SEASONAL EFFECTS IN INTEREST RATE FUTURES MARKETS

AN IFOX AND LIFFE PERSPECTIVE

EDEL BARNES

University College Cork

ABSTRACT

This paper assesses the evidence for and against the existence of pricing regularities in a variety of interest-rate futures contracts traded on IFOX and LIFFE, together with a comparative analysis of the fixed-income securities which underlie these futures contracts. The study results indicate that pricing anomalies are present for all futures examined, save the IFOX Short Gilt. However, while seasonal effects in cash markets exist for all long-dated fixed-income securities, there is no evidence of anomalous price behaviour in either the DIBOR or LIBOR markets. Overall, the study conclusions call somewhat into question the validity of the Efficient Markets Hypothesis in the context of the markets investigated.

INTRODUCTION

The wealth of research which has been conducted in the finance field in the past 30 years or so has considerably enhanced our understanding of capital markets, financial management and pricing issues. Significant advances, both methodological and technical, together with the increasing sophistication of databases used in empirical research have rendered it possible to test many of the theoretical concepts that form the basis of how we view our financial environs. However as econometric techniques become more refined, numerous pricing anomalies have been uncovered, which call seriously into question many of our basic paradigms. One example is the notion that markets are efficient and that abnormal returns can be earned only by chance.

This study investigates the existence of pricing regularities in the three interest-rate futures contracts traded on the Irish Futures and Options Exchange (IFOX), and comparable contracts traded on the London International Financial Futures Exchange (LIFFE). The Irish futures exchange commenced trading operations on 29 May 1989. Both the three-month DIBOR contract and the 20-year Long Gilt contract have been traded from this date. Given the considerable volatility of interest rates in recent times, Long Gilt futures have frequently been traded both for hedging and speculative reasons. The DIBOR future, traded for a wider variety of purposes, is the most actively traded future on the Irish exchange, and this is reflected in its large trading volume. IFOX launched a future on a notional five-year Government Gilt on 6 September 1990, and there has been substantial activity in this contract since its inception. LIFFE commenced trading on 30 September 1982 and is the oldest and most prominent financial futures exchange in Europe. LIFFE offers trades in 14 financial futures, and by 1992 average daily trading volume exceeded 326,000 contracts with a nominal value of stg£64 billion.[1]

Anomalous price behaviour has been extensively researched in the US, UK and elsewhere. Emphasis was initially placed on the cash market for stocks and fixed-income securities, but Chiang and Tapley (1983), Cornell (1985), Johnson, Kracaw and McConnell (1991), and Yadav and Pope (1991) followed with analyses of pricing regularities in various futures markets. This paper examines for the first time the issue of seasonal effects in the Irish interest-rate futures markets. The sample facilitates comparisons of futures contracts with their underlying securities in the cash market. For additional comparative purposes, an analysis for the corresponding LIFFE futures is undertaken.

The next section outlines briefly the implications of the Efficient Markets Hypothesis (EMH) for pricing futures contracts, and some of the influences underpinning the methodology applied in the study are discussed. The third section of the paper describes the empirical analysis and results pertaining to pricing regularities in the Irish and UK markets. The penultimate section discusses the feasibility of trading rules, based on the results of this study. The last section contains a summary of the author's findings.

MARKET EFFICIENCY AND FUTURES TRADING

A market is efficient if the speed and quality of the price adjustments to new information prevent most, if not all, investors from earning abnormal profits. There is a certain 'normal' return one would expect to earn by holding securities. This return generally comprises a risk-free rate and a premium for bearing risk exposure to market movements. A price quoted by the market is the best estimate of true value at any point in time. In an efficient market it is not possible to identify under-priced or over-priced securities consistently, or to employ a trading rule which will outperform the market other than by chance. Contending that a market is efficient is not to suggest that the market is 100 per cent correct in its assessment of a security's value, 100 per cent of the time, because we are always faced with uncertainty. Rather, the market as a whole offers the best estimate of price because it represents a consensus view of professionals, all of whom are undertaking fundamental and/or technical analysis, and are continuously factoring new information into price by competitive buying and selling. If all historic, current and anticipated information is incorporated into security prices, then prices will only react to surprise information, which by definition cannot be predicted. Consequently, security price movements are random and one cannot predict future price trends. This Random Walk Hypothesis (RWH) and Fama's (1970) Efficient Markets Hypothesis (EMH) are closely allied. In short, they assert that past trading patterns cannot be used to predict future prices.

In relation to futures markets, the Efficient Markets Hypothesis implies that the price quoted for a futures contract is an unbiased estimate of the future spot price of the security underlying that contract, given all current information available in relation to the spot and derivative instruments. If price adjusts immediately to the release of any new information, the opportunities will not arise for speculators to trade futures to exploit relative mispricings. Furthermore, the 'return' to either a long or short futures position would arise solely from the convergence of futures prices towards spot as contracts near maturity, and intuitively this occurs at a steady rate over time. A priori, therefore, one would expect that the pattern of average daily returns would be the same over time for all futures contracts traded, and that returns would not be influenced in any way by the particular day of the week, or indeed time of the day, at

which the trade is made. Stated succinctly, one would expect the distribution of returns to be equal across days of the week, and over the trading day.

