# Nonstationarity in the Mexican interest rate futures market

Pedro Gurrola[†*]
Department of Business
Instituto Tecnológico Autónomo de México

Renata Herrerías [†]
Department of Business
Instituto Tecnológico Autónomo de México

12th March 2007

**Abstract**

The growing importance of the Mexican TIIE-futures, which are amongst the most actively traded derivatives contracts worldwide, motivates the examination of their behavior. In particular, this study addresses the question of two sources of nonstationarity, day-of-the-week effects and abnormal behavior at expiration days. The analysis is done in the context of GARCH models using 36 rollover series for contracts expiring from 3 weeks to 35 months ahead. Evidence shows the presence of a weekend effect where rate changes tend to be positive on Mondays and negative on Fridays, together with higher volatility at expiration dates in short-term contracts.

**JEL Classification: G13,G15**

**Keywords:** Interest rate futures, day-of-the-week effect, trading patterns.

---

[*]Corresponding author. Address: Department of Business, ITAM. Av. Camino Sta. Teresa 930. CP-10700 México, D.F., México. E-mail: pgurrola@itam.mx, Tel.: (5255)56284000, ext. 6525; Fax: (5255)54904665.

[†]The authors thank the support of the Asociación Mexicana de Cultura A.C. They also thank the valuable comments from Richard D.F. Harris and the anonymous referee from BALAS Conference.

# 1 Introduction.

The existence of nonstationary patterns in futures contracts prices has been documented extensively in the finance literature. For example, contract month volatility, day-of-the-week, year, and calendar month effects, have been identified for equity, stock indexes and commodities futures (Crato & Ray, 2000; Galloway & Kolb, 1996; Kenyon, Kenneth, Jordan, Seale & McCabe, 1987; Khoury & Yourougou, 1993; Milonas & Vora, 1985). However, for interest rates futures the number of studies about the existence of prices anomalies is still reduced and frequently limited to short-term contracts.

Interest rate futures are highly liquid traded financial assets mainly used for hedging purposes. The lower transactions costs, their ability to expand risk management capabilities and their flexibility, among other reasons, have boosted their popularity over the last decades not only in mature markets, but also in emerging economies. Like other derivative instruments, interest rates futures are supposed to increase price efficiency of financial markets and to improve risk sharing among economic agents.

The aim of this article is to study the presence of day-of-the-week and expiration day effects in the Mexican interest rate futures market. In particular, the study considers futures contracts whose underlying consists of 28-day deposits that produce yield at the 28-day Interbank Equilibrium Interest Rate (Tasa de Interes Interbancaria de Equilibrio, or TIIE). This is the rate that serves as a measure of the average cost of funds in the Mexican interbank money market. The effects on futures daily rate changes are tested using a GARCH(1,1) model specification that includes daily dummies and a dummy for expiration day effects, in both the conditional mean and the conditional volatility functions.

The main motivation for studying this market lies in its growing importance: the Mexican Derivatives Exchange (MexDer), reached in the first ten months of 2006 a volume of 255.99 million contracts, making it the eighth largest exchange worldwide. Its leading contract, the 28-day TIIE interest rate futures, experienced during the same period the largest increase in volume in any futures contract, becoming the third most actively traded futures contract in the world after CME's Eurodollar and Eurex' Eurobond contracts (Holz, 2007). With such impressive growth, the behavior and characteristics of this emerging market are certainly important to many participants, including non-Mexican investors.

The day-of-the-week effects, i.e. evidence that asset returns present different distributions in some of the days of the week, have been extensively reported in equity, foreign exchange, commodities and T-Bill markets around the world (Aggarwal & Rivoli, 1989; Agrawal & Tandon, 1994; Berument & Kiymaz, 2001; French, 1980; Harvey & Huang, 1991; Jaffe & Westerfield, 1985; Lakonishok & Levi, 1982). In most of these studies there is evidence of a weekend effect: Friday returns are reported to be abnormally high and Monday returns abnormally low and, on average, negative.

Literature on day-of-the-week and futures markets is more limited. Chiang & Tapley (1983) found weekly patterns, including Monday effect, on a variety of future contracts. Studies of Dyl and Maberly (1986a and 1986b) found evidence about the existence of day-of-the-week effect on the S&P500 stock index futures rejecting the hypothesis of equal mean returns across days of the week. Similar results were obtained by Gay & Kim (1987) for commodity futures.

Seasonal patterns in futures price volatility have also been reported. Most studies attribute seasonal changes in volatility mainly to scheduled macroeconomic announcements and to other public information releases. This conclusion is in line with efficient market hypothesis where asset prices should change only with the arrival of new information. For example, Harvey & Huang (1991) found higher volatility of price returns of major currencies futures on Thursdays and Fridays. They attribute this phenomenon to the concentration of scheduled announcements of macroeconomic indicators on those days of the week. Also, Ederington & Lee (1993) reported higher volatility of currency futures and interest rates futures immediately after macroeconomic announcements. They show that volatility is different across days of the week on announcements days only. In contrast, Han, Kling & Sell (1999), after controlling for the announcement effect and maturity effect, found a strong day-of-the-week effect in Deutsche Mark and Japanese Yen futures. Their results suggest that currency futures are not moved by announcements of macroeconomics indicators, but by factors such as trading process and market microstructure.

In the case of interest rates futures, Johnston, Kracaw & McConnell (1991) identified Monday effects on T-bond future contracts, but found no significant seasonal patterns on T-bill contracts. Lee & Mathur (1999) found a Monday and Thursday effect using data of futures contracts listed in the Spanish derivative market. On average, Monday returns are negative for all studied contracts and particularly, volatility is higher on Monday for MIBOR90 and MIBOR360 contracts. Also, Buckle, ap Gwilym, Thomas, & Woodhams (1998), analyzing intraday empirical regularities in the Short Sterling interest rate futures, report a Monday effect in which returns, volatility and trading volume tend to be lower on Mondays than across the rest of the week.

In the last decades a great number of studies have been published regarding possible effects of stock indexes derivatives on the underlying. Evidence has been found of abnormal price behavior, higher trading volume or price reversals in the underlying assets around the expiration dates. This effect, known as expiration effect, arises primarily from a combination of factors including the existence of index arbitrage opportunities, the cash settlement feature of index options and futures, the unwinding of arbitrage positions in the underlying index stocks, and attempts to manipulate prices as explained, for example, in Stoll & Whaley (1997). In the case of interest rate futures a different but similar question arises: at the dates of expiration of short term contracts, are there persistent changes, upward or downward, on longer term contracts rates, in their volatility, or in both? A priori, one should expect price movements consistent with the term structure determined by the forward rate curve. However, such a behavior may also reveal seasonal patterns induced by trading activity. Hence, in this study the use of the term expiration effect will refer to the abnormal behavior of futures contracts with different maturities on the days around the expiration dates, which in the case of the 28-day TIIE futures correspond to the Wednesdays on the third week of every month.

Relative to previous literature, the contribution of this study is threefold. First, it documents the existence of day-of-the-week and expiration day patterns in a market for which, in spite of its growing importance, there are almost no previous studies. Usually these anomalies are attributed to the arrival of new information; however, the rationale behind the anomalies in the Mexican market may be different. The TIIE futures market is a very liquid market but with only few participants. For example, in 2006 there were on average seven operations per day per type of contract, each of them for an amount of around 20 million U.S. Dollars. The contrast between the large size of the market and the small number of participants suggests the market could behave differently in comparison to other more mature markets. It may be the case that the reduced number of participants promotes some collusion among them, and this collusion could originate the nonstationary patterns in prices.

This study also expands upon previous research in using not only next-to-expiration contracts but a whole set of 36 rollover time series, ranging from the next-to-expiration contract to the contract with expiration in 35 months. This data set permits to assess the existence of nonstationarity and to identify trading patterns not only for next-to-expiration contracts but also for long term contracts. This allows to distinguish between the effects of trading activity and those of information arrival. For example, under the assumption that new information does not necessarily equally affect short and long run contracts, a monotonic behavior across futures contracts will denote a day-of-the-week anomaly highly influenced by trading activity patterns, and to a lesser extent by new information arrival.

Finally, the consideration of long term contracts also leads to study the possible effect of expiration days on the whole forward curve. To the best of our knowledge, this effect on long term futures contracts has not been previously studied.

