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Pricing Efficiency of the 3-Month KLIBOR Futures Contracts: An Empirical Analysis.

Marina Abdul Razak*

Obiyathulla Ismath Bacha**

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Dept of Business Administration,
Faculty of Economics and Management Sciences
International Islamic University, Malaysia
obiya@iiu.edu.my

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*Candidate for MBA **Corresponding Author

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Abstract

This study is an empirical investigation of the pricing efficiency of Malaysia's Interest Rate Futures contract, the 3 month KLIBOR futures contract. The paper also examines several issues related to pricing efficiency. The study spans the contract's entire 10 year history, June 1996 to June 2006. In line with findings in other markets, we find a preponderance of overpricing. Almost 80% of the mispricing constituted overpricing of the futures contract. Mean overpricing was 8 basis points. Our results lend support to the hypothesis that there may be a "Futures Habitat Premium". Underpricing, though less frequent was of a larger magnitude and had higher volatility. Even after adjusting for brokerage costs, most of the price deviations were arbitrageble. Analysis of the impact of switch in Central Bank target policy rate, away from the underlying asset of the futures contract, showed higher pricing deviation post switch. Our examination of the interest rate announcement effect, showed the spot market to be more responsive and faster in reaction than the futures market. The magnitude of reaction to rate cuts appears to be different at different interest rate levels.

Section 1: Introduction

Since the introduction of the Treasury bill futures contract by the Chicago Mercantile Exchange (CME) in 1976, interest rate derivatives, in particular Interest Rate Futures (IRF) contracts have been hugely popular. Over the 5 year period 2000 to 2005 global traded volume of interest rate derivatives had grown by about 150% or an annual growth rate approximating 30%[1]. Even this impressive growth rates pale when compared to growth in the first 25 years of their introduction (1976-2000). The popularity of interest rate derivatives is obviously rooted in interest rate volatility. As Keynes famously stated, *uncertainty leads to the requirement of risk transfer*[2]. Globally speaking, interest rate volatility has obviously been higher over the last 30 years than any previous period. Though there are several reasons for this increased volatility, three often cited ones are (i) inflation uncertainty, (ii) the collapse of the Bretton Woods Systems and (iii) the movement away from the Keynesian school to the supply-side/monetarist philosophy in macro policy making. Each of these three developments had significant effects on rate movements. Since nominal rates are dependent on inflation rates, inflation uncertainty increases nominal interest rate uncertainty. The collapse of the Bretton Woods system has meant that most of the world's currencies are on some form of floating or managed float system. Since domestic interest rate constitute a very important lever for central banks in influencing exchange rates, exchange rate requirements have often dictated interest rate movements, thereby increasing the volatility of interest rates. The philosophical switch from the Keynesian school to the supply side/monetarist school has also contributed to increased rate volatility. This has to do with the fact that while the Keynesian prescription of monetary policy would be to keep (target) interest rate and allow money supply to fluctuate, the monetarists proscribe the opposite. As the monetarist school gained prominence, it became fashionable to target the money supply and allow rates to fluctuate.

[1] Futures Industry Association; www.futuresindustry.org
[2] See Cornel (1981)

Aside from the above three factors and the resultant increase in interest rates, the popularity of interest rate derivatives also has to do with the fact that unlike other derivative categories like equities or currencies that have exposure specific potential users, interest rate derivatives have a much broader constituency since interest rate exposure is applicable to just about all business that are either net savers or borrowers.

While IRF contracts have been very successful in the US and other developed markets, their performance in the few Asian markets that have introduced them have been mixed. This, perhaps being a reflection of the tightly controlled interest rate regime characteristic of emerging markets.

This paper undertakes an empirical examination of the 3 month KLIBOR futures contract which is Malaysia's oldest interest rate futures contract. The underlying asset for this contract is the spot 3 month interbank rate, KLIBOR (Kuala Lumpur Interbank Offer Rate). Introduced in May 1996 on the then Malaysian Monetary Exchange (MME), the contract has had fairly good though patchy liquidity. Compared to some of the more recently introduced IRFs[3], the 3 month KLIBOR futures have had much better performance. Total volume and open interest have averaged close to 20,000 and 25,000 contracts per month respectively over the one year period to June 06.

1.1: Motivation/Justification

This paper undertakes a comprehensive study of several key issues related to the trading of the 3 month KLIBOR futures contract. The study covers the 10 year period June 1996 to June 2006. Aside from the fact that there is a dearth of studies on IRF contracts traded in emerging markets, there are several reasons why this contract is interesting. The Malaysian interest rate environment is unique in many ways. Though interest rates are

[3] MGS (Malaysian Government Securities) Future Contracts of 3, 5 and 10 years maturity were introduced in 2003.

supposedly "controlled" by the Malaysian Central Bank, Bank Negara Malaysia (BNM), the first ten years of this contract has witnessed vastly different interest rate regimes. Mostly the result of extraneous 'shocks' beyond the control of BNM. The first and most obvious externally induced shock was the speculative attack on the Malaysian Ringgit and the subsequent currency crisis from mid 97 to 98. As was the case with other Asian central banks, BNM in preserving its foreign reserves had resorted to using the interest rate lever. Short term interest rates increased substantially as part of the currency's defense. Overnight rates increased several fold. While such rate hikes may have brought relief to the currency, the substantial increases began to hurt interest sensitive sectors, in particular the banking system. Faced with rapid increases in NPL (non-performing loans) and a seriously weakened banking system, the Malaysian government adopted what came to be called "unorthodox" policies i.e. capital controls. This imposition of capital control, the key feature of which was a one year moratorium on capital outflows and pegging of the currency, made Malaysia's response unique relative to other Asian crisis countries. These unorthodox policy responses resulted in very interesting rate dynamics. Interest rates, especially short-term ones that had increased substantially during the speculative attack, reversed coursed and started to fall sharply with the imposition of capital controls. Though the Ringgit was pegged to the US dollar and covered interest arbitrage would have required Malaysian interest rates to be in line with the US rates, the control of capital made it possible for BNM to sharply reduce interest rates and provide relief to the domestic banking system without endangering the currency peg. Capital controls ensured that neither covered nor uncovered interest arbitrage was possible.

In addition to the interesting dynamics in Malaysian interest rates that these policy responses entailed, the 10 year period of this study also witnessed the switch in BNM's interest rate intervention tool. Where previously the central bank had used the 3 month

KLIBOR as the target for its policy implementation or *intervention rate,* effective April 2004, the BNM uses what is known as the *Overnight Policy Rate* (OPR). Now that the instrument of policy is no more the underlying asset of the IRF contract, the hedging effectiveness of the futures contract ought to be seriously impaired.

The issues outlined above make a study of the Malaysian IRF contract relevant and worthy. This then is the motivation for the study. We examine four broad issues related to the 3 month KLIBOR futures contract. First, we examine the pricing efficiency of the contract. Second, we examine if and how profitable arbitrage would have been when mispricing was found. Third, we examine the impact of currency crisis on pricing efficiency. Finally, we examine the impact on both the IRF and the underlying spot asset of BNM's interest rate policy announcement.

1.2: Overview of 3-month KLIBOR Futures Contract

The trading of 3-month KLIBOR futures contract began on 28 May 1996 as the first Malaysian exchange-traded interest rate derivative on the Malaysian Monetary Exchange (MME). It was also the only Ringgit interest rate futures contract traded in the world. Following a series of mergers, MME has since 2003 become part of Malaysia's only derivatives exchange, Bursa Malaysia Derivatives Bhd. This derivatives exchange is a wholly owned subsidiary of Bursa Malaysia, Malaysia's only stock- exchange.

The contract represents a three-month Ringgit interbank time deposit in the Kuala Lumpur wholesale money market. KLIBOR being the *Kuala Lumpur Inter Bank Offer Rate*. It is cash settled and has a contract size of RM1 million. Tenor is of a three month maturity on a 360-day year and is quoted in index terms (100.00 minus annual percentage yield to two decimal places). The minimum price fluctuation (tick size) is one basis point or 0.01 percent which is equivalent to RM25 per contract (RM1 million x 3/12 x one basis point). The

contract months are two serial months and the quarterly cycle months of March, June, September, and December, up to 5 years ahead. The final trading day falls on the 3rd Wednesday of the delivery month.

Table 1 below provides the total annual and average daily trading volume for 3 months KLIBOR futures contract. It is clear from the table that following a respectable beginning in 1996, volume increased in 1997 but fell sharply in 1998 and 1999. The Malaysian economy was in the throes of the currency crisis.