Traditionally, researchers have tested for seasonal or day of the week effects by statistically assessing returns classified by day of the week. Initially, one computed daily close-to-close returns for the particular spot or futures market contract being studied, and performed the Student's two-tailed t-test to test the null hypothesis that sample means are significantly different from zero. Mean daily returns can be defined as:

$$r_{t,t+1} = \text{Ln}\left[\frac{P_{t+1}}{P_t}\right]$$

where $r_{t,t+1}$ = return from period t to period t+1
P_{t+1} = the contract price quoted for day t+1
P_t = the contract price quoted for day t and
Ln = the natural logarithm.

The t-statistic tests the following hypotheses:

$$H_0 : E(r_{t,t+1}) = 0$$
$$H_1 : E(r_{t,t+1}) \neq 0$$

and the test statistic itself is defined as

$$t = \frac{X - \mu}{s_x/\sqrt{n}}$$

where n = number of observations,
X = mean return of the random sample of observations,
s_x = sample standard deviation which is an estimate of the population standard deviation, s and
μ = $E(r_{t,t+1})$ i.e. the mean return for each day of the week.

The null hypothesis of equality in the distribution of returns across days of the week would be rejected if the observed t-statistics exceeded a particular critical value for a given sample size and significance level. A more reliable and accurate indication of joint equality in the distribution of daily returns can be obtained by employing a dummy variable mul-

tiple regression model. Gibbons and Hess (1981), Keim and Stambaugh (1984), Rogalski (1984) and Harris (1986) employed a model, which included dummy variables for each day of the trading week:

$$R_t = b_M D_{M,t} + b_T D_{T,t} + b_W D_{W,t} + b_H D_{H,t} + b_F D_{F,t} + e_t \quad [1]$$

where R_t = return on day of the week t
b_i = regression coefficient for day of the week i
$D_{i,t}$ = 1 if day t is the ith day of the week, 0 otherwise
e_t = random error term for day t.

The regression F-statistic (F_5) tests the hypotheses :

$$H_0 : b_M = b_T = b_W = b_H = b_F = 0$$
$$H_1 : b_M = b_T = b_W = b_H = b_F \neq 0$$

Johnson, Kracaw and McConnell (1991) maintain that a regression of this form introduces bias into the coefficients if the true mean return is non-zero, and recommend the following model:

$$R_t = a_0 + b_T D_{T,t} + b_W D_{W,t} + b_H D_{H,t} + b_F D_{F,t} + e_t \quad [2]$$

where all variables are similar to those in equation 1 but the regression intercept a_0 reflects Monday's mean return with the regression coefficients gauging the *deviation* of each day's return from that of Monday. The F-statistic (F_4) produced by this model tests the hypotheses

$$H_0 : b_T = b_W = b_H = b_F = 0$$
$$H_1 : b_T = b_W = b_H = b_F \neq 0$$

(Note that in equations [1] and [2] above, R_t the return on day of the week t is taken to imply the return for period t,t+1 (for example, Monday's daily return is the natural logarithm of Monday's closing price divided by Monday's opening price), for consistency with earlier

expressions. For ease of exposition the more cumbersome subscripts are shortened here.)

The null of equality would be rejected if either F_4 or F_5 exceeded a certain critical value, determined by sample size and a specified significance level (α). Newbold (1991) comments that the null hypothesis of equality of means across a population is ambiguous when the variability *around* the sample mean is small compared with the variability *among* the sample means. One-way analysis of variance (one-way ANOVA) can be generalised as being a t-test for the comparison of two population means from independent random samples, and can be recast as a dummy variable regression whose F-statistic should exactly replicate the F_4 statistic discussed above. One-way ANOVA is particularly useful where a sample is characterised by around- and/or among-mean variability. Where a data sample exhibits a number of outliers or extreme values, the dummy variable regression/ANOVA approach used in many US studies may not be appropriate. Gultekin and Gultekin (1983), Theobald and Price (1984), and Donnelly (1991) employ the non-parametric Kruskal-Wallis (KW) test, which is sensitive to differences in population means and is widely regarded as a non-parametric alternative to ANOVA. The KW statistic tests the hypothesis that all days of the week have an equal distribution of returns.[2]

