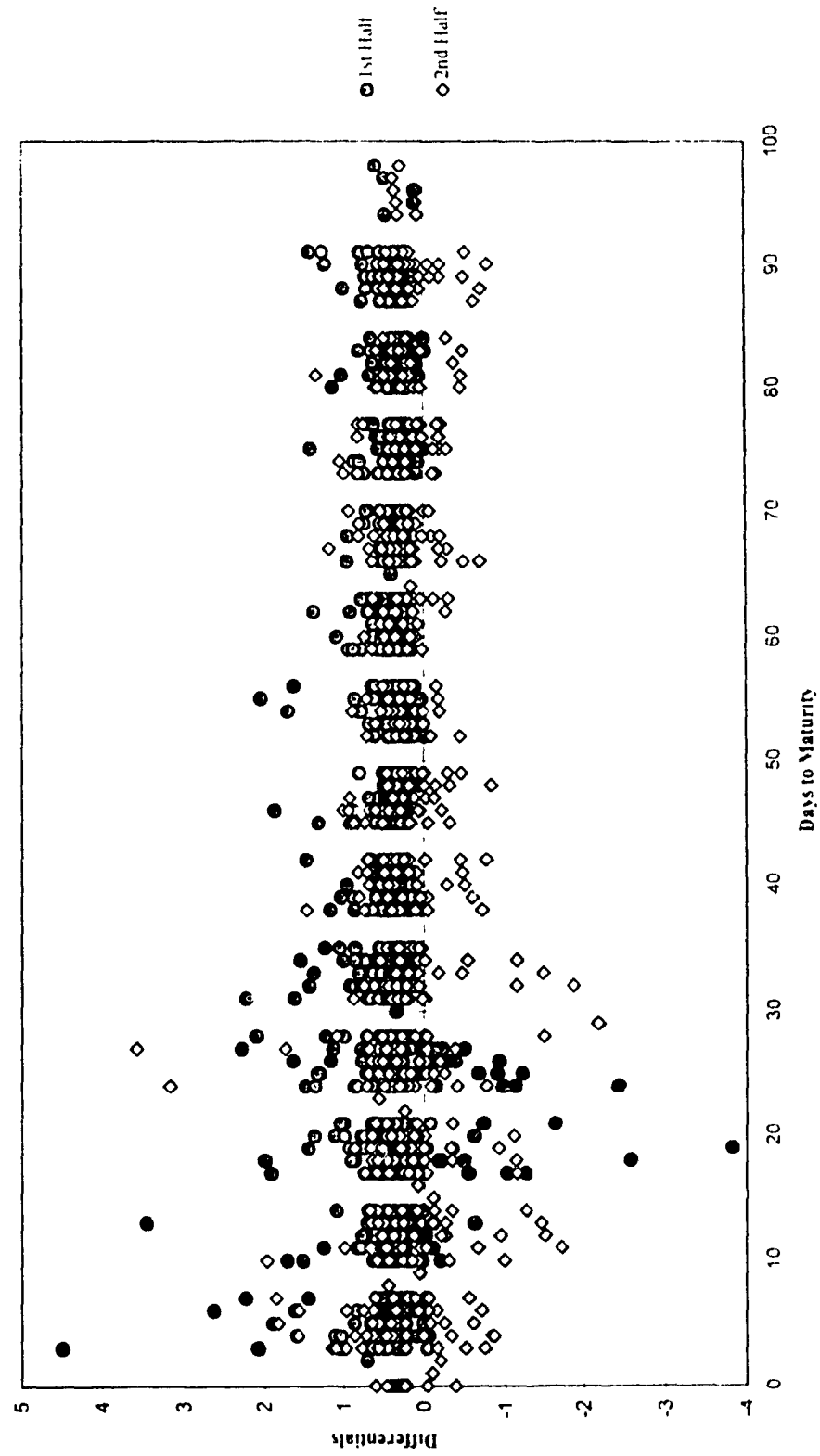


Figure 5: Non-Annualized BAX Differentials Considering Transaction Costs Versus Days to Maturity.