Table 1: Traded Volume of 3-month KLIBOR Futures Contract

Year	Total Trading Volume	Average Daily Trading Volume
1996*	40,933	273
1997	76,384	309
1998	24,738	101
1999	28,994	117
2000	44,812	184
2001	54,914	223
2002	64,307	259
2003	119,659	486
2004	141,969	572
2005	162,592	658
2006**	132,865	1,098

Note: * denotes data under observation from 28 May 1996 to December 1996. ** denotes data under observation from January 2006 to June 2006.

Ironically, through volume was lowest in these two years, these were also the period of extreme interest rate volatility induced by the currency crisis. Following economic stabilization and recovery in 2000, volume has shown a slow but steady recovery. While volume growth has increased steadily over the last six years, most of that volume is in the nearby contract. The next to nearby contract has very thin trading with periods of zero trading. The distant contracts though listed, have almost no activity. Thus, with the exception of the nearby contract which has active trading later contracts are illiquid. Still, the exchange provides a settlement price at the end of each day.

While a single trade may change the settlement price of these distant contracts most days the settlement price is determined by averaging the last bid and offer prices. So a quoted price for a distant contract, though changing, may not be a price at which a transaction was done, simply the average of bid and offer prices. Given this problem with illiquidity, our study is restricted to only the nearby contracts of quarterly maturity. Thus, for the 10 year period of our study, we examine a total of 40 contracts (four quarterly contracts per year).

While we are aware of one previous study on the 3 month KLIBOR futures contract[4], we are not aware of any previous published paper on this Malaysian contract. This paper differs from the previous study in several ways. The methodology used, coverage of issues, duration of study and scope are all broader/ different here. The paper is divided into five parts. Section 2 below reviews previous literature relevant to this study. The following section, section 3 presents our research questions, data and methodology. Section 4 presents our results and analysis while section 5 concludes.

[4] Taufik, et al (2006), 17th AFA Conference Proceedings.

Section 2: Review of Literature

In this section we examine previous research relevant to the issues at hand. Recall that we propose to examine three broad issues, pricing efficiency of the 3month KLIBOR futures contract, extent of arbitrage opportunity, the impact of the central bank switch of target rate on efficiency and the announcement effect. Given this objective, we examine previous work on pricing efficiency, arbitrage and convergence of interest rate futures prices.

2.1: Pricing, Arbitrage and Convergence

There appears to be two competing arbitrage based models of pricing interest rate futures contracts. The first is the cost of carry model, the generalized form of which is used in pricing commodity and equity futures contracts. The second model, the *Unbiased Expectations Hypothesis* (UEH) is essentially based on the logic that an interest rate futures contract should have a yield that reflects yield expectations impounded in the cash market yield curve. Thus in pricing a 3month futures contract one would use the quoted 3 and 6 month spot yield to compute the implied yield. In using the UEH, the implied yield which will determine the correct price of a 3month KLIBOR futures contract, would be computed based on the following assumptions[5]:

i. There are m- and n-day KLIBOR time deposit ($m < n$) with a face value of RM1 million traded in the cash market;

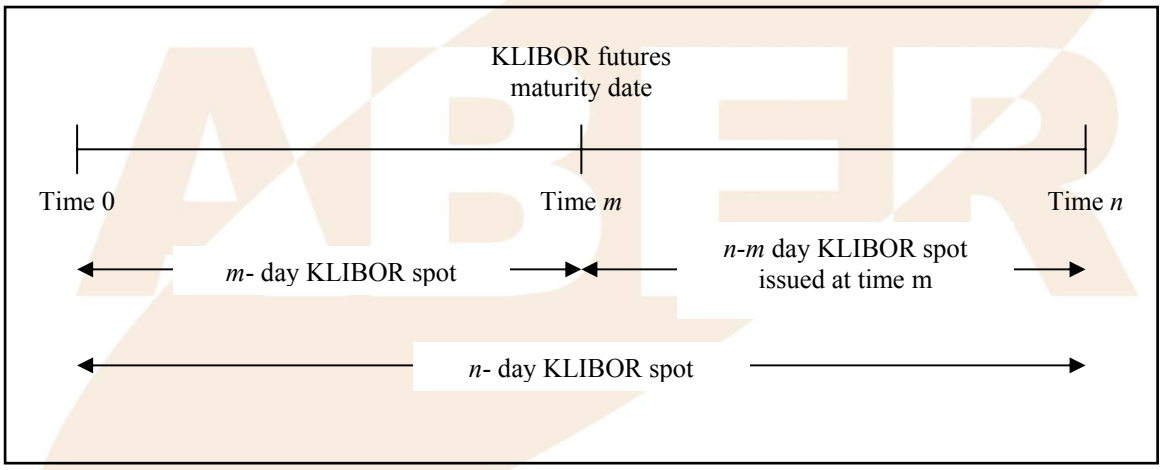
ii. A KLIBOR futures contract with a maturity date of m is available in the futures market. This contract is based on any $n - m$ day KLIBOR time deposit with a face value of RM1 million and a maturity date of n;

iii. KLIBOR time deposit (spot) and KLIBOR futures are divisible.

[5] Poskitt (1998) states that there is one limitation in this analysis i.e. futures contract is treated as a forward contract with daily settlement-to market feature of a futures contract is ignored. He argued that the limitation is justified since the expected path of futures yield is unknown and the present value of the daily settlement-to market cash flows could not be determined. Thus, it is impossible to know if the futures contract should trade at a discount or premium to an equivalent forward contract.

The quoted yield for interest rate futures contract at time 0 is the rate of borrowing or lending beginning on the maturity day of futures contract. Based on the pricing model, the 3-month KLIBOR futures yield at time 0 implies the 3-month KLIBOR expected to prevail at time *m*. In order to determine the correct pricing of the futures contract with a maturity date of *m*, it is vital to know the expected yield of 3-month KLIBOR at time *m.* The expected three month rate at time *m* could be determined by calculating the implied forward rate (IFR) given the two KLIBOR rates i.e. rates of *m*-day (60-day) and *n*-day (180-day) KLIBOR at time 0. The IFR represents the implied rate of *n* – *m* day KLIBOR at time *m*. this relationship is illustrated in Figure 1.

Figure 1: Relationship of Cash Market Yield to Theoretical Yield of 3-month KLIBOR Futures Contract



Based on this model, the theoretical price of the derivative contract at time 0, $P\left(r^{r}_{0,n-m}\right)$ should equal:

$$P\left(r^{r}_{0,n-m}\right)=\frac{P\left(r_{0,n}\right)}{P\left(r_{0,m}\right)} \qquad (1)$$

where $P\left(r_{0,n}\right)$ is the price on the *n* day KLIBOR at time 0 at $r_{0,n}$ cash yield and $P(r_{0,m})$ is the price of the *m* day KLIBOR at time 0 at $r_{0,m}$ cash yield. Thus, the above relationship could be translated into the following equation in finding the theoretical price of interest rate futures contract:

$$r^{f}_{0,n-m} = \left[\frac{1+\left(r_{0,n} \times \frac{n}{360} \right)}{1+\left(r_{0,m} \times \frac{m}{360} \right)} - 1 \right] \times \frac{360}{n-m} \qquad (2)$$

Arbitrageurs would be able to make a profit when the futures price deviates from its theoretical price (given the magnitude of deviation is large enough to cover transaction costs).

Note that the implied yield, derived from Equation 2 is often known as the *Implied Forward Rate (IFR).* While the IFR would be appropriate for a forward rather than a futures contract, several previous studies, notably, Kawaller and Koch (1984), Hegde and Branch (1985), and Poskitt (1998, 2002) argue that the forward-futures differential is negligible and non arbitrageable. Cox et al. (1981) argue that prices of otherwise equivalent futures and forward contracts will be identical if interest rates are non stochastic.

2.1.1: The Cost of Carry Model

The Cost of Carry (COC) model, first propounded by Working (1949)[6], argues that an arbitrage opportunity would arise if the spot price of a commodity, its time adjusted cost of storage and financing cost is not equal to its futures price. Since financial derivatives have no physical underlying, the carrying cost is essentially the financing cost, i.e. financing margins. Since such costs would be minimal for short dated instruments, many researchers have shown that the COC model would generate the same theoretical yield as the UEH model when the short term yield of the spot market is used as financing cost[7]. Thus, Poskitt (1998) modifies Equation 2 above to calculate the theoretical price of an IRF contract using the COC model.