Although the approach of Johnson et al. (1991) is the major influence, this study applies a combination of several methodologies in examining the issue of pricing regularities on IFOX and LIFFE. As a check on the validity of the t-test findings, both F_4 and F_5 regression models are also undertaken for all futures contracts studied, and for all spot market instruments. Although there were no obvious outliers in the sample data, a rigorous analysis of the regression residuals revealed that the normality assumptions required for ordinary least squares (OLS) analysis were not strictly borne out. Therefore a KW statistic is also calculated for each data set. Autocorrelation of the model residuals was not a major econometric problem encountered in this study. However, Anderson (1985) established that the variance of futures price changes may vary over time given factors such as seasonality and declining time to maturity. In a number of cases, the regression residuals were found to be heteroscedastic. Where this was the case, the regression set was standardised by the standard deviation of the futures index return for each day of the

week (see Gay and Kim, 1987). This author's results are qualitatively the same, regardless of whether the adjustment for heteroscedastic effects is made or not, and in no case did model coefficients become substantially (more) significant/insignificant as a result of the transformation. In the interests of clarity, only the F-statistics for the adjusted data sets were reported where such correction was necessary.

EMPIRICAL ANALYSIS

1. The data requirements for this research project for the period 29 May 1989 to 31 December 1992 were as follows: Daily closing futures prices from IFOX for the following contracts:[3]
   (a) Long Gilt Future contract
   (b) Short Gilt Future contract
   (c) Three-month DIBOR Future contract.
2. A series of daily opening and closing futures prices from LIFFE for the following contracts:
   (a) Long Gilt Futures contract
   (b) Three-month LIBOR Futures contract.[4]
3. Series of daily closing prices for the following Irish cash gilts:
   (a) 8½% Capital, redeemable 1/10/2010
   (b) 8¾% Capital, redeemable 30/09/2012
   (c) 9% Capital, redeemable 30/07/1996.[5]
4. Series of daily closing prices for the following UK cash gilts:
   (a) 9% Treasury, redeemable 2008,
   (b) 8% Treasury, redeemable 2009.
5. Series of daily closing rates for the three-month DIBOR and the three-month LIBOR.

IFOX and LIFFE futures prices were obtained on diskette from the respective Exchanges while spot price data was obtained from DATASTREAM. These prices were used to calculate continuously compounded returns (defined as the natural logarithm of daily price relatives). Close-to-close (daily), close-to-open (non-trading time) and

open-to-close (trading time) returns were computed for each LIFFE contract, while daily returns only were obtained for all cash gilts and for the IFOX futures. Nearby contracts were used in the main, except during delivery month when the next nearest to delivery future was used. This yielded a non-overlapping daily series of price changes for each futures contract.

Daily Returns in the Irish and UK Spot and Futures Markets

Details of the returns series examined are as follows :

INTERBANK OFFERED RATE FUTURES AND SPOT INSTRUMENTS

- Close-to-close returns for the DIBOR and IFOX DIBOR future, where the spot position involves undertaking to deposit IR£100,000 at a particular DIBOR rate for three months

- Close-to-close returns for the LIBOR and LIFFE LIBOR future, where the cash position is a deposit of stg£100,000 at a particular LIBOR three-month rate. Close-to-open and open-to-close returns were also calculated for the LIBOR future.

LONG GILT FUTURES AND CASH SECURITIES

- Daily return series for Irish long-dated government bonds (the 8½%, 2010 and the 8¾, 2012), and for the IFOX Long Gilt future

- A corresponding series for UK long-dated Treasuries (the 9%, 2008 and the 8%, 2009), and for the LIFFE Long Gilt future. Trading time and non-trading time returns for the LIFFE Long Gilt future were also obtained.

SHORT GILT FUTURES AND CASH SECURITIES

- Returns classified by day of the week for the Irish short-dated government gilt (the 9%, 1996) and for the IFOX Short Gilt future were examined.

A preliminary graphical analysis was undertaken of the distribution of daily returns across the days of the week, for the IFOX Long Gilt future and its underlying long-dated Government gilts, for the LIFFE Long

Gilt future and its associated UK Treasury bonds, and for the DIBOR and LIBOR futures and spot positions.