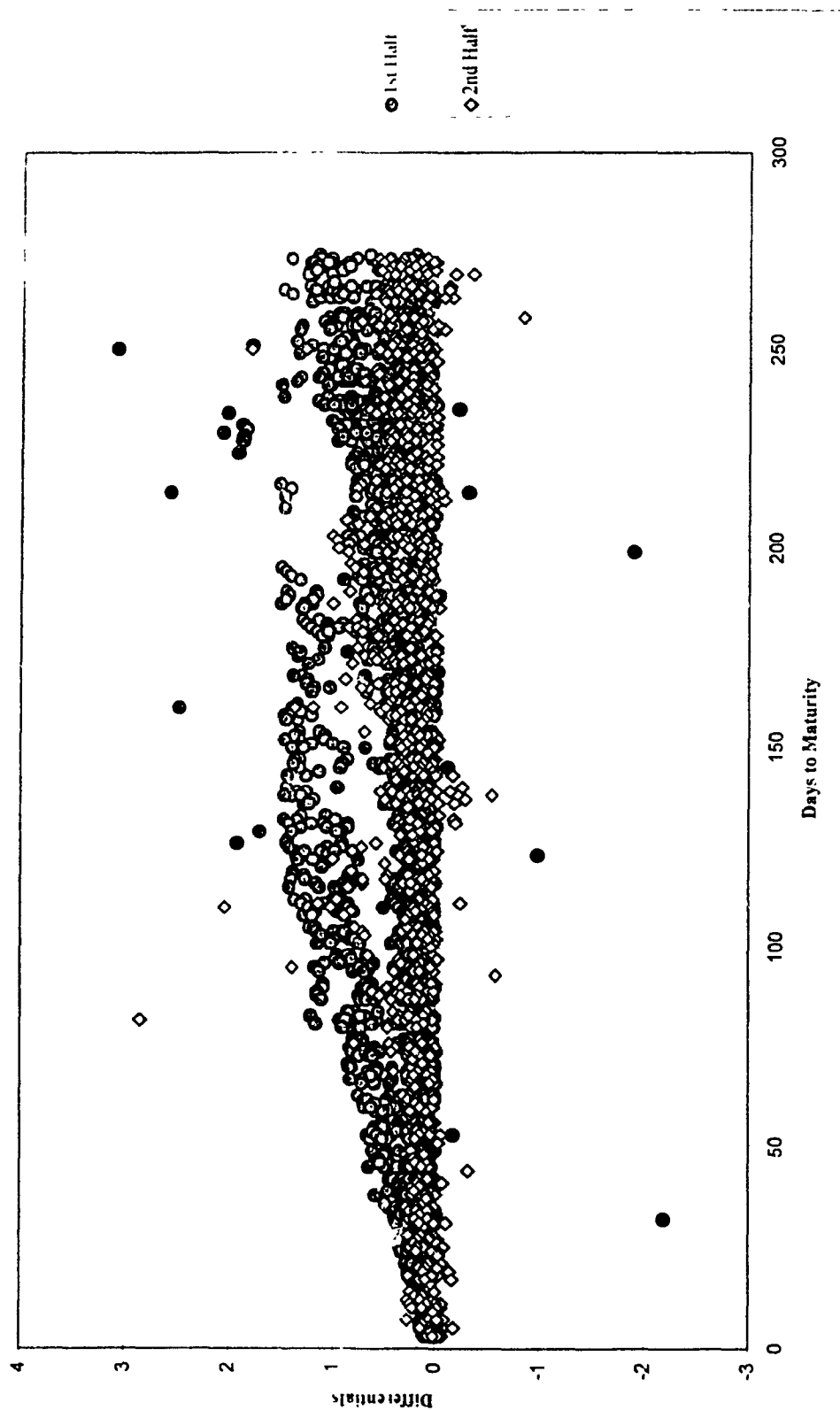


Figure 6: Annualized BAX Differentials Considering Transaction Costs Versus Days to Maturity.