The main findings can be summarized as follows,

- TIIE futures rate changes are strongly heteroscedastic.
- There is a weekend pattern consistent with the Monday effect observed in other interest rate futures markets: On Mondays rates tend to increase while on Fridays they tend to decrease. This effect seems to be a consequence of trading activities.
- There are expiration effects on short-term TIIE futures contracts: on the expiration dates (usually every month's third Wednesday), the volatility of contracts expiring in seven month or less increases.

The rest of the article is organized as follows. The next section provides the background on the 28-day TIIE futures contract and describes the data and the methodology employed. In section three the results are reported. Concluding remarks are given in the last section.

# 2 Data and Methodology

## 2.1 The TIIE Futures Contract

Since March 1996, Banco de Mexico determines and publishes the short-term interest rate benchmark known as Tasa de Interés Interbancario de Equilibrio, or TIIE. There are two variants for the TIIE: 28- and 91-day. The 28-day TIIE rate is based on quotations submitted daily by full-service banks using a mechanism designed to reflect conditions in the Mexican peso money market. The participating institutions submit their quotes to Banco de Mexico by 12:00 p.m. Mexico City time. Following the receipt of the quotes, Banco de Mexico determines the TIIE in accordance with the stated procedures. Rates quoted by institutions participating in the survey are not indicative rates for informational purposes only; they are actual bids and offers by which these institutions are committed to borrow from or lend to Banco de Mexico.

Banco de Mexico may deviate from the stated procedure for determination of the TIIE rates if it detects any collusion among participating institutions or any other irregularity.

The TIIE futures contracts are traded in the Mexican Derivatives Exchange (MexDer). Each 28-day TIIE futures contract covers a face value of 100,000 Mexican Pesos (approximately 9,100 US Dollars). MexDer lists and makes available for trading different series of the 28-day TIIE futures contracts on a monthly basis for up to ten years. It is important to observe that, in contrast with analogous instruments like CME's Eurodollar or LIFFE's Short Sterling futures, TIIE futures quotes are in terms of future yields, not in terms of prices.

The last trading day and the maturity date for each series of 28-day TIIE futures contracts is the bank business day after the Central Bank holds the primary auction of government securities in the week corresponding to the third Wednesday of the maturity month. Since these primary auctions are usually held every Tuesday then, in general, expiration days for TIIE futures correspond to the third Wednesday of every month. For purposes of discharging obligations, settlement date on maturity is the bank business day after the maturity date.

## 2.2 Sample Data

The data used in this study are obtained from the MexDer. In particular, the analysis uses daily settlement rates for 28-day TIIE futures contracts from January 2nd, 2003 to June 30th, 2006 (a total of 888 daily observations), for contracts expiring every month from January 2003 to June 2009. Using these daily observations, a panel is created by rolling over contracts: for each series, once the most immediate contract is close to maturity, we rollover each of the series to the contract that is next according to maturity. In applying this kind of rolling over methods there is no generally accepted procedure on the choice of rollover date. The most common choices include switching at the expiration date, at the time of volume crossover or at some arbitrary number of days before the expiry of the front month contract. Considering that the shortest TIIE futures contract has only three weeks to maturity, and that abnormal rate variability may arise at the expiration date (Ma, Mercer & Walker, 1992), the switching is done 5 trading days before the contract expires.

The result of this procedure is a panel consisting of 36 rollover series according to time to maturity. The first series contains rates for the most immediate contract, the second one contains rates for the contract that will be delivered in one month, the third one rates for the contract with delivery date in two months, and so on. In other words, for every trading day between January 2nd 2003 and June 30th 2006 there are settlement yields for 36 futures contracts expiring from 3 weeks to the next 35 consecutive months. For each of these series, plus the series of TIIE spot rates, the analysis considers the series of logarithmic rate changes

$$r_t = \ln(S_t/S_{t-1}),$$

where $S_t$ is the settlement rate on day $t$. We will sometimes refer to these $r_t$ simply as rate changes.

There is evidence that the choice of rollover date and linking method can potentially generate biases on the statistical properties of the series (Geiss, 1995; Ma, Mercer & Walker, 1992; Rougier, 1996). In order to minimize the impact that the splicing procedure may have on the statistical tests, increments across the splicing points are not included in the statistical calculations, resulting in a data set of 37 series of daily yield changes (including the one corresponding to the spot rate) with 845 observations each one.

Table I provides summary statistics of each of the series of rate changes. Almost no mean is statistically different from zero and the standard deviation tends to increase when contracts approach expiration. Most of the contracts show positive skewness and all series, including the spot rate, are leptokurtic. For all series the Bera-Jarque statistic rejects the hypotheses of normality.

With the exception of only one series (No. 18) , the Engle (1982) LM-test for an autoregressive conditional heteroscedasticity (ARCH) effect clearly rejects the null of no ARCH effect in both the futures and TIIE rate changes. Further evidence that rate changes are not independently drawn from a normal distribution is provided by the autocorrelation of the series. The Ljung-Box test for autocorrelation of rate changes and squared rate changes (not reported in the Table) indicates that there is evidence of dependence.

As a test for robustness and to support other results another panel that contains the data aligned by days to maturity instead of calendar day is constructed. That is, taking series that matured from January 2003 until June 2006, daily volume is tracked since the day the contract first appeared. This type of panel helps to observe the average traded volume relative to days to expiration. Currently, there are contracts with maturity up to ten years; however, on average the results obtained are robust over 750 trading days before expiration (around 3 years). Figure 1 presents the number of contracts traded according to months before expiration. The results show that the traded volume increases monotonically as the contract approaches expiration. As in other futures market, contracts with the shortest maturity are far more liquid than contracts with maturities longer than three months. A weekly analysis over the last 6 months, as shown in Figure 2, indicates that the peak in trading volume is reached around four to ten weeks before expiration while in the last four weeks volume declines.

## 2.3 Methodology

The statistical significance of expiration and day-of-the-week effects is examined using the following regressions for each of the series. To address the autocorrelation the equation of the conditional mean is set as an AR(1) process

$$r_t = \mu + \phi r_{t-1} + \sum_k \delta_k D_{kt} + u_t, \qquad u_t \sim \mathcal{N}(0, h_t) \tag{1}$$

where, for each of the series considered, $\mu$ is a constant for the mean equation, $r_t$ is the logarithmic change of settlement rates on day $t$ and the residuals, $u_t$, are assumed to be normally distributed with mean zero and variance $h_t$. The variables $D_{kt}$, with $k \in \{M, T, H, F, Z\}$, are binary dummies representing the day of the week or the maturity: $M$ stands for Monday, $T$ for Tuesday, $H$ for Thursday, $F$ for Friday and $Z$ for the last three days of the contract, that is, Monday, Tuesday and Wednesday of the expiration week (approximately every four weeks). Given that a constant term is allowed in the regression equation, Wednesdays dummy is omitted since this is the usual expiration day for all contracts.

Additionally, the variance of TIIE futures contracts is examined using a GARCH(1,1) model with day of the week and maturity days as exogenous variables:

$$h_t = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1} + \sum_k \gamma_k D_{kt} \tag{2}$$

where $h_t$ is the conditional variance for the series on day $t$, and $D_{kt}$ represent the exogenous variables mentioned before. The maximum likelihood estimates were obtained with RATS (v.5) software package using the Berndt-Hall-Hall-Hausman algorithm. Since the accuracy of GARCH model estimation and of the associated $t$-statistics may depend on the software employed, the maximum likelihood estimation was also performed under EViews package using the Marquardt optimization algorithm. Although the coefficient estimates and their standard errors differ slightly, the reported results are qualitatively the same.

# 3 Results

## 3.1 Day-of-the-Week Effects

In testing for seasonality, a preliminary statistical analysis is performed using the standard methodology. Considering the 36 series, rate changes are classified by day of the week, year by year and for the entire period. Mean changes and other statistics are computed for each day of the week, and $t$-tests are performed for comparing two means. Since this procedure implies dividing the sample in multiple subsamples, a standard $F$-test is performed to test the null hypothesis that means across all days of the week are jointly equal. Failure to reject the null would suggest that any apparent patterns observed when performing significant tests in isolation are not robust and are probably due to the effect of multiple subsamples.