Figure 1: Day of the Week Effect
DIBOR Future and Cash

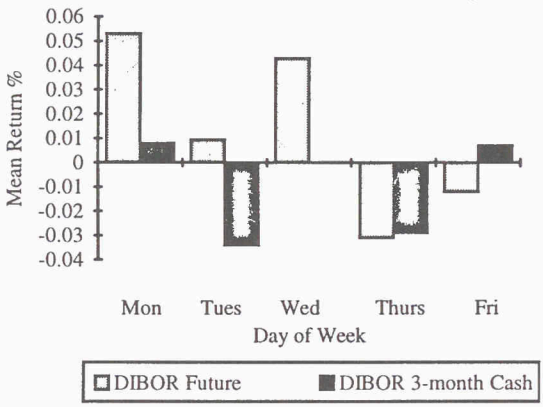


Figure 2: Day of the Week Effect
LIBOR Future and Cash

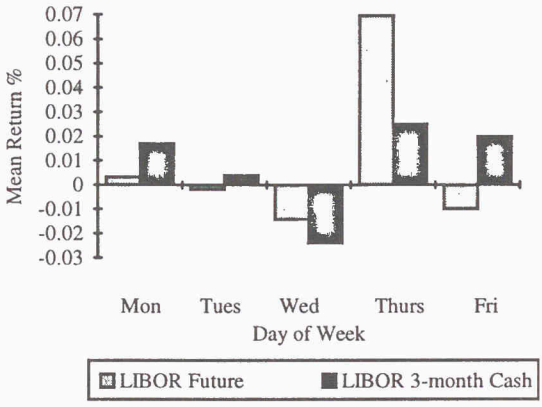


Figure 3: Day of the Week Effect
IFOX LG Future and Cash Gilts

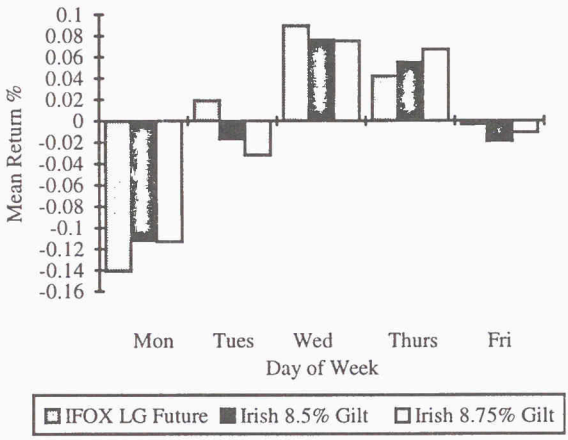
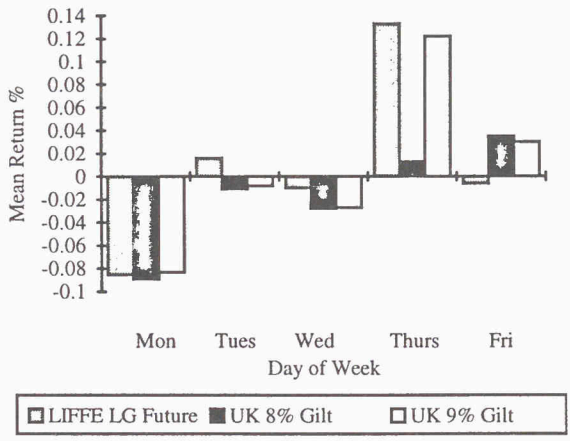


Figure 4: Day of the Week Effect
LIFFE LG Future and Cash Gilts



On initial perusal, the 'usual' anomalous pattern of daily returns (negative Monday return, positive Wednesday return) appears to be evident just for the long gilt futures and the long-dated fixed-income securities underlying these contracts. Monday mean daily returns are significantly negative and there is a strong positive midweek mean return which occurs on Thursday for the UK positions and on both Wednesday and Thursday for the Irish positions. In contrast, the LIBOR Monday returns are positive, albeit not strongly so, and Thursday mean returns are again strongly positive. For the DIBOR positions, however, Monday mean returns are positive and the highest of the week, and the Thursday mean return is negative. It appears therefore that there are some patterns in the distribution of daily returns, but that although the pattern for longer-maturity instruments is broadly similar to that documented for stock markets around the world, a somewhat different pattern pertains to the DIBOR/LIBOR return distributions.

Summary statistics for each series of daily returns, classified by day of the week, were initially examined to obtain an early indication of whether returns were equally distributed across days of the trading week. Mean close-to-close returns and corresponding t-statistics are reproduced in **Table 1**.

A preliminary examination of the results in **Table 1** indicates some tentative patterns in the distribution of returns. For both the IFOX Long Gilt future and the underlying Irish long-dated gilts there appears to be a negative Monday seasonal, which is significant at the 1 per cent level, and a positive Wednesday effect, significant at the 5 per cent level. For the corresponding LIFFE Long Gilt future and its underlying cash securities, the negative Monday effect is also evident (although significant at only the 10 per cent and 5 per cent levels respectively), and there is a strong positive Thursday seasonal at the 1 per cent level of significance. No other daily return is significantly different from zero for either the IFOX/LIFFE Long Gilt futures or for the long-dated gilts. With regard to the LIBOR position, the strongly positive Thursday return is also evident for both spot and futures investments, although there is no indication of a Monday seasonal. The IFOX DIBOR future exhibits a negative (albeit not highly significant) Friday return and a positive Monday return, which is contrary to the observed pattern for the longer-dated investments. However, these effects are not present for the cash

position. Finally, there appears to be no evidence of seasonal effects for either the IFOX Short Gilt future or the Irish government short-dated gilt.