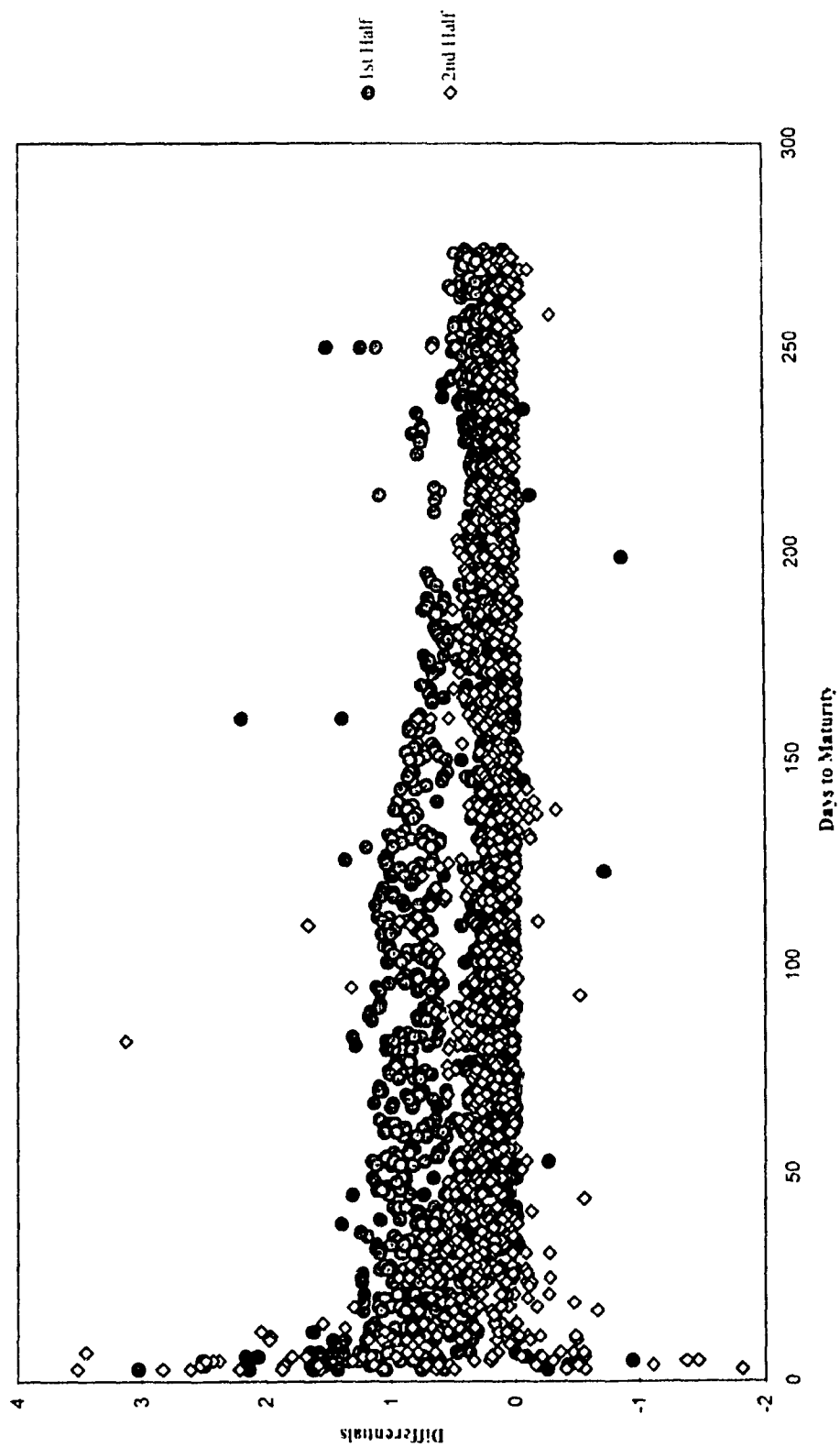


Figure 7: Non-Annualized BAR Differentials Considering Transaction Costs Versus Days to Maturity.