The results of this analysis are presented in Table II. It can be seen that, for the entire period and all the subperiods, Monday means are always positive while Friday means are always negative. Moreover, the highest mean rate change for the entire sample occurs on Mondays (0.00144) and the lowest occurs on Fridays (-0.00180). This pattern is repeated when the sample is divided by calendar year, except in 2003 when the lowest mean change is on Thursdays (-0.00331). To test if the observed difference between Mondays and Fridays mean changes is significant, a $t$-test is performed. For the entire period and all the subperiods, the $t$-test rejects the null that Monday and Friday means are equal while the $F$-test confirms in all cases that the means across days of the week are significantly different. Concerning volatility there is not any noticeable pattern across the days of the week, although Table II shows that on annual basis the standard deviation has been gradually decreasing.

To reinforce the above analysis, Table III presents summary statistics for trading volume by day of the week, year by year and for the entire period. Consistently, either Tuesdays or Thursdays are the days with higher trading activity, suggesting there is no relation between rate changes on Mondays and Fridays and higher trading volume. Tuesdays and Thursdays volume coincides with trading activities in the Treasury Certificates market as will be explained later. It is worth mentioning that the lower trading volume in 2005 is explained by tax issues that increased the OTC trading on TIIE Swaps, provoking local banks to move their books offshore.

The maximum-likelihood parameter estimates for the GARCH model with all the dummies are reported in Panels A and B of Table IV. Table V reports the analysis of residuals, confirming the adequacy of the model for all the series considered, with the exception of series 33 and 35, which appear to still have significant serial correlation, according to the Ljung-Box statistics. In line with the trading pattern shown in Figure 1 these exceptions could be attributed to low trading volume.

The results in Panel A of Table IV show that, in accord to the results obtained previously (Table II), in the conditional mean equation, Monday's coefficients ($\delta_M$) are always positive and frequently significant while Friday's ($\delta_F$) are always negative and almost always significant. This indicates that changes on the TIIE futures rates tend to be positive on Mondays (from Friday close to Monday close) and negative on Fridays.

Since futures yields and futures prices have an inverse relation, this Monday pattern is consistent with the Monday effect reported in other interest rate futures markets, like in Buckle et al. (1998) for the Short Sterling futures, in Johnston et al.( 1991) for T-bond future contracts, or in Lee and Mathur (1999) for the Spanish MIBOR-futures market. However, the significant low rates on Fridays seem to be idiosyncratic. Since there is no scheduled macroeconomic announcement or other public information release occurring on those days of the week, this anomaly seems to be produced by the particular characteristics of the trading activity in the Mexican futures market. The last line of Table IV reports the coefficients for the spot rate, showing that TIIE rate changes on Friday are also significant and negative. The fact that on Fridays the spot rate also tends to decrease leads to suspect that the weekend abnormal behavior on future contracts could be a consequence of the positions on the TIIE spot rate presented by market participants on Fridays. On Mondays participants may then bring back rates to match market conditions inducing, on average, positive changes. The rest of the days of the week do not appear to have any significant effect on the conditional mean.

Related with day-of-the-week effect and volatility, several observations are worth mentioning. On Table IV Panel B it can be seen that coefficients for Tuesdays, Thursdays and Fridays dummies in the conditional variance equation are significant for short run contracts but not for longer terms. There are also some significant coefficients in estimations for contracts expiring around two or three years, but not for contracts in between. For example, contracts expiring in two years present significant coefficients for Tuesdays' dummies. Higher volatility on Tuesdays should exist for any term contract as this is the day when the Central Bank carries out the auction of Treasury Certificates (CETES) in the primary market. This is the leading interest rate in money market.

Even though there are important announcements on Tuesdays, and on Thursdays the market is more liquid because Treasury Certificates are settled, the presence of significant coefficients on Fridays does not help to discriminate between the reaction to public announcements and trading activities. Given that on Tuesdays new information concerning interest rates arrives, higher volatility should be related with these events, supporting Harvey & Huang (1991). Alternatively, if the market is more liquid on Thursdays and market participants may manipulate rates on Fridays, then volatility should be explained by trading activities and market microstructure consistently with the results of Andersen & Bollerslev (1998) for spot rates. Friday effect may be attributable to some collusion among participants to lower their margin requirements.

In general, even if the day-of-the week effect on volatility is not as unambiguous as it is for mean rate changes, the results provide some indication that on Mondays the TIIE futures market shows no structural change in volatility. Also there is evidence that, as a whole, short term contracts are more volatile than longer term contracts. This is further demonstrated by the magnitude of the dummies coefficients, that progressively decrease as the term of the contract increases, and by the results on volume presented in Figures 1 and 2.

## 3.2 Expiration Day Effects

In this section the expiration day effects on rates changes and volatility are investigated. This analysis is performed considering a dummy variable that takes the value one on Mondays, Tuesdays and Wednesdays of the expiration week and zero otherwise.

The estimated coefficients are reported in the last column of Table IV, Panels A and B. Results for the conditional mean indicate that the coefficients for this dummy are always negative, although only in eleven cases they appear to be significant. With respect to the estimates for expiration day effect dummy in the GARCH process, the null hypothesis of no structural change cannot be rejected for contracts maturing in seven months or less. In these cases coefficients are positive and different from zero at the 5% significance level, meaning that the conditional volatility of those contracts increases when the next-to-expiration contract matures. On the other hand, there are no significant alterations in the spot rate near expiration days.

Apparently, on the days prior to expiration, market participants change their hedging positions to contracts expiring one to six months ahead, while longer term contracts are not considered by investors for their rollover strategies. Since short term contracts involve lower basis risk, this preference for short term contracts can be due to hedgers preferring to assume frequent rollover transaction costs than the risk of future mispricing.

# 4 Conclusions

The growing importance of the 28-day TIIE futures contract, the third most actively traded futures contract in the world, motivates a detailed examination of its behavior. Specifically, this paper investigates sources of nonstationarity in these contracts, searching for day-of-the-week and expiration day effects. The presence of these effects, both in the rate changes and in their volatility, is tested in the context of GARCH models.

The results show that there is a Monday effect similar to the one observed in other interest rate futures markets: rates (prices) tend to increase (decrease) on Mondays. In addition to this, rates tend to decrease on Fridays. Since there is no scheduled macroeconomic announcement or other public information release occurring on those days of the week, this anomaly seems to be produced by the particular characteristics of the trading activity in the market. The fact that on Fridays the spot rate also tends to decrease leads to suspect that the anomaly could be attributable to the need of market participants to lower their margin requirements during the weekend and to other reporting necessities. That is, given that TIIE spot rate is determined by the bid-ask positions set by a few participants (usually six or seven major banks), it may happen that on Fridays those participants set positions with lower values than the rest of the week to diminish the cost of money during the weekend. If this is the case, it indicates that the fact that only few participants trade these contracts makes it easy to induce nonstationarity patterns and, in consequence, market inefficiencies. In any case, the existence of such patterns opens the possibility of abnormal profits by taking long positions on Fridays and closing them on Mondays.

Concerning volatility, event though it is not possible to accurately assess the cause of a day-of-the-week effect, it has been shown on Mondays there is no structural change in volatility. On the other hand, the difference in volatility between short and long term contracts has also implications in the adequate specification of margin requirements. Since low margins promote investment and high margins tend to diminish it, it may be important for the clearinghouse to establish a margin policy that distinguishes between contracts with high or low volatility in order to optimize the relation between investment and risk control.

With respect to a possible abnormal behavior during the expiration days, there is evidence of significant changes in conditional volatility around days previous to expiration in contracts with seven months or less to maturity. Apparently, on the days prior to expiration market participants roll their hedging positions to contracts expiring one to six months ahead, while longer term contracts are not considered by investors for their rollover strategies. Since short term contracts involve lower basis risk, this preference for short term contracts can be due to hedgers preferring to assume frequent rollover transaction costs instead of the risk of future mispricing.

# References

Aggarwal, R., & Rivoli, P. (1989). Seasonal and day-of-the-week effect in four emerging stock markets. Financial Review, 24, 541-550.

Agrawal, A., & Tandon, K. (1994). Anomalies or illusions? Evidence of stock markets in eighteen countries. Journal of International Money and Finance, 13, 83-106.

Andersen, T.G., & Bollerslev, T. (1998). Deutsche mark-dollar volatility: Intraday activity patterns, macroeconomic announcements, and longer run dependencies. The Journal of Finance, 53, 219-266.

Berument, H., & Kiymaz, H. (2001). The day of the week effect on stock market volatility. Journal of Economics and Finance, 25, 181-193.

Buckle, M., ap Gwilym O., Thomas, S.H., & Woodhams, M.S. (1998). Intraday empirical regularities in interest Rate and equity index futures markets, and the effect of macroeconomic announcements. Journal of Business, Finance & Accounting, 25 (7) & (8), 921-943.