[6] See Poskitt (1998).
[7] Poskitt (1998) used overnight rate of cash market as short term yield in measuring marginal costs of funds. Kawaller and Koch (1984) used repurchase rate as measurement of finance cost since repurchase agreement is largely used in raising short-term funds in US market.

$$r^{f}_{0,n-m} = \left[\frac{1 + \left(r_{0,n} \times \frac{n}{360} \right)}{\left(1 + r_{0/n}/360\right)^{m}} - 1 \right] \times \frac{360}{n-m} \qquad (3)$$

where $r_{o/n}$ is the overnight rate of cash market and this rate is converted to a daily rate and compounded for *m* days to obtain the *m*-day rate.

2.2: Evidence of Pricing Efficiency

The first paper to examine the pricing efficiency of an IRF contract was probably that of Rendlemen and Carabini (1979) who studied the Treasury bill futures contract traded on the International Monetary Market of the CME. They find that in the absence of transaction cost, the nearby futures contracts have been overpriced while longer-term futures contracts have been underpriced[8]. Overall, there appears to be a tendency for the market to become less efficient over time. Furthermore, the standard deviation of the mispricing of the nearby contracts increases monotonously over time. After considering differential transactions costs' impact, they suggest that many quasi-arbitrage opportunities existed in the Treasury bill futures market[9]. They however show that the inefficiencies are not large enough to attract short term portfolio manager in exploiting the opportunities. In addition, they found no pure arbitrage opportunities available in The Treasury bill futures market which signifies a highly efficient market with regard to pure arbitrage opportunities. So, while price inefficiency and arbitrage opportunities did exist, transaction costs make it unprofitable for pure arbitrage but profitable for quasi-arbitrage.

[8] Overpricing occurs when quoted futures price exceeds theoretical price and its matching arbitrage strategy is cash and carry arbitrage strategy. Underpricing occurs when theoretical price exceeds quoted futures price and its matching arbitrage strategy is reverse cash and carry arbitrage strategy.

[9] For Rendlemen and Carabini (1979) quasi-arbitrage opportunity involves selling of securities from an existing portfolio and the extent of mispricing allows trader to earn a profit in excess of low transaction cost. In contrast, pure arbitrage opportunity involves short selling in the spot market and the extent of mispricing allows trader to earn a profit in excess of all transaction cost. Elton et al. (1984) argued that unlike closing prices, high frequency data could capture profit from intraday trades. Since simultaneous transactions could not occur at the same time, intraday prices enable to provide a realistic assumption at what price the trade is taken place. Thus, they found the market is not perfectly efficient for pure arbitrage strategy.

That pure arbitrage would not be profitable with Treasury bill futures is confirmed by Kawaller & Koch (1984) who find that when overnight Repo (RP) rates are in the Cost of Carry model to price the futures, the nearby futures contracts are price efficient. In contrast to these results, Elton, Gruber & Rentgler (2001), using intraday data, find that the T-bill futures market is not *perfectly efficient*. They find that a strategy of buying the cash T-bill or pseudo T-bill and shorting the futures would have earned returns larger than transaction costs. Thus, they show that pure arbitrage is possible. While they do not test for pricing efficiency, the fact that a short futures, long cash strategy can lead to pure arbitrage profit implies that the nearby futures contract must be overpriced.

Hegde & Branch (1985) also find nearby T-bill futures contracts to be overpriced relative to the implied forward rate. Furthermore, they find the magnitude of overpricing to be about twice that of underpricing. However, the variability of over pricing is about half that of underpricing. As contract maturity approaches, the overpricing tends to decline while the variability increases. A finding in line with the Samuelson hypothesis. They report that mispricing of the nearby contract worsened substantially following the October 1979 Federal Reserves switch in monetary policy from targeting interest rates to targeting the money supply. With this policy switch the magnitude of overpricing had more than doubled while that of underpricing had increased five times. Prior to October 1979, overpricing of nearby contracts was insufficient for pure arbitrage but allowed quasi-arbitrage. Post October 1979 however, they found that the number of pure arbitrage opportunities had increased markedly. The authors argue that since the overpricing is too large to be explained by margin costs, taxation, risk premium, or other costs, the futures premium may be attributable to what is known as the "futures habitat premium".

Poskitt (1998) examines bill futures contracts traded in New Zealand. In addition to examining the pricing efficiency of these contracts, he tests the appropriateness of both the

UEH (IFR) and COC pricing models. He finds the UEH (IFR) model to be more accurate than the COC models in predicting actual bill futures yield. As for mispricing, consistent with other previous studies, he found the nearby futures to be overpriced and the mean mispricing to narrow as the contract nears maturity. In a subsequent study, Poskitt (2002) which uses intraday data, he confirms the overpricing of the nearby contract. However, this overpricing was only sufficient to allow quasi not pure arbitrage.

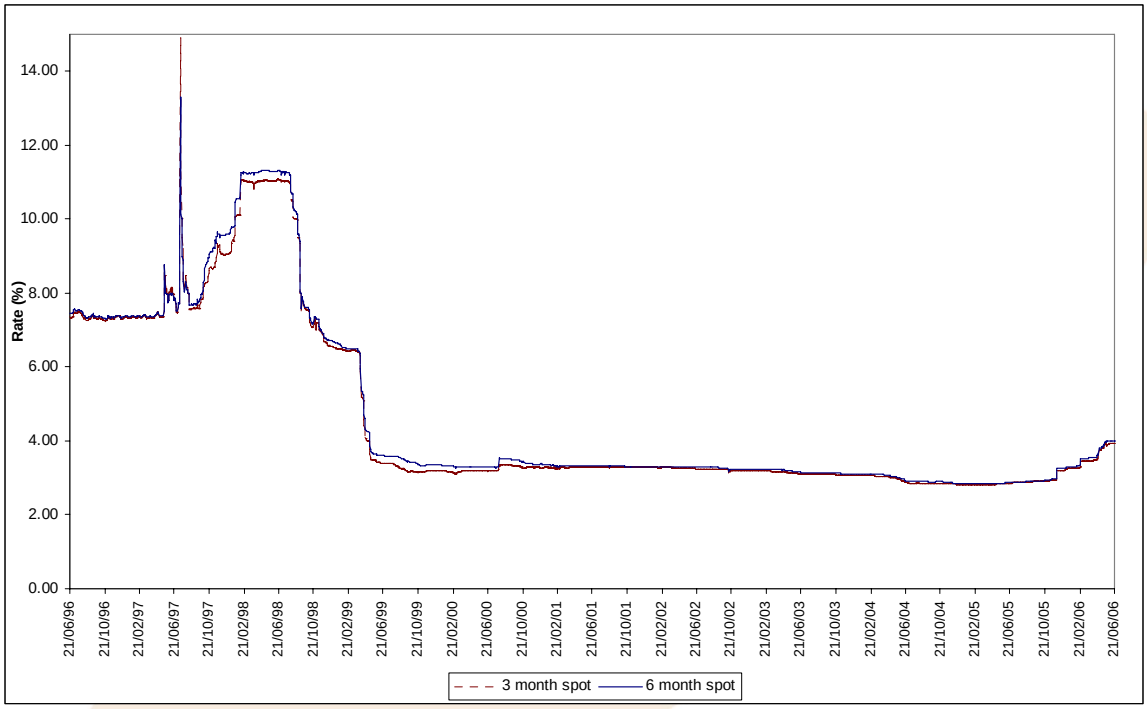
The sole previous study of 3month KLIBOR futures contracts by Taufiq et al. (2006) examined pricing efficiency. They examined 8 quarterly month contracts over the 7 year period, June 1996 to 2003. In pricing the futures contracts, they determine IFR by extrapolating short-term rates via bootstrapping to determine 6 month rates. The bootstrapped rates are used in determining the IFR and thereby the futures price. They examine the behavior of nearby and distant contracts. They report that the nearby contracts were overpriced while the distant ones underpriced. The mispricing tended to decline as the contract approached maturity. Since the first 4 of the 8 contracts they examined had lower mispricing, they conclude that hedging effectiveness has reduced.