Table 1: Mean Daily Returns for Irish and UK Futures (F) and Cash (C) Investments[1,2,3]

Contract	Mon	Tues	Wed	Thurs	Fri
DIBOR(F)	0.0531	0.0094	0.0429	-0.031	-0.012
t-stat	(2.19**)	(1.04)	(1.06)	-(0.38)	-(1.93***)
DIBOR(C)	0.008	-0.034	0.00	-0.029	0.007
t-stat	(0.14)	(-1.29)	0.00	(-1.19)	(0.50)
LIBOR(F)	0.0033	-0.0019	-0.0143	0.0696	-0.0099
t-stat	(0.29)	(-0.23)	(-1.29)	(2.65*)	(-1.08)
LIBOR(C)	0.017	0.004	-0.024	0.025	0.020
t-stat	(1.49)	(0.52)	(-1.08)	(2.26**)	(1.14)
IFOX LG	-0.1409	0.0191	0.0895	0.0423	-0.0032
t-stat	(-3.15*)	(0.45)	(2.26**)	(1.04)	(-0.09)
IR 8½%	-0.112	-0.017	0.076	0.055	-0.019
t-stat	(-2.65*)	(-0.46)	(2.19**)	(1.31)	(-0.64)
IR 8¾%	-0.113	-0.032	0.075	0.067	-0.011
t-stat	(-2.62*)	(-0.85)	(2.47**)	(1.64)	(-0.38)
IFOX SG	-0.0511	-0.023	0.0234	0.033	0.0159
t-stat	(-1.63)	(-0.57)	(0.98)	(1.06)	(0.67)
IR 9%	-0.038	-0.025	0.021	0.038	0.003
t-stat	(-0.58)	(-0.97)	(1.54)	(1.55)	(0.06)
LIFFE LG	-0.0854	0.016	-0.01	0.1328	-0.006
t-stat	(-1.8***)	(0.36)	(-0.23)	(2.71*)	(-0.12)
UK 8%	-0.089	-0.011	-0.028	0.0129	0.035
t-stat	(-2.07**)	(-0.32)	(-0.71)	(2.96*)	(0.70)
UK 9%	-0.083	-0.008	-0.027	0.122	0.03
t-stat	(-2.07**)	(-0.24)	(-0.73)	(2.99*)	(0.64)

1. Student two-sided t-statistics are in parentheses.
2. *, **, and *** indicate significance at the 1%, 5% and 10% levels respectively.
3. Mean returns are for the close-to-close period.

INTERBANK OFFERED RATE FUTURES AND SPOT INSTRUMENTS

Table 2: Interbank Offered Rate Cash (C) and Futures (F) Mean Returns (%) Classified by Day of the Week[1,2,3]

Contract	Mon	Tues	Wed	Thurs	Fri
	Irish DIBOR and IFOX DIBOR Future				
DIBOR F	0.0541	0.0094	0.0429	-0.031	-0.0177
	(2.19**)	(1.04)	(1.06)	(-0.38)	(-1.93***)
DIBOR C	0.008	-0.034	0.00	-0.029	0.007
	(0.14)	(-1.29)	0.00	(-1.19)	(0.50)
	UK LIBOR and LIFFE LIBOR Future				
LIBOR	0.0033	-0.0019	-0.0143	0.0696	-0.0099
C-TO-C	(0.29)	(-0.23)	(-1.29)	(2.65*)	(-1.08)
LIBOR	0.0029	-.0009	-0.0053	0.0541	-0.0004
C-TO-O	(0.29)	(-0.19)	(-0.74)	(2.65*)	(-0.05)
LIBOR	0.0005	-0.0026	-0.0126	0.0180	-0.0092
O-TO-C	(0.09)	(-0.34)	(-1.77***)	(1.79***)	(-1.23)
LIBOR C	0.017	0.004	-0.024	0.025	0.020
	(1.49)	(0.52)	(-1.08)	(2.26**)	(1.14)

1. T-statistics are in parentheses.
2. Mean returns are for the close-to-close period, except where otherwise stated.
3. *, ** and *** indicate significance at the 1%, 5% and 10% levels respectively.

The first (second) half of **Table 2** presents evidence of seasonal effects in DIBOR (LIBOR) cash and futures trading. Looking initially to the DIBOR case, we see that the pattern of daily returns is quite different between the spot and futures markets. No daily return is significantly different from zero for the cash-market investment. Regression test statistics (F_4, F_5 and KW) reported in **Table 5** below indicate that the null hypothesis of an equal distribution of returns across the days of the week cannot be rejected at even the 10 per cent significance level.