Chiang, R., & Tapley, C. (1983). Day-of-the-week effects and the futures market. Review of Research in Futures Markets, 2, 356-410.

Crato, N., & Ray, B.K. (2000). Memory in returns and volatilities of futures contracts. The Journal of Futures Markets, 20, 525-543.

Dyl, E.A., & Maberly, E.D. (1986a). The daily ditribution of changes in the price of stock index futures. The Journal of Futures Markets, 6, 513-521.

Dyl, E.A., & Maberly, E.D. (1986b). The weekly pattern in stock index futures: A further note. The Journal of Finance, 61, 1149-1152.

Ederington, L. H., & Lee, J. H. (1993). How markets process information: News releases and volatility. The Journal of Finance, 48, 1161-1191.

Engle, R. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. Econometrica, 50, 987-1008.

French, K. (1980). Stock returns and the weekend effect. Journal of Financial Economics, 8, 55-69.

Galloway, T., & Kolb, R.W. (1996). Futures prices and the maturity effect. The Journal of Futures Markets, 16, 809-828.

Gay, G.D., & Kim, T-H. (1987). An investigation into seasonality in the futures market. The Journal of Futures Markets, 7, 169-181.

Geiss, C. (1995). Distortion-free futures price series. The Journal of Futures Markets, 15, 805-831.

Han, L-M., Kling, J.L., & Sell, C.W. (1999). Foreign exchange futures volatility: day-of-the-week, intraday, and maturity patterns in the presence of macroeconomic announcements. The Journal of Futures Markets, 19, 665-693.

Harvey, C.R., & Huang, R.D. (1991). Volatility in the foreign currency futures market. Review of Financial Studies, 3, 543-569.

Holz, R. (2007). Trading volume: Nearly 10 billion contracts traded worldwide in 10 months. Futures Industry Magazine, January-February. Retrieved March 5, 2007, from http://www.futuresindustry.org.

Jaffe, J., & Westerfield, R. (1985). The weekend effect in common stock returns: The international evidence. The Journal of Finance, 40, 433-454.

Johnston, E. T., Kracaw, W.A., & McConnell, J.J. (1991). Day-of-the-week effects in financial futures: An analysis of GNMA, T-Bond, T-Note, and T-bill contracts. Journal of Financial and Quantitative Analysis, 26, 23-44.

Kenyon, D., Kenneth, K., Jordan, J., Seale, W., & McCabe, N. (1987). Factors affecting agricultural futures price variance. The Journal of Futures Markets, 7, 73-91.

Khoury, N., & Yourougou, P. (1993). Determinants of agricultural futures price volatilities: Evidence from Winnipeg Commodity Exchange. The Journal of Futures Markets, 13, 345-356.

Lakonishok, J. & Levi, M. (1982). Weekend effect in stock returns: A note. The Journal of Finance, 37, 883-889.

Lee, C.I., & Mathur, I. (1999). Efficiency tests in the Spanish futures markets. The Journal of Futures Markets, 19, 59-77.

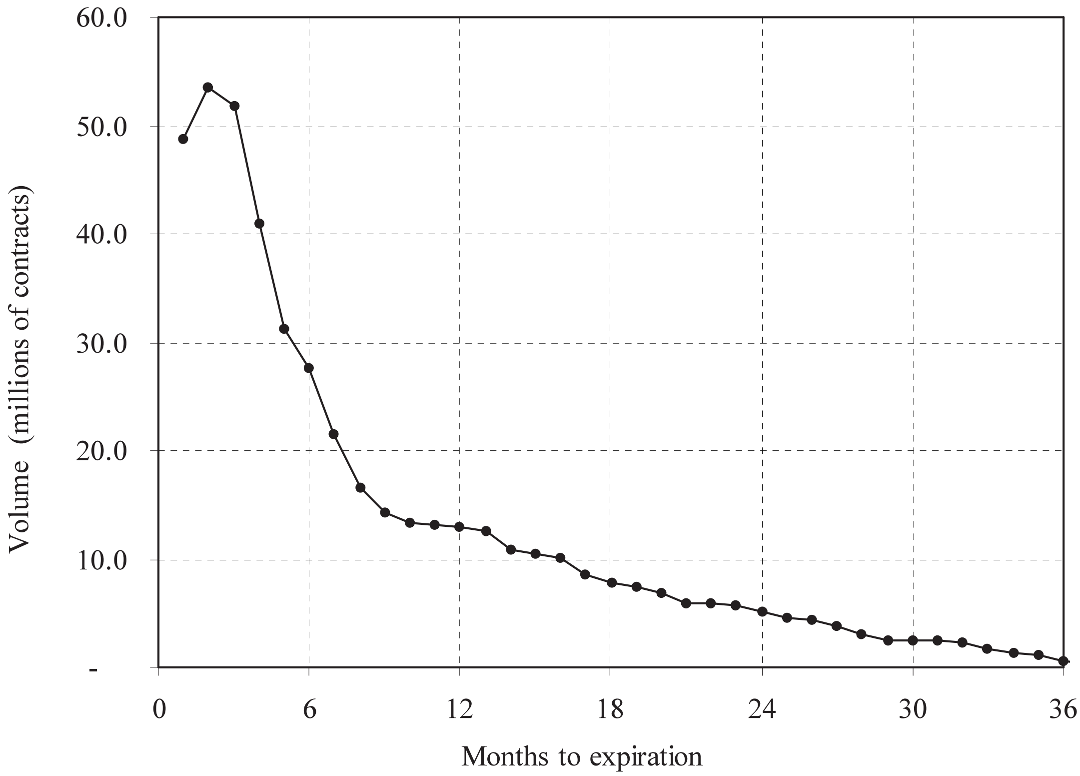
Ma, C., Mercer, J., & Walker, M. A. (1992). Rolling over futures contracts: A note. The Journal of Futures Markets, 12, 203-217.

Milonas, N.T., & Vora, A. (1985). Sources of nonstationarity in cash and futures prices. Review of Research in Futures Markets, 4, 315-326.

Rougier, J. (1996). An optimal price index for stock index futures contracts. The Journal of Futures Markets, 16, 189-199.

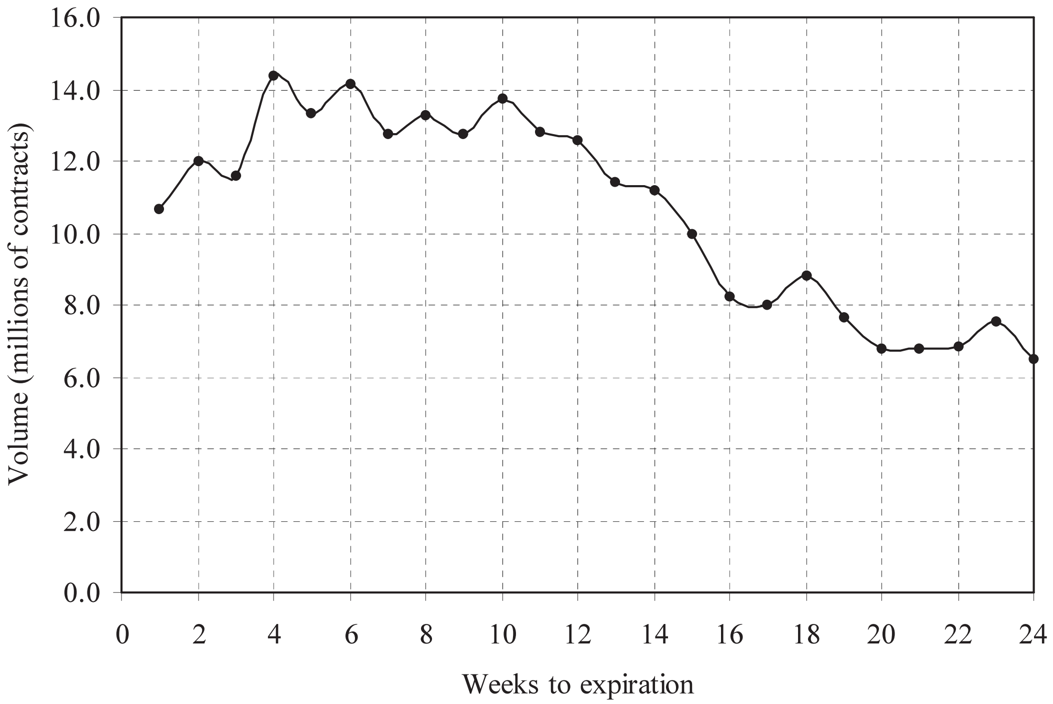
Stoll, H.R., & Whaley, R.E. (1997). Expiration-day effects of the All Ordinaries Share Price Index Futures: Empirical evidence and alternative settlement procedures. Australian Journal of Management, 22, 139-174.