Convergence is an important criteria of pricing efficiency of a futures contract. If the underlying asset of a spot and futures contract is the same, convergence implies that the futures price at maturity must equal the spot price on that day. Non convergence would give rise to riskless arbitrage. Samuelson (1965) stated that as the futures contract approaches time to maturity, the volatility of futures price change increases and converges with spot price on maturity. Volatility increases as the futures contract approaches maturity due to increase in level of sensitivity towards information of the commodity as the contract nears maturity. He further suggested that futures price is the expected spot price at maturity based on the assumption that market competition forces spot and futures prices to converge at maturity. Thus, arbitraging activities force the futures price to converge with the spot price maturity.

Section 3: Data and Methodology

Malaysia's interest rate environment though highly regimented, has witnessed some interesting dynamics during the 10 year period of this study. Figure 2 below shows the movements in 3 month and 6 month KLIBOR rates.

Figure 2: Daily 3- and 6-month KLIBOR Spot Behavior from 21 June 1996 to 21 June 2006



Both are interbank spot rates. Though several other tenors are transacted in the interbank market, some 80% of instruments traded are of 3 month of tenor. As such most interbank market participants would be exposed to movements in 3 month rate. This appears to have been the justification for the 3 month tenor of the futures contract.

The onset of East Asian currency crisis in mid 1997 led to sharp increases in both the 3 and 6 month rate. In July 1997 both rates almost doubled from where they were in early 1997. Rates fell back temporarily the following month but were forced up again as the crisis worsened. Rates rose steadily until early 1998 and remained at slightly more than 11% for the next 6 months. These were very high rates by Malaysian standards. On 1st September 1998,

the Malaysian government announced a package of initiatives aimed at ameliorating the situation. This involved three key strategies, imposition of capital controls on short-term portfolio flows, a one year moratorium on capital outflows and the pegging of the Malaysian Ringgit to the US dollar at RM3.80. With the capital controls in place, the Central bank was in a position to cut rates. As Figure 2, shows, a series of interest rate cuts were undertaken from September 1998. Rates kept falling until the 3 month KLIBOR leveled off at about 3% annualized. Despite the peg of the Ringgit to the US dollar, the capital controls enabled the Malaysian Central bank to cut rates and maintain a negative spread against US interest rates. The capital control effectively prevented covered or uncovered interest arbitrage from forcing rate convergence with the US[10]. It is obvious that these dynamics would have significance impact on the pricing efficiency of the IRF contract.

3.1: Description of Data and Methodology

Recall that our main objective is to examine pricing efficiency and related issues over the first 10 years of the IRF contract's life. Within the context of these, we examine the impact of the currency crisis and the Central bank's switch in the target interest rate, on pricing efficiency. Finally, we examine the effect of Central bank announcement on interest rate on both the IRF and 3 month KLIBOR spot. Thus, we address a total of 5 research questions. These are as follows:

i. How efficiently is the 3 month IRF priced and how has pricing efficiency evolved?
ii. How profitable would arbitrage strategies be if there is mispricing?
iii. What was the impact of the currency crisis on the pricing efficiency of the 3 month IRF contract?

[10] The rate cuts undertaken by the Fed following the September 11 attacks helped to narrow the otherwise negative spreads.

iv. What is the impact of Bank Negara's switch in the target policy rate from the 3 month KLIBOR rate to the Overnight Policy Rate (OPR)?

v. What is the effect of Central bank interest rate announcements on the price of the IRF contract and the underlying 3 month spot rate?

Given the above five questions, our research design in addressing each of the questions is as follows: We examine pricing efficiency by first computing the theoretical price. For this we follow Poskitt (1998, 2002) who found the UEH or IFR to be more accurate than COC model. We compute the IFR on daily basis using daily quotations of the 3 and 6 month KLIBOR spot rates. The IFR is computed as;

$$r_t^{IFR} = \left[\frac{1 + \left(r_{t,n}^s \times n/360 \right)}{1 + \left(r_{t,m}^s \times m/360 \right)} - 1 \right] \times \frac{360}{90} \qquad (4)$$

where $r_{t,m}^s$ and $r_{t,n}^s$ are the time t rate quote on m- and n-day KLIBOR while m and n are the time t tenor on m- and n-day KLIBOR respectively.

3.1.1 Assessing Extent of Mispricing and Arbitrage Opportunities

When the quoted futures price deviates from its IFR, arbitrage opportunity exists. In other words, if mispricing exists, arbitrage opportunity also exists. Thus, the formula for extent of mispricing replicated from Poskitt's study can be computed as:

$$r_{Diff,t} = r_t^f - r_t^{IFR} \qquad (5)$$

where r_t^f is the futures yield (i.e. 100 – quoted price) at time t and r_t^{IFR} is the IFR at time t.

Rendlemen and Carabini (1979) assumed that when buyers and sellers face the same amount of transaction cost, they will likely to trade near the no-transaction cost value of index. This is approximately the mid-point of the no-arbitrage range. Hegde and Branch (1985) defined zero trading costs as the minimal trading cost faced by market participants.

Thus, this study follows the stated assumptions in analysing availability of arbitrage opportunities provided by 3-month KLIBOR futures contract.

3.1.2 Measuring Profitability Level from Arbitraging Strategies

Arbitraging activity would be profitable only if the profit level exceeds its transaction cost. When the futures contract is overpriced, the matching arbitrage strategy is *cash and carry arbitrage strategy*. When the contract is underpriced, the matching arbitrage strategy is a *reverse cash and carry arbitrage strategy*. The formulas for these strategies are:

$$\Pi_{CC} = \left[\left(p_t^f - p_T^f\right) \times RM\ 25 \times 100\right] + \left[\left(\left(r_{t,n}^s - r_{T,m}^s\right) \times RM\ 1mil\right) \times \left(\frac{90}{360}\right)\right] \quad (6)$$

$$\Pi_{RCC} = \left[\left(p_T^f - p_t^f\right) \times RM\ 25 \times 100\right] + \left[\left(\left(r_{T,m}^s - r_{t,n}^s\right) \times RM\ 1mil\right) \times \left(\frac{90}{360}\right)\right] \quad (7)$$

where Π_{CC} and Π_{RCC} denote profits from cash and carry arbitrage strategy and reverse cash and carry arbitrage strategy respectively. Meanwhile, p_t^f and p_T^f denote futures price at time t and at maturity respectively. $r_{T,m}^s$ and $r_{t,n}^s$ represent cash price of 3-month KLIBOR at maturity and cash price of 6-month KLIBOR at time t.

In constructing the data series, this study calculates arbitrage return for -30 and -60 trading days before maturity of a particular contract month and then switches to the next contract month. A total of 80 samples (40 samples for each particular trading window) are observed in this study.

3.1.3 Analysis of Convergence Property

Since convergence is a key issue in pricing efficiency and arbitrage presumes convergence, we check for the presence of convergence. Convergence exists when futures price equals cash price at maturity:

$$r_T^f = r_T^s \quad (8)$$

where r_T^f and r_T^s denote the futures yield and cash price at maturity.

3.1.4 Evaluating Interest Rate Announcement Effect

In evaluating the impact of Bank Negara's announcement of interest rate changes, we examine the market reaction on the spot 3-month KLIBOR rate and the change in price/yield of the IFR contract. With the exception of one announcement[11] most interest rate announcements are made after the market closes at 6.00 pm. Thus, we examine the reaction in both the spot and IRF using an event-study methodology. Essentially, examining the quotations 5 days before and after the announcement day. We examine whether the direction and magnitude of change in both markets were in line with the rate announcement. Since no records on announcements prior to 1998 were available, we examined a total of 29 announcements between 1998 to June 2006. Of these, 12 were announcements of decrease in rates, 3 were increases and the remainders 14 were announcements that left the rates unchanged.

A similar event-study method is used in analyzing the impact of switch in the policy target rate from 3-month KLIBOR to the overnight policy rate (OPR). We examine two, two year period windows before and after OPR implementation on 26th April 2004. As is evident from Figure 2, the 4 year window period from 25th April 2002 to 25th April 2006 were not periods of significant change in interest rates. Thus, there would be no confounding of other factors. The impact of policy rate switch is examined by testing for statistical difference between the pre and post windows.

[11] The announcement of 3rd September 1998 which was made during trading hours (3.00pm), this was necessitated by the capital controls imposed the prior day.

In the same way, we examine the impact of the currency crisis on both these factors by comparing the 30 month period, March 1997 to September 1999 with the rest of the study period.

