

## Analyzing the Arbitrage Opportunities and their Determinants in Deliverable Futures Contracts: Evidence from Pakistan

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### Abstract

*This study explores arbitrage opportunities in Deliverable Futures Contracts (DFC) that arise due to mispricing and also examines the factors affecting it. The cost of carry model is used to calculate the fair prices of futures. Mispricing is taken as a direct measure of arbitrage opportunities. With one-year daily data, collected from data portal of Pakistan Stock Exchange, mispricing is calculated in DFCs on 22 stocks. Summary statistics of mispricing confirms the presence of arbitrage opportunities in selected stocks. Random Effect Tobit regression results indicate that time to contract expiry, volatility in underlying stock, trading volume of ready market, and trading volume of future market significantly explain mispricing.*

**Keywords:** Arbitrage, cost of carry model, futures, mispricing, stock market, tobit

**JEL Classification:** G12; G13; G14

### Introduction

A large number of studies have been devoted to check the pricing efficiency of futures, being traded on various stock markets worldwide. These studies have used the famous cost of carry model, developed by Cornell and French (1983), to arrive at fair prices of futures contracts. Any difference of fair price of futures contract from its actual price i.e. mispricing, is actually an arbitrage opportunity. Earlier studies also examined the mispricing in relation to some factors. These factors mainly include time to contract expiry, volatility of underlying stock, liquidity, and open interest, etc. Many researchers confirmed the existence of arbitrage opportunities in derivatives and the significant effect of the aforesaid factors.

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While talking about the derivatives we cannot ignore the efficacy of future. According to Bialkowski and Jakubowski (2012), a Single Stock Futures (SSF) i.e. futures contract on individual stock, helps the investors to hedge the risk of price changes in the underlying stock, secure their dividend and voting rights, and to exploit the difference between the theoretical and actual price of future. When this contract is settled through physical delivery of underlying stock, it is known as Deliverable Futures Contract.

In the context of Pakistan, these derivatives are studied for their role in pricing and volatility of the underlying stock (Awan & Shah, 2014; Jamal & Fraz, 2013; Khan, Shah, & Abbas, 2011; Khan & Hijzi, 2009; Ullah & Shah, 2013). However, the presence of arbitrage opportunities due to mispricing in SSF at Pakistan Stock Exchange (PSX) and the factors affecting these opportunities are yet to be confirmed. This research contributes to the existing literature first by calculating arbitrage opportunities, as indicated by mispricing in DFCs being traded at PSX, and then by relating mispricing with the factors affecting it. The outcomes of this study have implications for PSX investors and regulators.

The remainder of this paper is structured as follows. Section 2 presents the literature review and the theoretical framework. The research methodology is discussed in section 3. Section 4 provides results and discussion. Conclusions are stated in section 5. Recommendations are made in section 6. Section 7 discusses the limitations of this study.

### **1.1. Problem Statement**

Futures contract provide arbitrage opportunities if not fairly priced. This attribute of the futures contract is not examined in the context of Pakistan and these contracts are generally assumed as risk hedging instruments only. A study from Pakistan is needed to examine the arbitrage opportunities in single stock futures and the factors affecting these opportunities.

### **1.2. Research Objective**

The main objective of this study is to examine arbitrage opportunities in DFCs at PSX with respect to time to maturity, price volatility

of the underlying stock, the liquidity of cash and futures market, and open interest.

## 2. Literature Review

According to an estimate, derivatives are traded on about eighty organized exchanges worldwide. The pricing efficiency of this instrument has been tested in many markets since its introduction. As the value of the futures contract is derived from the spot price of underlying asset, researchers have studied the future-spot price relationship to draw inferences about the efficiency or inefficiency of futures markets, their role in facilitating the arbitrage, and the impact of futures on volatility and liquidity of the underlying asset.

### 2.1. Futures in the Context of Pakistani Stock Market

Single stock futures were introduced in Pakistan in the year 2001. The futures market of Pakistan could not get much attention from the researchers. A few studies have examined futures-spot relationship to check the spot price volatility (Awan & Shah, 2014; Khan et al., 2011; Khan & Hijzi, 2009) and as spot price discovery function (Jamal & Fraz, 2013; Ullah & Shah, 2013). While discussing numerous other ways to invest in stock market, Khan and Hassan (2013) also talk about trading in futures. But no study has checked the presence of arbitrage opportunities in single stock futures.