Figure 1: Number of 28-day TIIE futures contracts traded per month relative to contract expiration




Numbers are millions of contracts traded during each month before the expiration date.

Figure 2: Number of 28-day TIIE futures contracts traded per week relative to contract expiration




Numbers are millions of contracts traded during the last 24 weeks before the expiration date.

Table I: Summary Statistics of 28-day TIIE Futures Daily Rate Changes.

| *Series* | *Mean* | *Std. Dev.* | *Skewness* | *Excess Kurtosis* | *Bera-Jarque* | *ARCH-LM* |
|---|---|---|---|---|---|---|
| 1 | −0.00112* | 0.0141 | −0.323 | 9.509 | 3198.23* | 79.44* |
| 2 | −0.00085 | 0.0138 | 0.360 | 6.349 | 1437.60* | 49.87* |
| 3 | −0.00084* | 0.0122 | 0.161 | 3.591 | 457.68* | 92.08* |
| 4 | −0.00068 | 0.0122 | −0.117 | 5.411 | 1032.59* | 73.81* |
| 5 | −0.00071 | 0.0118 | 0.094 | 4.453 | 699.24* | 94.19* |
| 6 | −0.00070 | 0.0114 | 0.006 | 3.908 | 537.84* | 81.31* |
| 7 | −0.00060 | 0.0110 | −0.044 | 3.633 | 464.90* | 38.54* |
| 8 | −0.00054 | 0.0110 | −0.022 | 2.594 | 237.03* | 40.61* |
| 9 | −0.00049 | 0.0110 | 0.196 | 2.080 | 157.71* | 61.88* |
| 10 | −0.00044 | 0.0105 | 0.227 | 2.184 | 175.18* | 43.37* |
| 11 | −0.00046 | 0.0100 | 0.211 | 2.291 | 191.01* | 31.59* |
| 12 | −0.00041 | 0.0105 | 0.226 | 3.494 | 437.12* | 37.56* |
| 13 | −0.00041 | 0.0110 | 0.042 | 2.904 | 297.10* | 43.05* |
| 14 | −0.00043 | 0.0105 | 0.151 | 2.615 | 244.03* | 33.34* |
| 15 | −0.00042 | 0.0105 | 0.197 | 2.506 | 226.51* | 34.50* |
| 16 | −0.00040 | 0.0105 | 0.335 | 2.741 | 280.41* | 43.92* |
| 17 | −0.00036 | 0.0100 | 0.185 | 1.713 | 108.10* | 44.25* |
| 18 | −0.00037 | 0.0105 | 0.321 | 4.337 | 676.65* | 9.87 |
| 19 | −0.00038 | 0.0100 | 0.306 | 2.529 | 238.41* | 19.83* |
| 20 | −0.00035 | 0.0100 | 0.275 | 2.050 | 158.63* | 24.49* |
| 21 | −0.00042 | 0.0100 | 0.126 | 2.171 | 168.15* | 17.03* |
| 22 | −0.00042 | 0.0100 | 0.005 | 2.125 | 158.94* | 14.77* |
| 23 | −0.00037 | 0.0100 | 0.042 | 1.996 | 140.56* | 19.88* |
| 24 | −0.00042 | 0.0100 | 0.015 | 2.591 | 236.41* | 32.76* |
| 25 | −0.00037 | 0.0100 | −0.100 | 2.944 | 306.47* | 28.88* |
| 26 | −0.00035 | 0.0100 | −0.063 | 3.055 | 329.14* | 21.11* |
| 27 | −0.00035 | 0.0095 | 0.124 | 2.574 | 235.39* | 25.19* |
| 28 | −0.00036 | 0.0095 | 0.123 | 2.746 | 267.71* | 17.52* |
| 29 | −0.00030 | 0.0095 | 0.302 | 3.205 | 374.50* | 25.57* |
| 30 | −0.00030 | 0.0089 | 0.444 | 3.235 | 396.14* | 29.83* |
| 31 | −0.00031 | 0.0089 | 0.484 | 3.548 | 476.16* | 22.55* |
| 32 | −0.00036 | 0.0089 | 0.415 | 3.587 | 477.28* | 29.13* |
| 33 | −0.00022 | 0.0100 | 0.773 | 6.117 | 1401.43* | 55.15* |
| 34 | −0.00036 | 0.0126 | 0.171 | 10.176 | 3649.93* | 55.15* |
| 35 | −0.00018 | 0.0158 | −0.076 | 9.456 | 3148.70* | 208.33* |
| 36 | −0.00041 | 0.0184 | −0.523 | 15.837 | 8868.85* | 98.62* |
| TIIE | −0.00032 | 0.0151 | 0.928 | 7.054 | 1873.26* | 140.12* |

Note. Each series consists of 845 observations. Series number corresponds to the months to expiration. The 1% critical value of the Bera-Jarque statistic is 9.21. The ARCH-LM is the $LM$-statistic of autoregressive conditional heteroscedasticity effect with 5 lags.

* indicates significance at 5% level.

Table II: Statistics of Daily Rate Changes According to the Day of the Week.

| | | *Mon* | *Tues* | *Wed* | *Thurs* | *Fri* | *All days* | *t-stat* | $F_5$ |
|---|---|---|---|---|---|---|---|---|---|
| *All* | *Mean* | 0.00144 | -0.00055 | 0.00004 | -0.00165 | -0.00180 | -0.00045 | 16.19* | 88.19* |
| | *Std. Error* | 0.00015 | 0.00014 | 0.00014 | 0.00015 | 0.00013 | 0.00006 | | |
| | *Std. Dev.* | 0.01178 | 0.01139 | 0.01073 | 0.01034 | 0.01073 | 0.01110 | | |
| | *Max* | 0.10862 | 0.07032 | 0.08281 | 0.12758 | 0.08837 | 0.12758 | | |
| | *Min* | -0.15101 | -0.10862 | -0.06754 | -0.09970 | -0.12009 | -0.15101 | | |
| | *Sample* | 6372 | 6444 | 6300 | 5004 | 6336 | 30456 | | |
| *2003* | *Mean* | 0.00139 | -0.00266 | -0.00047 | -0.00331 | -0.00184 | -0.00131 | 6.48* | 28.00* |
| | *Std. Error* | 0.00038 | 0.00034 | 0.00034 | 0.00038 | 0.00032 | 0.00016 | | |
| | *Std. Dev.* | 0.01649 | 0.01477 | 0.01401 | 0.01479 | 0.01330 | 0.01482 | | |
| | *Max* | 0.10862 | 0.06287 | 0.08281 | 0.12758 | 0.08837 | 0.12758 | | |
| | *Min* | -0.15101 | -0.10862 | -0.06754 | -0.09970 | -0.12009 | -0.15101 | | |
| | *Sample* | 1836 | 1836 | 1692 | 1476 | 1764 | 8604 | | |
| *2004* | *Mean* | 0.00166 | 0.00126 | 0.00075 | -0.00078 | -0.00214 | 0.00020 | 9.52* | 36.34* |
| | *Std. Error* | 0.00029 | 0.00026 | 0.00025 | 0.00022 | 0.00028 | 0.00012 | | |
| | *Std. Dev.* | 0.01240 | 0.01132 | 0.01080 | 0.00830 | 0.01205 | 0.01130 | | |
| | *Max* | 0.05977 | 0.07032 | 0.04625 | 0.05946 | 0.06812 | 0.07032 | | |
| | *Min* | -0.09407 | -0.04699 | -0.05560 | -0.03692 | -0.05946 | -0.09407 | | |
| | *Sample* | 1872 | 1872 | 1836 | 1368 | 1872 | 8820 | | |
| *2005* | *Mean* | 0.00044 | -0.00058 | -0.00073 | -0.00058 | -0.00127 | -0.00054 | 8.22* | 16.97* |
| | *Std. Error* | 0.00013 | 0.00016 | 0.00014 | 0.00017 | 0.00016 | 0.00007 | | |
| | *Std. Dev.* | 0.00554 | 0.00692 | 0.00603 | 0.00628 | 0.00683 | 0.00637 | | |
| | *Max* | 0.02204 | 0.02367 | 0.02272 | 0.03414 | 0.01912 | 0.03414 | | |
| | *Min* | -0.01709 | -0.02222 | -0.02350 | -0.02608 | -0.02757 | -0.02757 | | |
| | *Sample* | 1800 | 1872 | 1836 | 1440 | 1800 | 8748 | | |
| *2006* | *Mean* | 0.00312 | 0.00007 | 0.00108 | -0.00203 | -0.00207 | 0.00010 | 14.64* | 49.33* |
| | *Std. Error* | 0.00022 | 0.00035 | 0.00035 | 0.00032 | 0.00027 | 0.00014 | | |
| | *Std. Dev.* | 0.00658 | 0.01028 | 0.01080 | 0.00870 | 0.00825 | 0.00929 | | |
| | *Max* | 0.02538 | 0.04039 | 0.03335 | 0.02382 | 0.02368 | 0.04039 | | |
| | *Min* | -0.01326 | -0.03023 | -0.04472 | -0.03568 | -0.03727 | -0.04472 | | |
| | *Sample* | 864 | 864 | 936 | 720 | 900 | 4284 | | |