As previously mentioned, this study covers the 10 years period June 1996 to June 2006. A total of 40 quarterly contracts are examined. Since we only study the nearby contract and on a daily basis, we switch to a new quarterly contract on the day following the expiration day of the current contract. A total of 2,069 trading days were covered. Data for this study were sourced from BLOOMBERG, the Bank Negara, Bursa Malaysia, and Securities Commission Websites. Daily quotes of the 3 and 6-month KLIBOR were sourced from BLOOMBERG while the daily settlement price of the nearby 3-month KLIBOR futures contract were sourced from Bursa Malaysia. Rate announcements by Bank Negara were sourced from the BNM Website.

Section 4: Results and Analysis

For ease of elucidation, we present and discuss our results in the order of our five research questions. We therefore begin with results of pricing efficiency. Table 2 below presents a summary of our results on pricing efficiency.

TABLE 2: Daily Mispricing for Nearby Contract Based on Terms to Maturity

Based on Rate	***Days to Maturity***			
Difference	***90-61 days***	***60-31 days***	***30-0 days***	***90-0 days***
Panel A				
Sample Size	849	858	902	2,609
Mean	-0.0793	-0.0611	-0.1114	-0.0844
Standard Deviation	0.3433	0.3416	0.1983	0.3012
Mean Absolute	0.1828	0.1765	0.1216	0.1596
Minimum	-4.19	-2.20	-2.21	-4.19
Maximum	1.92	2.13	0.42	2.13
H_0: $r_{Diff} = 0$; t statistics	-6.73 *	-5.24 *	-16.87 *	-14.31 *
Panel B				
Overpriced (days)	591	657	815	2,063
Mean	-0.1881	-0.1552	-0.1287	-0.1541
Standard Deviation	0.2989	0.1942	0.1993	0.2320
Underpriced (days)	235	175	62	472
Mean	0.1864	0.2832	0.0718	0.2072
Standard Deviation	0.3171	0.5286	0.0866	0.3986

NOTE: * denotes statistical significance at 5% level.

Panel A presents the results across all 40 contracts while Panel B segregates according to overpriced and underpriced contracts. There are two points to note in reading the table. First, following Posskitt (1998), we show the breakdown of mispricing for the full 90 days that each contract is studied and 3 window periods of 30 days each. The second point to note is that the *negative mean*, implies that the futures contract is *overvalued.* Essentially, the quoted futures price implies a yield lower than the IFR computed using Equation 4. Thus all overpriced contracts would show a negative mean whereas underpriced ones, positive means.

Overall, across all 40 contracts (2,609 days), we find a mean mispricing of 8.44 basis points. Since the futures yield was lower than that dictated by the COC model, the -8.44 basis

points implies that on average the Malaysian IRF contract is overvalued/overpriced by about 8 basis points. Looking at Panel B, overpriced contracts are on average overvalued by 15.4 basis points whereas mean underpricing for undervalued contracts is 20.7 basis points. While the size of overvaluation maybe smaller (15.4bps vs. 20.7bps), the frequency of overvaluation is almost 4 times that of undervaluation. More than 80% of the contracts are overvalued. Collectively, of the 2,609 days examined, we find mispricing on 2,535 days (2,063 days of overpricing, and 472 days of underpricing) or 97% of the time.

When examining the dynamics of mispricing over a contracts' life, Poskitt (1998) argues that since cases of overpricing offset that of underpricing, the mean absolute differential rather than mean differential is the superior measure. Looking at the mean absolute differential in Panel A, we see an interesting dynamic. Though overall mispricing is almost 16 basis points, we see a steady decline in the measures as a contract approaches maturity. The absolute differential goes from 18.3bps for the 90-61 day window to 12.2bps for the last 30 day window. As for the standard deviation of rate differential, we again see a markedly lower measure for the final 30 days relative to earlier periods. In consonant with theory, the extent of mispricing reduces as maturity is approached. In addition, the deviation in mispricing also reduces. This same pattern of reduced mispricing and volatility of mispricing is also evident for both overpriced and underpriced contracts.

Interestingly, these results are almost identical with previous studies that have examined nearby contracts. Rendlemen & Carabini (1979), Kawaller & Koch (1984), Hegde & Branch (1985), Poskitt (1998 & 2002) have all found IRF contracts to be overpriced and the extent of mispricing reduces as maturity approaches. The first three studies had examined US Treasury bill futures while the last, NZ bank bill futures.

4.1.1: Pricing Efficiency: Convergence

When we examined for convergence at maturity, 36 of our 40 contracts had full convergence. In four cases, convergence did not occur. The four contracts were March and June 98, and March and June 2000. The March 98 contract was undervalued by 7 basis points at maturity while the June 98 contract was overpriced by 4 basis points. We believe this non-convergence had to do with the fact was this was about the worst period of the crisis where interest rates had plateaued at the highest level. While non-convergence during the depth of the crisis was not surprising, the non-convergence of the latter two contracts in 2000 was. Both contracts were overpriced at maturity by 2 basis points. On further investigation, we believe the deviation was probably due to two factors. In January and February of 2000, the central bank had undertaken a massive contraction of liquidity. Though rates were stable, we believe this large monetary policy action probably caused the deviation for the March 2000 contract. By June 2000, the negative interest spreads with the US had caused net outflows[12], this coupled with the massive liquidity had led to an unusual situation. Bank deposit rates had fallen below the 3-month interbank rate, obviously a highly unusual situation. We believe the non-convergence of the June 2000 contract is attributable to these peculiarities.

4.1.2: Pricing Efficiency; Evolution

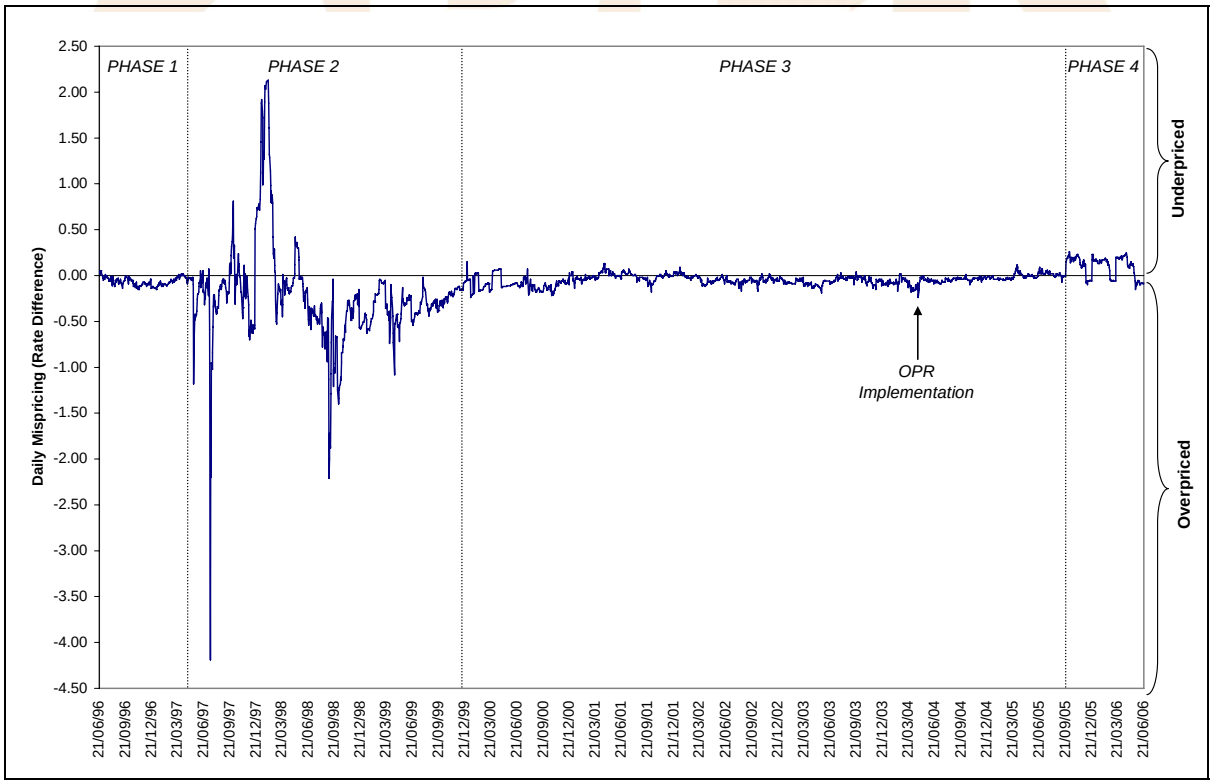
Figure 3 below is a plot of daily mispricing for the 10 year period of study. Note that a positive rate difference implies underpricing which appears above, while a negative rate difference implies overpricing and appears on the downside. The figure confirms the finding in Table 2 about the preponderance of overpricing. Overall, there appear to be four distinct phases: A first phase until May 1997 where mispricing appears minimal followed by an approximately 30 month period until December 1999 which coincides with the currency

[12] Capital controls were in place, but exporters were delaying remitting funds backhome in order to take advantage of higher rates in US.

crisis. This second period has the highest mispricing. Though again mostly overpriced, there are periods of sharp underpricing. The subsequent phase, a period from December 1999 to October 2005 again has minimal mispricing. The final phase October 2005 to June 2006 interestingly is almost consistently underpriced.