### 2.2. Futures in the Context of Foreign Stock Markets

Since the introduction of stock index futures in the US market in 1982, relative pricing of futures and the underlying asset has been a great interest of researchers. Along with other motives, academicians and practitioners had checked the future spot price relationship to look for *arbitrage opportunities* as well that arise due to mispricing in futures.

Brenner, Subrahmanyam, and Uno (1989) studied the behavior of prices of Japanese stock as represented by Nikkei Stock Average (NSA) index and NSA futures. Theoretical fair prices were obtained using the cost of carry model and after comparison with

actual prices, the presence of mispricing was confirmed in NSA futures. The study concludes that future contracts are generally sold at a discount rate.

Stoll and Whaley (1990) checked the temporal relation between price movements of S&P 500 and MM index futures and underlying stock indices. The study checks the volatility of index futures against the stock indices and the deviation of futures from their true values. Results indicate that returns from futures indices lead the stock indices by five minutes on average. The study found pieces of evidence that new information circulates in futures market first and then it is transmitted to the stock market. Arbitragers then come into action and trade to bring futures prices back to equilibrium.

Yadav and Pope (1990) analyzed the pricing efficiency of UK FTSE-100 contracts traded on London International Financial Futures Exchange (LIFFE) before and after the big bang. While accounting for relevant transaction costs, separate results for the different types of investors were reported. The average of mispricing returns was significantly positive when these contracts were initially underpriced and vice versa. Among various other determinants, only time to contract expiration was found to be significantly relevant in explaining percentage mispricing. Both inter-day and intraday volatility were found to be relatively greater in the futures market.

The number and size of pricing violations in S&P 500 index options before and after the introduction of SPDRs<sup>3</sup> at AMEX were examined by Ackert and Tian (2001). The study stated that arbitrage trading is vital to bring efficiency in the market as it moves the prices back to their fair values. Empirical results supported that SPDRs improved the connection between index and options market. *Liquidity* and stock index *volatility* were found to be important determinants for mispricing in index options.

Misra, Kannan, and Misra (2006) confirmed the violation of spot-futures parity theorem in the case of NSE Nifty futures and also considered the determinants of these violations in the Indian stock

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<sup>3</sup>Standard and Poor's Depository Receipts (SPDR) or Spider was a derivative product and it was introduced to replicate S&P 500 stock index.

market. Price violations were estimated in Nifty futures<sup>4</sup> for a period of one year. Significant mispricing, providing an average profit of 2422 Indian rupees per contract, was found. According to this study, mispricing was greater in extent for far the month futures contracts than for the contracts which are going to expire soon. Mispricing band was larger for the contracts with negative price deviations and more *liquidity*. *Open interest* was another significant and positive determinant of mispricing. Arbitrage opportunities were not changing due to rising or declining trends in the market.

Vipul (2008) found mispricing in 6 highly liquid single stock futures in the Indian stock market. After accounting for 0.35 % and 0.70 % transaction cost for NSE members and financial institutions respectively, the study confirmed the existence of arbitrage opportunities. Using VAR framework, the study checked if certain factors (*mispricing, change in open interest, change in volume of underlying stock and future contract and change in volatility of underlying stock and futures contract*) have the ability to predict each other. Evidence of strong autocorrelation among these variables was found and each one could be explained by its past values. Mispricing didn't lead or lag any other variable.

Fassas (2010) investigates the pricing efficiency of FTSE/ATHEX-20 index futures by using the cost of carry model and found that significant profit-making opportunities for arbitragers exist even after considering the roundtrip transaction cost. A significant relationship between mispricing and *dividend payments, short-selling restrictions, implied volatility* and, the *volume* of the ready and future market is also seen.

Bialkowski and Jakubowski (2012) found that trading activity in SSFs is explained by different determinants. The study states that in order to determine the efficiency of the futures market, spot-future mispricing is often used as a benchmark. It can be expected that magnitude of mispricing is negatively correlated to trading activity as indicated by *trading volume* or *open interest*. Conversely, mispricing at some level encourages arbitrageur to trade and make a

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<sup>4</sup> Underlying product is Nifty index that traces the behavior of a portfolio of fifty blue chip stocks and covers twenty two sectors of the Indian Stock Market.

profit, therefore, a positive association is also expected between the magnitude of mispricing and trading activity. SSFs, by this study, are found to be more efficiently priced around ex-dividend dates.