Note. Summary statistics of 28-day TIIE futures contracts, considered all together, and classified by day of the week, year by year and for the whole period (January 2nd. 2003 to June 30th., 2006). $t$-stat tests the null hypothesis that Monday mean is different from Friday's using a two tailed $t$-test. $F_5$ is the $F$-statistic testing the null hypothesis that mean changes are equal across all five days of the week. The critical 0.05 value for the $F_5$-test is 2.76 (aprox.). * indicates significance at 5% level.

Table III: Trading Volume Statistics According to the Day of the Week.

| | | *Mon* | *Tues* | *Wed* | *Thurs* | *Fri* | *All Days* |
|---|---|---|---|---|---|---|---|
| *Whole period* | *Mean* | 579,153 | 769,805 | 711,997 | 752,576 | 594,477 | 681,798 |
| *(2003-2006)* | *Std. Error* | 56,043 | 65,737 | 62,593 | 98,740 | 51,536 | 30,737 |
| | *Max* | 5,087,510 | 6,594,200 | 7,856,000 | 14,360,000 | 6,945,000 | 14,360,000 |
| | *Min* | 13,000 | 90,400 | 60,500 | 47,900 | 61,000 | 13,000 |
| | *Std. Deviation* | 747,711 | 881,949 | 842,105 | 1,298,721 | 681,755 | 915,413 |
| | *Sample* | 178 | 180 | 181 | 173 | 175 | 887 |
| *2003* | *Mean* | 547,320 | 680,054 | 766,559 | 667,132 | 567,695 | 645,726 |
| | *Std. Error* | 60,716 | 51,327 | 74,432 | 64,642 | 59,238 | 28,208 |
| | *Max* | 1,962,353 | 1,935,860 | 2,180,300 | 1,950,000 | 1,932,000 | 2,180,300 |
| | *Min* | 41,000 | 90,400 | 108,500 | 105,000 | 62,000 | 41,000 |
| | *Std. Deviation* | 437,830 | 366,550 | 531,551 | 447,854 | 414,663 | 446,903 |
| | *Sample* | 52 | 51 | 51 | 48 | 49 | 251 |
| *2004* | *Mean* | 680,133 | 898,899 | 836,717 | 756,589 | 708,818 | 776,460 |
| | *Std. Error* | 120,286 | 155,702 | 150,015 | 105,051 | 136,770 | 60,350 |
| | *Max* | 5,087,510 | 6,594,200 | 7,856,000 | 4,005,500 | 6,945,000 | 7,856,000 |
| | *Min* | 132,000 | 192,000 | 182,000 | 142,300 | 61,000 | 61,000 |
| | *Std. Deviation* | 867,398 | 1,122,786 | 1,081,777 | 735,360 | 986,263 | 967,478 |
| | *Sample* | 52 | 52 | 52 | 49 | 52 | 257 |
| *2005* | *Mean* | 309,243 | 502,492 | 357,481 | 451,517 | 339,242 | 393,035 |
| | *Std. Error* | 73,840 | 67,720 | 47,174 | 131,942 | 43,297 | 35,630 |
| | *Max* | 3,780,000 | 2,544,652 | 1,923,500 | 6,755,200 | 1,675,000 | 6,755,200 |
| | *Min* | 13,000 | 125,010 | 60,500 | 47,900 | 65,050 | 13,000 |
| | *Std. Deviation* | 522,127 | 488,335 | 340,177 | 942,257 | 303,080 | 567,846 |
| | *Sample* | 50 | 52 | 52 | 51 | 49 | 254 |
| *2006* | *Mean* | 991,646 | 1,240,394 | 1,064,560 | 1,522,926 | 909,403 | 1,146,369 |
| | *Std. Error* | 229,763 | 275,468 | 239,249 | 563,506 | 142,687 | 143,804 |
| | *Max* | 4,636,244 | 6,194,500 | 5,286,244 | 14,360,000 | 2,660,000 | 14,360,000 |
| | *Min* | 59,000 | 106,070 | 166,504 | 174,010 | 129,000 | 59,000 |
| | *Std. Deviation* | 1,125,605 | 1,377,342 | 1,219,937 | 2,817,528 | 713,437 | 1,607,778 |
| | *Sample* | 24 | 25 | 26 | 25 | 25 | 125 |

Note. 28-day TIIE futures trading volume statistics grouped by day of the week, for each year and for the whole analyzed period (January 2nd. 2003 to June 30th., 2006).

Table IV: Panel A. Conditional Mean Equation Estimates

| Series | $\mu \times 10^3$ | $\phi$ | $\delta_M \times 10^3$ | $\delta_T \times 10^3$ | $\delta_H \times 10^3$ | $\delta_F \times 10^3$ | $\delta_Z \times 10^3$ |
|---|---|---|---|---|---|---|---|
| 1 | −0.0289 | 0.1479* | 0.4282 | −0.8227* | −0.2157 | −0.6915 | −0.3566 |
| 2 | 0.6116 | 0.1946* | 0.2012 | −1.1532 | −1.833* | −1.6175* | −1.1068 |
| 3 | 0.7353 | 0.2167* | 0.1971 | −1.8535* | −2.0438* | −2.2670* | −1.2414 |
| 4 | 0.1134 | 0.1760* | 1.3282* | −1.2615 | −1.2838 | −1.9581* | −1.8690* |
| 5 | −0.2039 | 0.1643* | 1.5081* | −1.1512 | −0.9495 | −1.4258* | −0.9732 |
| 6 | 0.2849 | 0.1882* | 0.8163 | −2.0550* | −1.1520 | −2.5535* | −1.7116* |
| 7 | −0.0799 | 0.1544* | 1.3230 | −1.1070 | −0.9264 | −1.8045* | −1.2403 |
| 8 | −0.5383 | 0.1652* | 2.0695* | −0.5468 | −0.2762 | −1.9414* | −0.6787 |
| 9 | 0.1555 | 0.1580* | 1.0509 | −0.8342 | −0.7098 | −2.3557* | −1.8814* |
| 10 | 0.0003 | 0.1863* | 1.4309 | −0.8182 | −0.5963 | −2.0995* | −1.3279 |
| 11 | 0.2053 | 0.1641* | 1.4385 | −1.1199 | −0.8981 | −2.1125* | −1.5371 |
| 12 | 0.2684 | 0.1107* | 1.3113 | −0.8637 | −1.3282 | −1.9237* | −1.6937 |
| 13 | −0.0623 | 0.1011* | 1.6022 | −0.5077 | −0.9202 | −1.7263 | −1.7647 |
| 14 | −0.3985 | 0.0971* | 2.0151* | −0.2318 | −0.0910 | −1.6033 | −1.7096 |
| 15 | 0.2663 | 0.1355* | 1.5674 | −0.9408 | −1.0773 | −2.0938* | −1.5592 |
| 16 | 0.3902 | 0.1413* | 1.2057 | −1.2357 | −1.5006 | −2.0721* | −1.5846 |
| 17 | 0.2923 | 0.1455* | 1.8130 | −1.2632 | −1.1519 | −1.8791* | −1.6565 |
| 18 | 0.1119 | 0.1387* | 2.1922* | −0.6668 | −1.1851 | −1.3971 | −1.8677 |
| 19 | 0.0995 | 0.1493* | 2.1960* | −0.7561 | −1.2514 | −1.1721 | −1.9101 |
| 20 | −0.3204 | 0.1453* | 2.4831* | −0.3457 | −0.9294 | −0.7241 | −1.7216 |
| 21 | −0.1443 | 0.1484* | 2.2199* | −0.5075 | −1.2023 | −1.1292 | −1.8864* |
| 22 | −0.2480 | 0.1332* | 2.0021* | −0.0286 | −1.1202 | −1.1698 | −1.9709* |
| 23 | 0.1368 | 0.1246* | 1.6228 | −0.4532 | −1.4132 | −1.8515* | −1.9441* |
| 24 | −0.0812 | 0.1171* | 1.6206 | −0.1899 | −0.9182 | −1.7976* | −1.7860* |
| 25 | 0.0641 | 0.1065* | 1.1966 | −0.6524 | −0.4936 | −2.1515* | −1.5686 |
| 26 | −0.2630 | 0.1217* | 1.4047 | −0.4738 | −0.2791 | −2.0491* | −1.0801 |
| 27 | −0.3946 | 0.1314* | 1.6077* | −0.5924 | −0.1711 | −1.9076* | −0.9144 |
| 28 | −0.1540 | 0.1391* | 1.8456* | −0.4548 | −0.2637 | −2.1599* | −1.1987 |
| 29 | −0.0601 | 0.1282* | 1.7089* | −0.2279 | −0.4647 | −2.2596* | −1.4409 |
| 30 | 0.1056 | 0.1418* | 1.7781* | −0.1242 | −0.8041 | −2.2251* | −1.6976 |
| 31 | 0.0844 | 0.1447* | 1.6850 | 0.1862 | −1.0338 | −2.2106* | −1.7390 |
| 32 | 0.0938 | 0.1495* | 1.6696 | 0.3327 | −0.9764 | −2.2938* | −1.9103* |
| 33 | −0.1814 | 0.1070* | 1.8918* | 0.8671 | −0.8349 | −2.0734* | −1.9081* |
| 34 | 0.1476 | 0.0004 | 1.6233 | 0.2399 | −1.4606 | −2.6770* | −2.0714 |
| 35 | 0.2967 | −0.1009* | 2.5275* | −0.2925 | −0.8258 | −2.3204* | −2.8998* |
| 36 | −0.2431 | −0.0539 | 0.7328 | −0.3188 | −1.2519 | −1.9510 | −2.3775* |
| TIIE | −0.0192 | 0.1351* | −0.6433 | 0.0420 | 0.9731* | −2.2720* | 0.2375 |