It appears that what dictates the pricing dynamics of the IRF is the interest rate movement in the underlying spot market. This is evident from the earlier Figure 2 which plotted the 3 and 6 month KLIBOR spot rates. The four phases seen in Figure 3 is also evident in the earlier Figure 2. The changeover from one phase to another in the mispricing dynamic coincides with a reversal in the interest rate trend. Phase one of lower mispricing in Figure 3, coincides with a period of stable interest rates. The second phase coincides with rate volatility during the crisis. The subsequent period of stable interest rates once again leads to the minimal mispricing in the third phase of Figure 3.

Figure 3: Daily Mispricing of 3-month KLIBOR Futures Contract from 21 June 1996 to 21 June 2006



Finally, the fourth phase of underpriced futures contracts coincides with a period of three interest rate increases[13] in Figure 2. It would appear from this analysis that underlying interest rate volatility more than anything else determines of the extent of mispricing in the IRF contract. It should be pointed out that several previous studies of IRF pricing, report increased mispricing in latter periods. Our results show a similar picture. Mispricing, as we saw, was higher in phase 4 than the prior phase. However, we believe that this has more do to with underlying rate volatility and the change to a rising interest rate regime rather than worsening market inefficiency as such.

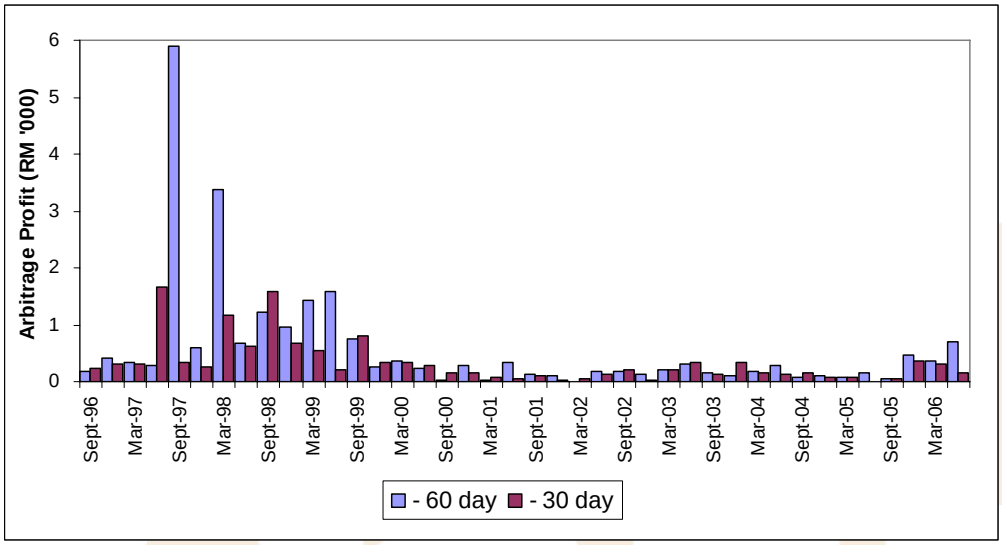
4.2.: Arbitraging the Mispricing

Given that there were periods of quite extensive mispricing, we looked at how profitable arbitrage could be. Figure A.1. in Appendix shows the average daily mispricing for each of our 40 nearby contracts. In deciding on arbitrage strategy, we examine the mispricing on day 30 and day 60 prior to maturity. If the contract is overpriced at that point, we adopt a cash and carry strategy, alternatively, a Reverse Cash and Carry strategy is used if we find underpricing.[14] The assumption is that the arbitrage strategy once implemented is held until contract maturity. Figure 4 shows the arbitrage profit attainable, Table A.1 in Appendix shows the profits when an estimated transaction cost of RM35 is included. Inclusive of transaction costs, 2 contracts in each case (30 or 60 day) would not be profitable. The 38 other contracts give positive profits for the passive arbitrage strategy. Net of transaction cost, the profits range from RM1,640 to RM 15 for the 30 day period and between RM5,865 and RM15 for the 60 day. As expected, the largest profits occur during the period of the currency crisis. Not surprisingly, the pattern of arbitrage profits appears to follow the pattern of

[13] The three increases were in the OPR rate
[14] Cash and Carry would be to short the 3-month KLIBOR futures and long the 6month KLIBOR spot. A Reserve Cash and Carry would be the opposite.

mispricing. The last 3 contracts which showed substantial underpricing in Figure 4 provide substantial arbitrage profits to the reverse cash and carry strategy.

FIGURE 4: Arbitrage Gross Profit for 30- and 60 Trading Days Prior to Maturity



4.3: Impact of Currency Crisis on Pricing Efficiency

Since the period of the currency crisis witnessed sharp reversals in interest rates and the adoption of policies that were not necessarily market friendly, we examined the impact on pricing efficiency of the IRF contract. We analyzed the impact by comparing the 30 month period, March 1997 contract to September 1999 contract with the rest of the study period. Table 3 shows the results of our analysis.

TABLE 3: Relative Mispricing Crisis vs. Non Crisis

Daily Mispricing (Based on Full Window 90 – 0 Days)		
	Period of	
	Crisis	**Non Crisis**
Sample size (days)	715	1.894
Mean Mispricing	-0.2051	-0.0388
Std. deviation	0.5403	0.0853
Mean Absolute Mispricing	0.3898	0.0727
Minimum	-4.19	-0.40
Maximum	2.13	0.26
t-stat: for $H_0 : \mu_1-\mu_2 = 0$		t-stat = -12.98*

Note: Negative mispricing implies that the futures are overpriced. Positive would mean underpriced. * denotes statistical significance at 5% level.

The numbers show a sharp contrast between the two periods. First, IRF contracts were massively overvalued during the crisis. Mean mispricing is more than 5 times higher during crisis (20 bps vs. 3.9 bps), while the standard deviation is more than 6 times that of normal period. The mean absolute mispricing is also larger by the same magnitude as mean mispricing i.e. 5 times higher. The t-statistic for equality of means is rejected. Pricing efficiency was seriously affected during the period of the crisis. Given the evidence in Figure 3, this result is not entirely surprising. Aside from volatility in the underlying interest rate, the policy flip-flops and economic uncertainty of the period probably accounts for the obvious lack of arbitrage that could have reduced the deviation and improved pricing efficiency. Gaps in information and informational asymmetries were serious issues confronting market participants during the crisis.

4.4: Impact of switch in Intervention Policy Rate on Pricing Efficiency

Since the underlying spot of the IRF contract, the 3month KLIBOR was the intervention rate until 26th April 2004, the 3-month KLIBOR futures contract would have been a good instrument in hedging rate exposure. Additionally, as a futures contract directly linked to the target policy rate, liquidity and attention of traders on the IRF contract should

have been high. All this would imply a higher level of pricing efficiency. Thus, when in April 2004, the target policy rate was changed, there ought to have been an impact on the IRF contract's pricing efficiency. To see the extent of this impact, we examined daily mispricing for a 2 year period before and after the switch to the OPR (Overnight Policy Rate). Table 4 shows the results.

TABLE 4: Relative Mispricing Pre/Post OPR Implementation

Daily Mispricing (Based on Full Window 90 – 0 Days)		
	Pre OPR	**Post OPR**
Sample size (days)	562	563
Mean Mispricing	-0.0632	0.0196
Std. deviation	0.0382	0.0926
Mean Absolute Mispricing	0.0646	0.0714
Minimum	-0.24	-0.15
Maximum	0.04	0.26
t-stat: for $H_0 : \mu_1-\mu_2 = 0$	t-stat = -19.6* (Mean Mispricing) t-stat = -2.239* (Mean Abs.Mispricing)	

* denotes statistical significance at 5% level.