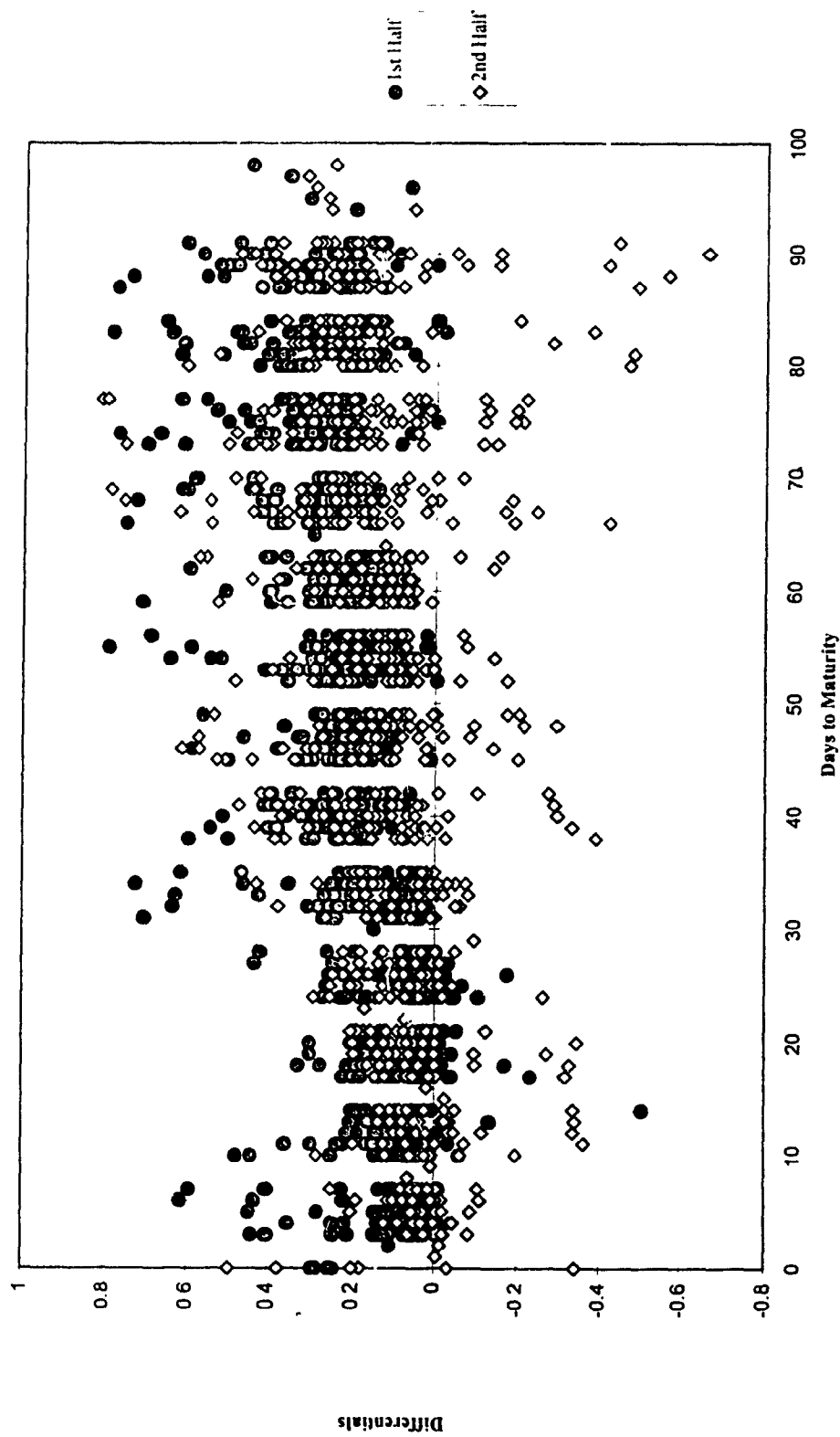


Figure 8: Annualized BAR Differentials Considering Transaction Costs Versus Days to Maturity.