On the other hand, there is evidence of seasonality in the futures market — Monday's (Friday's) mean return is positive (negative) and significant at the 5 per cent (10 per cent) level. The F_5 and KW statistics for this future reject the null of equality at the 10 per cent and 5 per cent levels

respectively. There was sufficient data for the LIBOR future to assess any concentration of seasonal effects in the trading or non-trading periods. The overall close-to-close returns indicate a strong positive Thursday effect. For the non-trading period, a significantly positive Thursday return was again present, while the trading period return was also positive but less significantly so. A difference of means test showed this seasonal to be concentrated largely in the close-to-open or non-trading period. Apart from weak indications of a negative Wednesday seasonal in the trading period, no other pattern in returns is evident. The positive Thursday return is also a feature of the LIBOR cash market, although it is less significant. This is in contrast to the DIBOR case where the seasonal is evident only in futures trading. From summary regression statistics for the LIBOR cash and futures markets reported in **Table 5**, the null hypothesis of equally distributed daily returns is accepted for the cash market, but rejected at a significant level for the future, where returns are concentrated mainly in the non-trading period.[6]

The significantly positive Monday mean return for the DIBOR future is inconsistent with findings of negative mean Monday returns in the stock market by Keim and Stambaugh (1984), Rogalski (1984) and Harris (1986), and Gibbons and Hess' (1981) findings for the US T-Bill cash market. However, this Monday seasonal is consistent with findings of Chiang and Tapley (1983) for US commercial paper futures, and of Johnson et al. (1991) for US T-Bill futures. Chiang and Tapley noted that Treasury futures recorded the highest return of the week on either Thursdays or Fridays, which is borne out by the strongly positive Thursday return for the LIBOR. Both the DIBOR and LIBOR futures exhibit negative albeit insignificant Friday returns. This is curious given the high Friday returns reported by Johnson et al. (1991) for Fridays in the T-Bill market. Overall, the evidence supports the hypothesis of a day of the week effect for the DIBOR and LIBOR futures and for the LIBOR cash market.

LONG AND SHORT GILT FUTURES AND CASH SECURITIES

Table 5 reports regression statistics (F_4, F_5, KW and MOOD) for the IFOX Long and Short Gilt futures, the LIFFE Long Gilt future and their respective underlying cash securities. **Tables 3** and **4** contain the actual regression coefficients obtained for these positions.

Table 3: Long Gilt Futures and Cash Instrument (C) Mean Returns (%) Classified by Day of the Week[1,2,3]

Contract	Mon	Tues	Wed	Thurs	Fri
Irish Long-dated Gilts and IFOX LG Future					
IFOX LG	-0.1409	0.0191	0.0895	0.0423	-0.0032
	(-3.15*)	(0.45)	(2.26**)	(1.04)	(-0.09)
8½% (C)	-0.112	-0.017	0.076	0.055	-0.019
	(-2.65*)	(-0.46)	(2.19**)	(1.31)	(-0.64)
8¾% (C)	-0.113	-0.032	0.075	0.067	-0.011
	(-2.62*)	(-0.85)	(2.47**)	(1.64***)	(-0.38)
UK Long-dated Gilts and LIFFE LG Future					
LIFFE LG	-0.0854	0.016	-0.010	0.1328	-0.006
C-TO-C	(-1.80***)	(0.36)	(-0.23)	(2.71*)	(-0.12)
LIFFE LG	-0.0424	0.021	0.008	0.0393	0.0495
C-TO-O	(-1.20)	(0.77)	(0.26)	(1.27)	(1.47)
LIFFE LG	-0.0532	-0.0098	-0.0142	0.105	-0.0615
O-TO-C	(-1.43)	(-0.23)	(-0.37)	(2.30*)	(-1.37)
8% (C)	-0.089	-0.011	-0.028	0.129	0.035
	(-2.07**)	(-0.32)	(-0.71)	(2.96*)	(0.70)
9% (C)	-0.083	-0.008	-0.027	0.122	0.030
	(-2.07**)	(-0.24)	(-0.73)	(2.99*)	(0.64)

1. T-statistics are in parentheses.
2. *, ** and *** indicate significance at the 1%, 5% and 10% levels, respectively.
3. Mean returns are for the close-to-close period, except where otherwise stated.

Table 4: Short Gilt Future and Cash Instrument (C) Mean Returns (%), Classified by Day of the Week[1,2,3,4]

Contract	Mon	Tues	Wed	Thurs	Fri
IFOX SG	-0.0511	-0.023	0.0234	0.033	0.0159
	(-1.63)	(-0.57)	(0.98)	(1.06)	(0.67)
IR 9%(C)	-0.038	-0.025	0.0210	0.038	0.003
	(-0.58)	(-0.97)	(1.54)	(1.55)	(0.06)

1. For the period 6 September 1990 to 31 December 1992.
2. T-Statistics are in parentheses.
3. *, **, *** indicate significance at the 1%, 5% and 10% levels respectively.
4. Mean returns are for the close-to-close period.