Note. The table reports the conditional mean coefficients under the following GARCH specification:

$$r_t = \mu + \phi r_{t-1} + \sum_k \delta_k D_{kt} + u_t, \qquad h_t = \alpha_o + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1} + \sum_k \gamma_k D_{kt}$$

where $D_{kt}$ are day of the week and maturity dummy variables ($k \in \{M, T, H, F, Z\}$). $M$ stands for Monday, $T$ for Tuesday, $H$ for Thursday, $F$ for Friday and $Z$ for the last three days of the contract, that is, Monday, Tuesday and Wednesday of the expiration week (approximately every four weeks). * indicates significance at the 5% level.

Table IV (continued). Panel B: Conditional Variance Equation Estimates

| Series | $\alpha_0 \times 10^3$ | $\alpha_1$ | $\beta_1$ | $\gamma_M \times 10^3$ | $\gamma_T \times 10^3$ | $\gamma_H \times 10^3$ | $\gamma_F \times 10^3$ | $\gamma_Z \times 10^3$ |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.0005 | 0.1157* | 0.8872* | −0.0093* | −0.0006 | −0.0002 | 0.0067* | 0.0040* |
| 2 | −0.0080* | 0.0398* | 0.9569* | 0.0026 | 0.0052 | 0.0147* | 0.0174* | 0.0031* |
| 3 | −0.0075* | 0.0528* | 0.9453* | 0.0012 | 0.0112* | 0.0139* | 0.0103* | 0.0039* |
| 4 | −0.0162* | 0.0670* | 0.9332* | 0.0037 | 0.0297* | 0.0256* | 0.0225* | 0.0036* |
| 5 | −0.0204* | 0.0693* | 0.9316* | 0.0035 | 0.0341* | 0.0296* | 0.0334* | 0.0059* |
| 6 | −0.0195* | 0.1657* | 0.8353* | 0.0006 | 0.0389* | 0.0299* | 0.0366* | 0.0002 |
| 7 | −0.0187* | 0.0644* | 0.9370* | −0.0012 | 0.0355* | 0.0326* | 0.0238* | 0.0088* |
| 8 | −0.0069* | 0.0720* | 0.9280* | −0.0266* | 0.0239* | 0.0039 | 0.0307* | 0.0054 |
| 9 | −0.0189* | 0.0620* | 0.9365* | 0.0013 | 0.0394* | 0.0206* | 0.0319* | 0.0042 |
| 10 | −0.0129 | 0.0645* | 0.9322* | −0.0043 | 0.0323* | 0.0120 | 0.0242* | 0.0039 |
| 11 | −0.0064 | 0.0464* | 0.9484* | 0.0037 | 0.0115 | 0.0044 | 0.0105 | 0.0055 |
| 12 | −0.0029 | 0.0501* | 0.9445* | 0.0036 | 0.0061 | −0.0010 | 0.0049 | 0.0052 |
| 13 | −0.0013 | 0.0880* | 0.9011* | −0.0005 | 0.0107 | −0.0065 | 0.0072 | 0.0022 |
| 14 | 0.0111 | 0.1209* | 0.8629* | −0.0221 | 0.0022 | −0.0316* | 0.0076 | −0.0048 |
| 15 | 0.0001 | 0.0472* | 0.9488* | −0.0046 | 0.0111 | −0.0037 | −0.0063 | 0.0065 |
| 16 | 0.0075 | 0.0866* | 0.8868* | −0.0113 | 0.0035 | −0.0317* | 0.0145* | −0.0060 |
| 17 | −0.0036 | 0.0527* | 0.9348* | 0.0005 | 0.0189 | −0.0057 | 0.0065 | 0.0017 |
| 18 | 0.0065 | 0.0376* | 0.9571* | −0.0077 | 0.0007 | −0.0161 | −0.0124 | 0.0050 |
| 19 | −0.0017 | 0.0468* | 0.9442* | 0.0039 | 0.0106 | −0.0064 | 0 | 0.0034 |
| 20 | −0.0025 | 0.0763* | 0.9064* | 0.0076 | 0.0124 | −0.0085 | 0.0049 | 0.0028 |
| 21 | −0.0061 | 0.0488* | 0.9440* | 0.0017 | 0.0196 | 0.0007 | 0.0074 | 0.0046 |
| 22 | −0.0074 | 0.0499* | 0.9474* | −0.0033 | 0.0236 | 0.0012 | 0.0124 | 0.0047 |
| 23 | −0.0079 | 0.0504* | 0.9463* | −0.0013 | 0.0260* | 0.0014 | 0.0117 | 0.0034 |
| 24 | −0.0071 | 0.0548* | 0.9387* | 0.0075 | 0.0195 | 0.0010 | 0.0086 | 0.0020 |
| 25 | −0.0069 | 0.0543* | 0.9465* | −0.0094 | 0.0299* | 0.0066 | 0.0049 | 0.0049 |
| 26 | −0.0007 | 0.0563* | 0.9490* | −0.0243* | 0.0252* | 0.0058 | −0.0117* | 0.0131* |
| 27 | −0.0053 | 0.0525* | 0.9525* | −0.0184* | 0.0304* | 0.0125* | −0.0075 | 0.0153* |
| 28 | −0.0016 | 0.0465* | 0.9529* | −0.0121 | 0.0170 | 0.0025 | −0.0045 | 0.0087* |
| 29 | −0.0018 | 0.0486* | 0.9491* | −0.0121 | 0.0167 | 0.0008 | 0.0018 | 0.0045 |
| 30 | −0.0008 | 0.0422* | 0.9543* | −0.0095 | 0.0112 | 0.0021 | −0.0004 | 0.0040 |
| 31 | −0.0031 | 0.0424* | 0.9526* | −0.0018 | 0.0111 | 0.0038 | 0.0015 | 0.0048 |
| 32 | −0.0021 | 0.0412* | 0.9516* | 0.0030 | 0.0027 | 0.0050 | 0.0013 | 0.0030 |
| 33 | −0.0002 | 0.1196* | 0.8061* | −0.0128 | 0.0240* | 0.0123 | 0.0186 | −0.0018 |
| 34 | −0.0247* | 0.0845* | 0.9043* | 0.0251* | 0.0322* | 0.0213 | 0.0565* | −0.0010 |
| 35 | −0.0172* | 0.1969* | 0.7785* | 0.0975* | −0.0237 | 0.0304* | 0.0289* | 0.0004 |
| 36 | 0.0013 | 0.3408* | 0.7040* | 0.0339* | −0.0199 | 0.0187 | 0 | −0.0008 |
| TIIE | −0.0020 | 0.4543* | 0.6598* | 0.0123* | −0.0060* | 0.0056* | 0.0079* | 0.0010 |