Mean daily mispricing goes from being overpriced to underpriced. The mean absolute mispricing is approximately 10% higher. The standard deviation of mean mispricing is more then twice higher post switch to OPR. A t-test of means for mean mispricing and mean absolute mispricing, reject the hypothesis of equality in both cases at 5%. Both mispricing and standard deviation of mispricing in the IRF contract was higher following the change in target policy rate. This is a finding consistent with Hegde & Branch (1985) who find higher level of mispricing and larger arbitrage opportunity for T-bill futures contracts following the FED switch in focus from controlling interest rates to regulating money supply. Interestingly, Hegde & Branch (1985) also report a large increase in the variability of mispricing something congruent to our finding in Table 4 that standard deviation of mispricing increases more than two fold following switch in target policy rate.

While our finding that mispricing is higher, implying lower pricing efficiency post-OPR implementation is intuitive, one must be cognizant of the fact that shortly after OPR

implementation, the rate regime moved from one of rate cutes to rate hikes. So, the direction of rate changes obviously confound our result here.

4.5: Effect of Interest Rate Announcement on Spot and IRF Contract

Official announcement of interest rates and monetary policy stance were begun in 1998.[15] Over our period of study, there were a total of 27 announcements, of these 12 were of rate cuts, 3 of rate hikes and the remainder 12 announcements leaving interest rates unchanged. We examine the 15 announcements that involved a change in interest rates. Our objective is to examine how quickly the spot and futures price adjust, and whether these markets anticipate the rate changes. Most interest rate announcements by the central bank occur after markets close at 6.00 p.m.[16]. We examine a 10 day period around each announcement, that is 5 days before and after.

Tables A. 2A and A. 2B in the Appendix presents our results. The tables show a number of interesting factors. First, once the intervention rate goes below 6.00% reaction to further decreases meet with muted response in both the spot and futures market. For example for the 3 rate cuts before OPR introduction on 23 April 2004, the spot rate fell by 9bps, 1bp and 2 bps even though the intervention rate was cut by 50 basis points in each case . The responses of the futures to these same cuts were only marginally better. This reaction is in sharp contrast to the cuts announced in the early part of the rate cut cycle. For the first cut of July, 31,1998, both markets almost fully adjust to the 50 basis point cut. But for the subsequent three cuts, both the spot and futures fall by more than the announced cut. The cumulative reduction over the 11 days (including day 0) is much more than the announced cut. Panel B of each table shows the reaction to the 3 rate hike announcements. Though this were increases to the OPR not the 3 month KLIBOR rate, the 3 month spot rate responds better

[15] Since July 1998, BNM has publicly announced its interest rate policy.
[16] The exception was Thursday 03/09/98 when the announcement came during trading hours, the announcement a week from the previous announcement.

than earlier when the intervention rate was the 3 month rate. This is puzzling. It appears that rate cuts below the 6.00% rate elicit little response.

In just about all cases, most of the reaction happens of day 1. The last column of the tables show the capture-ratio, simply the ratio to which reaction in day 0 and day +1 capture the magnitude of rate change. For the first 4 cuts, more than 90% of the cut is adjusted for by end of day 1 in the spot market. Below the 6.00% intervention rate these capture ratio fall significantly but rise again in the period of rising rates. The two day capture ratio for the futures shows a similar but is smaller. This points to another interesting factor, the spot market appears to be more responsive and reacts faster than the futures!

Finally, we examine the cumulative change in yield in the respective markets prior to announcement (days -5 to -1), this change would give an indication of the markets ability to anticipate the rate change. For the rate cut cycle, both markets have negative cumulative yields for most of the 5 days prior to announcement. Implying that at least the direction of change is well anticipated by both markets. Interestingly, the magnitude of change pre-announcement differs between the markets. The spot market appears to have anticipated some rate cuts better than the futures, and vice-versa in other cases. Where rate hikes are concerned, the futures market appears to have gotten the direction wrong. Though small, the change in yield is negative for all three cases in the futures market just prior to rate increases. The sport market certainly appears to better anticipate rate increases. Figure A.2 in Appendix plots the capture ratio, which is a measure of the relative change in yield for day 0 and day 1 as a ratio of the announced change in rates.

Section 5: Summary and Conclusion

This study is an empirical investigation of the pricing efficiency of Malaysia's most popular IRF, the 3 month KLIBOR futures contract. The paper also examines other issues related to pricing efficiency. The study spans the contract's entire 10 year history, June 1996 to June 2006. The total of 40 nearby contracts that had traded over the 10 years were examined. The Unbiased Expectation Hypothesis, (UEH), was the model used in analyzing pricing efficiency on a daily basis.

Consistent with the earlier findings in other markets, we find a preponderance of overpricing. Almost 80% of the mispricing constituted overpricing of the futures contract. This finding supports the argument that there maybe a "*Futures Habitat Premium*".[17] Which implies that, for the many conveniences that a futures contract provides, traders would be willing to pay a higher price relative to the corresponding implied forward rate. Underpricing though less frequent, was of a larger magnitude and had a higher standard deviation. A phenomenon also reported by Hegde and Branch (1985) for the US T-bill futures contract. Also consistent with previous studies, we find the magnitude of mispricing and its standard deviation to decline as maturity is approached. While 90 % of the 40 contracts had full convergence, 4 contracts did not. Two of these contracts were during the depths of the currency crisis while the other two were marginally mispriced at maturity by 2 bps. We believe the non convergence of the latter two contracts had to do with the highly unusual rate environment of the time. When we examined the evolution of pricing efficiency over the 10 year period, we found mispricing to be dependent on changes in the rate cycle and interest rate volatility. Periods when the interest rate environment was volatile or when the rate regime switched from a rising rate regime to a declining one or vice-versa, witnessed the most mispricing.

[17] Chow and Brophy (1982) cited in Hegde and Branch (1985)

Given that mispricing was fairly extensive, we looked at the profitability of passive cash and carry and reverse cash and carry arbitrage strategies. Even after adjusting for transaction cost, profitable arbitrage was possible with most of the contracts. Our transaction costs only included brokerage costs, the cost of margins, marking to market, the cost of tailing the hedge etc. were not considered. As expected, the period of currency crisis saw the most mispricing. Mean mispricing was 5 fold higher during the crisis, while the volatility of mispricing, six times higher.

Our final two research questions revolved around the central bank's influence. First, we looked at the impact of the switch in the target policy rate on futures pricing. Next we examined the interest rate announcement effect. In the period following the policy target switch, we found higher mispricing. This is intuitive since the underlying asset of the IRF is no more the target rate. However, we believe our results are also confounded by the change in the interest rate cycle. Our analysis of the announcement effect produced some interesting results. While both the spot and futures reacted fully or more than the announced cut in the early period, both markets react in muted fashion once the intervention interest rate goes below 6 %. Between the two markets, the spot market appears to be more responsive and reacts faster than the futures market. Additionally, the spot market also appears to have anticipated rate cuts better than the futures market.

So what can we conclude about the pricing efficiency of 3 month KILBOR futures contract? Of the 2,609 trading days within the 10 year span of this study, we found mispricing on 2,609 trading days[18] or 97 % of the study period. And as our result from arbitrage opportunity shows, fairly good profits could have been made from simple buy and hold arbitrage strategies. On average the Malaysian IRF is overpriced by about 8.44 bps by comparison, in another emerging market, New Zealand, (Poskitt 1998, 2000) the deviation is

[18] See Table 2, overpricing on 2,063 days, underpricing on 472 days.

approximately 3 bps. Based on these findings we can only conclude that from a pricing view point, the 3 month KLIBOR futures contract is far from efficient.