Table 5: Regression Test Statistics for all Futures Contracts and Cash Instruments[1,2]

CONTRACT	F_4	F_5	KW (MOOD)
DIBOR (F)	1.82	2.00***	10.25**
DIBOR (C)	0.40	0.41	3.738
LIBOR (F) C-TO-C	5.38*	4.72*	15.37*
LIBOR (F)	4.60*	4.47*	7.452
C-TO-O			(8.67***)
LIBOR (F)	2.31***	1.87***	9.72**
O-TO-C			
LIBOR (C)	1.76	1.71	3.824
IFOX LG	4.43*	3.55*	18.02*
IR 8½% (C)	3.93*	3.15*	17.34*
IR 8¾% (C)	4.42*	3.54*	14.89*
LIFFE LG C-TO-C	2.75**	2.25**	12.15**
LIFFE LG C-TO-O	1.25	1.20	7.205
LIFFE LG O-TO-C	2.54**	2.05***	11.46**
UK 8% (C)	3.62*	2.92*	10.77**
UK 9% (C)	3.69*	2.98*	11.30**
IFOX SG	1.33	1.07	5.16
IR 9% (C)	0.61	0.49	2.839

1. C-to-C = close-to-close returns
   C-to-O = close-to-open (non-trading time) returns
   O-to-C = open-to-close (trading time) returns.
2. *, **, *** indicate significance at the 1%, 5% and 10% levels respectively.

Briefly, the null of equality in the distribution of returns for all long-maturity positions, both cash and futures, can be rejected at greater than the 5 per cent significance level. There is clearly a pronounced pattern in returns across the days of the week associated with these investments. All contracts exhibit strong and significantly negative Monday mean returns, although the effect is more strongly negative for the Irish positions. These results are consistent with findings of Gibbons and Hess (1981) and Flannery and Protopapadakis (1988) for the cash market,

and of Chiang and Tapley (1983) and Johnson et al. (1991) for interest rate futures. Overall seasonal effects are roughly similar for cash and futures markets, the main distinguishing feature being the positive mid-week return in both Irish markets on a Wednesday, which occurs on a Thursday for the UK cash and futures positions. There is no evidence of a returns pattern for the IFOX Short Gilt future or its associated spot investment. However this future has only traded since 6 September 1990. Some seasonal effects may emerge in the future, although the results of this early analysis suggest that the distribution of daily mean returns of the IFOX Short Gilt future is in fact equal.

TRADING RULES AND SEASONALITY

If prices rapidly and completely reflect all available information, and price movements occur only in response to unexpected 'news', one would expect security returns to be random and the distribution of returns across days of the week to be equal. This is consistent with efficient markets. The important question for investors is the extent to which any anomalous price behaviour (if it exists) can be translated into improved portfolio performance. If seasonal effects exist and are persistent over time, can trading rules be designed to exploit those patterns whose implementation costs are not prohibitive? In futures trading relatively low transactions costs, both commission and execution, facilitate profitable arbitrage for less pronounced pricing regularities than those required in the spot/cash market. This study indicates significant seasonalities in the pattern of returns. Market participants could have taken a long position in IFOX or LIFFE Long Gilt futures on Mondays when prices are low, and closed out that position by selling on Wednesday (Thursday) for the IFOX (LIFFE) futures. As the long side to futures trade profits when prices rise, this strategy would have yielded certain profits over the period of this study. Similar trading patterns potentially apply for the long-dated cash gilts and for the DIBOR and LIBOR futures. With regard to the DIBOR future, they would be bought on Friday evenings when prices are low and sold after Monday's positive return whereas LIBOR futures would be short sold on Thursday and that position closed out on Fridays. Trading rules appear inappropriate for IFOX Short Gilt futures or short-dated gilts in the sense that no statistically significant pattern in returns is evident. For all other contracts, however, if someone was going to trade anyway, it would make sense to

time trades, i.e., either to accelerate or delay trading to take advantage of the pattern of daily returns. For the spot market, an estimate of brokerage fees of approximately 2 per cent is not unreasonable, so that arbitrage-induced round-trip costs would more than offset any abnormal returns associated with the seasonal effects. It may be that timing trades *which will occur anyway* is the only beneficial strategy, given the distribution of returns. However, for the futures market, trading strategies would appear to be feasible. Until a sufficiently long period has elapsed to undertake a lengthy time series analysis of both futures markets, and IFOX in particular, it is impossible to say whether the observed seasonal effects are persistent over time, or whether they will gradually disappear as has been the case in other markets.

CONCLUSIONS

In recent years, international evidence of anomalous price behaviour in stock, fixed-income and futures markets has been identified. Evidence supports an unequal distribution of returns across days of the week and hours of the trading day, and is inconsistent with the predictions of the Efficient Markets Hypothesis that no one can earn abnormal profits other than by chance. The findings of this study are consistent with such international evidence, and are briefly summarised as follows:

1. The pattern of daily returns for the IFOX Short Gilt future and the Irish 9 per cent gilt (1996) reveals no significant day of the week effect, and is thus consistent with the EMH.

2. The DIBOR future exhibits a significantly positive (negative) Monday (Friday) mean return for the close-to-close period but these seasonal effects seem not to be a feature of the underlying DIBOR cash market.