Note. The table reports the conditional variance coefficients under the following GARCH specification:

$$r_t = \mu + \phi r_{t-1} + \sum_k \delta_k D_{kt} + u_t, \qquad h_t = \alpha_o + \alpha_1 u_{t-1}^2 + \beta_1 h_{t-1} + \sum_k \gamma_k D_{kt}$$

where $D_{kt}$ are day of the week and maturity dummy variables ($k \in \{M, T, H, F, Z\}$). $M$ stands for Monday, $T$ for Tuesday, $H$ for Thursday, $F$ for Friday and $Z$ for the last three days of the contract, that is, Monday, Tuesday and Wednesday of the expiration week (approximately every four weeks).

* indicates significance at the 5% level

Table V: Descriptive statistics for the estimated standardized residuals $u_t/\sqrt{h_t}$

| | *Standarized residuals* | | | | | | | *Squared standardized residuals* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Series* | *Skewness* | *Kurtosis* | *BJ* | *LB(8)* | *p-value* | *LB(16)* | *p-value* | *LB(8)* | *p-value* | *LB(16)* | *p-value* |
| 1 | 0.047 | 2.90 | 296.4 | 8.62 | 0.281 | 14.73 | 0.471 | 4.35 | 0.738 | 10.03 | 0.818 |
| 2 | 0.240 | 2.71 | 266.7 | 3.90 | 0.792 | 9.25 | 0.864 | 4.35 | 0.739 | 6.56 | 0.969 |
| 3 | 0.195 | 1.33 | 67.7 | 4.30 | 0.744 | 10.38 | 0.795 | 5.93 | 0.548 | 10.43 | 0.792 |
| 4 | 0.044 | 2.20 | 170.7 | 4.05 | 0.774 | 7.64 | 0.937 | 5.05 | 0.654 | 12.25 | 0.660 |
| 5 | 0.407 | 2.44 | 232.9 | 3.12 | 0.874 | 9.86 | 0.828 | 4.38 | 0.736 | 10.90 | 0.760 |
| 6 | 0.258 | 1.29 | 68.0 | 3.98 | 0.783 | 12.44 | 0.646 | 4.38 | 0.735 | 11.82 | 0.693 |
| 7 | 0.016 | 0.96 | 32.5 | 2.09 | 0.955 | 8.60 | 0.897 | 5.27 | 0.627 | 8.69 | 0.893 |
| 8 | -0.036 | 1.12 | 44.4 | 4.59 | 0.710 | 11.00 | 0.752 | 3.51 | 0.834 | 5.46 | 0.988 |
| 9 | 0.119 | 0.57 | 13.4 | 5.29 | 0.624 | 10.04 | 0.817 | 7.75 | 0.355 | 12.55 | 0.637 |
| 10 | 0.143 | 0.79 | 24.8 | 3.11 | 0.874 | 6.41 | 0.972 | 3.41 | 0.845 | 8.09 | 0.920 |
| 11 | 0.194 | 1.33 | 67.6 | 1.01 | 0.995 | 6.65 | 0.967 | 6.76 | 0.454 | 12.86 | 0.613 |
| 12 | 0.249 | 1.81 | 124.1 | 0.66 | 0.999 | 4.96 | 0.992 | 3.52 | 0.833 | 11.73 | 0.699 |
| 13 | 0.148 | 1.30 | 62.6 | 1.35 | 0.987 | 8.09 | 0.920 | 3.57 | 0.828 | 13.82 | 0.539 |
| 14 | 0.177 | 1.08 | 45.5 | 3.17 | 0.869 | 11.90 | 0.686 | 2.42 | 0.933 | 10.67 | 0.776 |
| 15 | 0.178 | 1.06 | 44.0 | 2.62 | 0.918 | 10.11 | 0.813 | 3.94 | 0.787 | 7.61 | 0.939 |
| 16 | 0.393 | 1.78 | 133.2 | 3.32 | 0.854 | 8.91 | 0.882 | 4.30 | 0.744 | 6.25 | 0.975 |
| 17 | 0.154 | 0.86 | 29.4 | 9.87 | 0.196 | 16.71 | 0.336 | 4.85 | 0.678 | 7.23 | 0.951 |
| 18 | 0.153 | 1.88 | 127.8 | 8.22 | 0.313 | 17.06 | 0.316 | 1.99 | 0.960 | 5.29 | 0.989 |
| 19 | 0.193 | 1.07 | 45.6 | 6.73 | 0.458 | 12.91 | 0.609 | 2.03 | 0.958 | 4.41 | 0.996 |
| 20 | 0.104 | 1.05 | 40.4 | 5.48 | 0.602 | 12.08 | 0.673 | 1.81 | 0.969 | 5.25 | 0.990 |
| 21 | -0.021 | 1.16 | 47.4 | 5.82 | 0.561 | 10.46 | 0.790 | 2.69 | 0.912 | 6.71 | 0.965 |
| 22 | -0.061 | 1.11 | 43.9 | 4.31 | 0.743 | 8.21 | 0.915 | 2.47 | 0.929 | 8.57 | 0.899 |
| 23 | -0.010 | 1.00 | 35.2 | 5.45 | 0.605 | 9.71 | 0.837 | 4.44 | 0.728 | 13.07 | 0.597 |
| 24 | -0.083 | 1.27 | 57.8 | 8.63 | 0.280 | 14.07 | 0.520 | 7.29 | 0.399 | 14.17 | 0.513 |
| 25 | -0.086 | 1.33 | 63.3 | 5.24 | 0.631 | 13.01 | 0.601 | 3.29 | 0.857 | 17.42 | 0.294 |
| 26 | -0.018 | 1.46 | 75.1 | 4.01 | 0.779 | 11.98 | 0.680 | 3.68 | 0.816 | 14.57 | 0.483 |
| 27 | 0.086 | 1.21 | 52.6 | 3.58 | 0.827 | 9.24 | 0.865 | 6.26 | 0.510 | 12.88 | 0.611 |
| 28 | 0.097 | 1.32 | 62.7 | 2.43 | 0.933 | 5.62 | 0.985 | 4.01 | 0.779 | 11.37 | 0.726 |
| 29 | 0.131 | 1.37 | 68.5 | 2.15 | 0.951 | 6.22 | 0.976 | 6.62 | 0.470 | 12.96 | 0.606 |
| 30 | 0.266 | 1.61 | 101.2 | 2.86 | 0.897 | 5.33 | 0.989 | 2.59 | 0.920 | 8.23 | 0.914 |
| 31 | 0.295 | 1.73 | 117.7 | 5.38 | 0.614 | 7.58 | 0.940 | 1.94 | 0.963 | 7.91 | 0.927 |
| 32 | 0.327 | 1.99 | 154.4 | 5.16 | 0.641 | 9.18 | 0.868 | 7.27 | 0.401 | 12.79 | 0.619 |
| 33 | 0.839 | 4.58 | 837.6 | 9.92 | 0.193 | 15.93 | 0.386 | 28.88 | 0.000 | 32.63 | 0.005 |
| 34 | 0.131 | 4.20 | 623.5 | 7.42 | 0.386 | 21.71 | 0.116 | 20.31 | 0.005 | 22.35 | 0.099 |
| 35 | 0.156 | 4.25 | 639.4 | 6.51 | 0.482 | 22.59 | 0.093 | 14.05 | 0.050 | 33.56 | 0.004 |
| 36 | 0.077 | 3.27 | 377.3 | 5.94 | 0.546 | 9.85 | 0.829 | 4.12 | 0.766 | 14.69 | 0.474 |

Note. This table presents normality and correlation tests for standardized residuals and squared standardized residuals under the GARCH(1,1) model and for the estimated coefficients. $LB(k)$ denotes the Ljung-Box statistic with $k$ lags.