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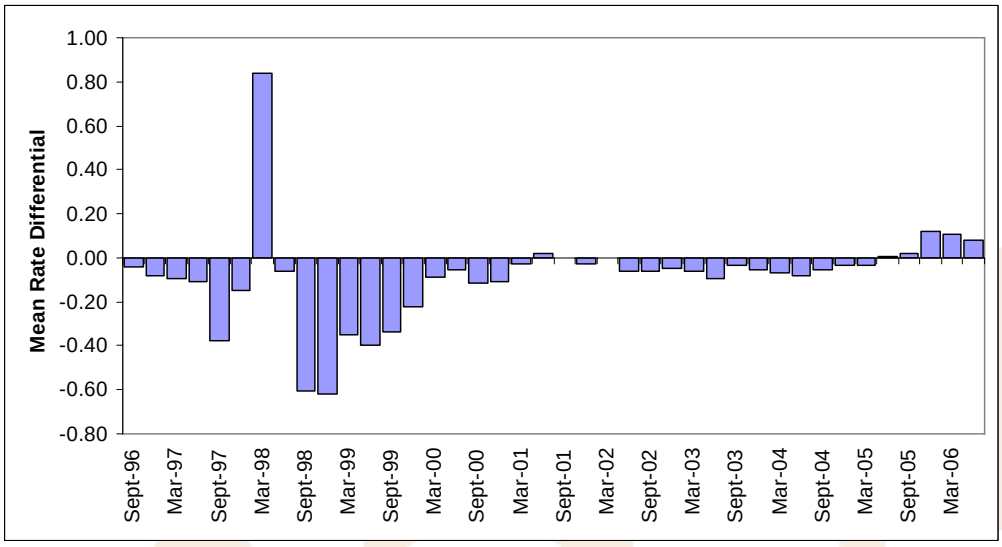
Appendix

Figure A.1

Average Daily Mispricing for Nearby Futures Contract Based on Contract Month



Notes: The above figure shows daily mispricing by contract month. Mean rate differences above zero represent underpricing whereas those below represent overpricing.

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Table A.1

Arbitrage Profit for 30 and 60 Trading Days Prior to Maturity

Nearby Contract Month	-30 Day Arbitrage Profit		-60 Day Arbitrage Profit	
	Gross (RM)	Net (RM)	Gross (RM)	Net (RM)
Sep-96	225	190	175	140
Dec-96	300	265	425	390
Mar-97	300	265	325	290
Jun-97	1,675	1,640	275	240
Sep-97	325	290	5,900	5,865
Dec-97	250	215	600	565
Mar-98	1,175	1,140	3,375	3,340
Jun-98	625	590	675	640
Sep-98	1,575	1,540	1,225	1,190
Dec-98	675	640	950	915
Mar-99	550	515	1,425	1,390
Jun-99	200	165	1,575	1,540
Sep-99	800	765	750	715
Dec-99	350	315	250	215
Mar-00	350	315	375	340
Jun-00	275	240	225	190
Sep-00	150	115	25	(10)
Dec-00	150	115	275	240
Mar-01	75	40	25	(10)
Jun-01	50	15	325	290
Sep-01	100	65	125	90
Dec-01	25	(10)	100	65
Mar-02	50	15	Correct Pricing. No arbitrage.	
Jun-02	125	90	175	140
Sep-02	200	165	175	140
Dec-02	25	(10)	125	90
Mar-03	200	165	200	165
Jun-03	350	315	300	265
Sep-03	125	90	150	115
Dec-03	325	290	100	65
Mar-04	150	115	175	140
Jun-04	125	90	275	240
Sep-04	150	115	75	40
Dec-04	75	40	100	65
Mar-05	75	40	75	40
Jun-05	Correct Pricing. No arbitrage.		150	115
Sep-05	50	15	50	15
Dec-05	375	340	475	440
Mar-06	300	265	375	340
Jun-06	150	115	700	665

Note: Transaction costs = RM35. It consists of brokerage fee RM22, exchange fee RM2, clearing fee RM1 and stamping charge RM10.

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Table A. 2A

Announcement Effect on KLIBOR Spot

Day of Announcement	Date of Announcement	3mIR / OPR	Magnitude of (Decrease) / Increase	Change in Spot Rate: Total Δ Pre-announcement 5 days	Total Δ Post-announcement 5 days	Cumulative Δ 11 days (*inclusive Day 0*)	Day 0	Day 1	Total Changes (*Day 0 + Day 1*)	Capture Ratio
Panel A: Decrease of 3-month Intervention Rate/OPR										
Friday	31/07/98	10.50%	-0.50%	-0.04	-0.42	-0.50	-0.04	-0.41	-0.45	-90.00
Monday	10/08/98	10.00%	-0.50%	-0.42	-0.49	-0.93	-0.02	-0.46	-0.48	-96.00
Thursday	27/08/98	9.50%	-0.50%	-0.03	-1.90	-1.98	-0.05	-0.42	-0.47	-94.00
Thursday	03/09/98	8.00%	-1.50%	-0.62	-0.19	-2.14	-1.33	-0.02	-1.35	-90.00
Monday	05/10/98	7.50%	-0.50%	-0.03	-0.37	-0.41	-0.01	-0.10	-0.11	-22.00
Monday	09/11/98	7.00%	-0.50%	0.17	-0.22	-0.07	-0.02	-0.16	-0.18	-36.00
Monday	05/04/99	6.50%	-0.50%	-0.53	-0.09	-1.26	-0.64	0.00	-0.64	-128.00
Monday	03/05/99	6.00%	-0.50%	-0.03	-0.47	-0.51	-0.01	-0.08	-0.09	-18.00
Monday	09/08/99	5.50%	-0.50%	-0.04	-0.05	-0.09	0.00	0.00	0.00	0.00
Thursday	20/09/01	5.00%	-0.50%	-0.01	0.00	-0.01	0.00	0.00	0.00	0.00
Wednesday	21/05/03	4.50%	-0.50%	0.00	-0.02	-0.02	0.00	-0.02	-0.02	-4.00
Friday	23/04/04	2.70%	Δ to OPR	0.00	-0.03	-0.03	0.00	-0.03	-0.03	#VALUE!
Panel B: Increase of 3-month Intervention Rate/OPR										
Wednesday	30/11/05	3.00%	0.30%	0.01	0.26	0.27	0.00	0.25	0.25	83.33
Wednesday	22/02/06	3.25%	0.25%	0.02	0.17	0.19	0.00	0.16	0.16	64.00
Wednesday	26/04/06	3.50%	0.25%	0.08	0.18	0.27	0.01	0.16	0.17	68.00

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Table A. 2B

Announcement Effect on KLIBOR Futures

Day of Announcement	Date of Announcement	3mIR / OPR	Magnitude of (Decrease) / Increase	Change in Futures Yield: Total Δ Pre-announcement 5 days	Total Δ Post-announcement 5 days	Cumulative Δ 11 days (*inclusive Day 0*)	Day 0	Day 1	Total Changes (*Day 0 + Day 1*)	Capture Ratio
Panel A: Decrease of 3-month Intervention Rate/OPR										
Friday	31/07/98	10.50%	-0.50%	0.00	-0.27	-0.34	-0.07	-0.28	-0.35	-70.00
Monday	10/08/98	10.00%	-0.50%	-0.27	-0.25	-1.03	-0.51	-0.05	-0.56	-112.00
Thursday	27/08/98	9.50%	-0.50%	-0.15	-3.05	-3.35	-0.15	0.00	-0.15	-30.00
Thursday	03/09/98	8.00%	-1.50%	-2.10	1.10	-2.10	-1.10	0.25	-0.85	-56.67
Monday	05/10/98	7.50%	-0.50%	-0.65	0.00	-0.80	-0.15	0.00	-0.15	-30.00
Monday	09/11/98	7.00%	-0.50%	0.11	-0.42	-0.31	0.00	-0.25	-0.25	-50.00
Monday	05/04/99	6.50%	-0.50%	-0.77	-0.10	-0.95	-0.08	0.15	0.07	14.00
Monday	03/05/99	6.00%	-0.50%	-0.10	-0.43	-0.58	-0.05	-0.06	-0.11	-22.00
Monday	09/08/99	5.50%	-0.50%	-0.03	-0.11	-0.29	-0.15	0.00	-0.15	-30.00
Thursday	20/09/01	5.00%	-0.50%	-0.01	-0.03	-0.03	0.01	-0.10	-0.09	-18.00
Wednesday	21/05/03	4.50%	-0.50%	-0.04	0.09	0.02	-0.03	0.04	0.01	2.00
Friday	23/04/04	2.70%	Δ to OPR	0.01	0.17	0.03	-0.15	0.07	-0.08	#VALUE!
Panel B: Increase of 3-month Intervention Rate/OPR										
Wednesday	30/11/05	3.00%	0.30%	-0.01	0.09	0.07	-0.01	0.08	0.07	23.33
Wednesday	22/02/06	3.25%	0.25%	-0.04	0.06	-0.02	-0.04	0.08	0.04	16.00
Wednesday	26/04/06	3.50%	0.25%	-0.03	0.12	0.08	-0.01	0.12	0.11	44.00