3. The LIBOR future results display a strongly positive Thursday effect, which is significant at the 1 per cent level. A difference of means test shows that this effect is mainly concentrated in the non-trading period when the market is closed. In contrast to the Irish market, this pattern of returns is also a feature of the UK cash market.

4. The pattern of significantly negative Monday returns with a high midweek return which has been documented for stock markets

around the world, is evident for both the IFOX Long Gilt future, and for fixed-income securities which could have been delivered against this future. Because of limitations in the data, it was not possible to ascertain whether this effect is manifested in trading-time or non-trading time.

5. A similar pattern existed for the LIFFE Long Gilt future and for the market in the long-dated gilts underlying it, over the period of this study. However, the positive and significant midweek return occurs on Thursdays in the UK market, and is concentrated in the trading-time period for LIFFE Long Gilt futures.

This evidence in support of the hypothesis of an unequal distribution of returns across the days of the week and in the case of the LIFFE futures across hours of the day, is inconsistent with, and calls seriously into question, the EMH in the context of today's financial environment. In the Irish context, Donnelly (1991) suggests that thin-trading in Dublin could cause returns on the *Irish Times* Cara Index to lag behind those of the UK market, although this suggestion is not statistically examined. It is true that thin-trading is a characteristic feature of the Irish Stock Exchange and that annual turnover has never exceeded IR£6 billion. However, the importance of the Irish gilt market is undisputed. Annual turnover of approximately IR£90 billion is common and the two Irish gilts examined in this study are the most extensively traded of the medium- to long-dated gilts in issue. The volume of trade in the IFOX interest rate futures mirrors the importance of the cash gilts market, as these futures are frequently traded for speculative and hedging purposes. Consequently, it is considered that the thin-trading argument provides an inappropriate explanation of the seasonal effects in the Irish market evidenced in this study. Nor can the argument that returns in the Irish market lag those of the UK market adequately or completely explain the Irish pricing regularities. The strongly negative and significant Monday return, which is a feature of trading in LIFFE Long Gilt futures and their underlying securities also occurs on Mondays in the corresponding Irish market, and the positive midweek effect occurs a day earlier in the Irish experience. Visually, there appears to be a *tentative* two-day lag in the pattern of DIBOR future returns *vis-à-vis* LIBOR future returns, but there is no statistical evidence to support this,[7] and no similar pattern in returns is evident for the corresponding cash markets. Had this study's findings of seasonal effects been

established solely for the futures market, the study findings of a day of the week effect in futures trading would have been easier to interpret as arising possibly from characteristics of trading in the spot market. This was not the case.

The results of this study point conclusively to the existence of pricing regularities in both the Irish and UK markets for fixed-income securities and related futures contracts. In futures markets in particular, where transactions costs are low relative to other markets, these findings are of considerable interest. In light of the principal study findings, it seems clear that profitable trading strategies could have been enacted over the period examined, which would have yielded abnormal profits over and above the normal market return.

NOTES

1 Source: *Into the Future*, London International Financial Futures Exchange, 1992.

2 The KW statistic is approximately distributed as a chi-square with n-1 degrees of freedom, where n is the number of populations being compared. It has been shown that for 10 per cent significance or less, the true significance level is smaller than that given by the chi-square distribution.

3 The official opening futures prices quoted by the Irish Exchange are the actual settlement prices for the previous day. Consequently, it was not possible to calculate close-to-open or open-to-close returns for the IFOX futures. The analysis is therefore confined to daily close-to-close returns for these contracts.

4 There is no Short Gilt Futures Contract traded on the London Exchange to date.

5 The period over which price data for the Short Gilt Futures Contract was collected was 6 September 1990 to 31 December 1992. For comparative purposes, price data for the 9% 1996 gilt, which is deliverable against the Short Gilt Futures Contract, was collected for the same period.

6 For the LIBOR future close-to-open returns, the KW test statistic indicates that the null of equality cannot be rejected even at the 10 per cent level, although both the F_4 and F_5 statistics are significant at the 1 per cent level. However, the MOOD statistic reconciles the

parametric and non-parametric results. MOOD is a non-parametric alternative to ANOVA which is more robust and reliable than the Kruskal-Wallis test when there are outliers/extreme values in the data set. Sometimes called a median or sign scores test for the one-way layout, MOOD tests H_0 : *population medians are all equal* against H_1: *medians are not all equal.* For the LIFFE LIBOR close-to-close returns, the MOOD test was deemed more appropriate as it is more robust than the KW against outliers.

7 Following Donnelly (1991), dummy variable regressions, which adjust for the influence of the previous day's LIBOR return and the return two days previously, were undertaken to test the hypothesis that the DIBOR returns lag those of the UK market. These showed that when the influence of the LIBOR is taken into account, there is no noticeable effect on the pattern of DIBOR daily returns.

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