Nandan, Agrawal, and Bhargava (2014) confirmed the deviation from fair prices of CNX Nifty futures. Negative mispricing is greater in frequency and magnitude. However, mispricing trend was found to be different for different sub-periods across the study period.

Deville, Gresse, and De Séverac (2014) investigated the direct and indirect impact of the introduction of index security (ETF) on underlying-index spot-futures pricing. The study found significant improvement in the no-arbitrage price relationship in post ETF period. Index-futures mispricing was found to decrease, at first, in a multivariate analysis that controlled the factors affecting spot-futures price relationship. The VAR analysis then indicated that index futures mispricing did not invite ETF trading and that ETF trading did not contribute to reducing index-futures mispricing. These findings failed to support the assumption that the improvement of no-arbitrage price relationship is mainly due to the introduction of ETF. However, some findings suggested that efficiency improvement, after ETF introduction, probably arose from a long-run indirect effect of structural change in the way traders distribute across index markets.

By using equity data from Taiwan Stock Exchange Corporation (TWSE) and futures data from Taiwan Futures Exchange (TAIFEX), Chang and Lin (2015) examined the cash futures basis to find arbitrage opportunities in Taiwan stock market. The magnitude of basis spreads was further related to the liquidity, volatility and informed trading and results for the period near to expiration and far from expiration were compared. Regression results indicated that increased trading and higher volatility tend to increase the spreads and market is dominated by the speculators.

Aggarwal (2015) arrived at the futures basis of 141 stocks using the cost of carry model to explore the arbitrage opportunities. These bases were then related to the basis risk, liquidity risk, liquidity cost, and stock volatility to find the limits to arbitrage.

Rambabu, Chaudhari, Sangishetty, and Naidu (2017) found profit-making arbitrage opportunities in futures and options using NIFTY 50 stocks as the underlying asset. It was noticed that these mispricing opportunities were due to market inefficiencies resulting from various factors such as fundamental risks, noise trader risk, information gap, financing issues, higher implied volatility, portfolio management problems, lesser liquidity of the markets and trade accompanied implementation cost.

Shankar, Sankar, and Kiran (2019) examined SSFs trading at NSE India. The study used multi-regime models to calculate mispricing bounds for over one hundred stocks that were further related to liquidity and volatility. Study concluded that an increase in mispricing is associated with a decrease in liquidity. However, even after controlling for the effects of liquidity, mispricing increased with increasing volatility.

### 2.3. Arbitrage Opportunities in Futures

The fundamental variable upon which the entire study is based is mispricing. Chang and Lin (2015) stated that the accessibility of a replicating portfolio identifies an arbitrage opportunity in a frictionless market if mispricing is not equal to zero. In order to determine arbitrage opportunities, as represented by mispricing, we first need to calculate the fair price of the futures contract. Cornell and French (1983) introduced the most reliable model for futures fair pricing.

$$F_t = S_t e^{(r-d)(T-t)}$$

The price structure given by this model relates the spot and futures prices as a function of time to maturity. The difference between the spot and futures price is contributed by the “cost to carry” the asset until its maturity. The cost of carry model doesn’t assume transaction cost, taxes, and short selling restrictions. This model further assumes that lending and borrowing rates are the same.

Ideally, the actual and theoretical fair price of a derivative given by cost of carry model should be equal in an efficient market. The *difference in the actual and theoretical fair price* of futures

results in mispricing (Vipul, 2008). The mispricing creates an arbitrage opportunity where trader simultaneously buys/sells the future and underlying asset to make a risk-free profit.

A number of studies adopted the cost of carry model to examine the pricing efficiency of futures and options and confirmed the existence of arbitrage opportunities in these derivative products (Ackert & Tian, 2001; Aggarwal, 2015; Brenner et al., 1989; Brenner, Subrahmanyam, & Uno, 1990; Burger & Smit, 1997; Chang & Lin, 2015; Fassas, 2010; Misra et al., 2006; Nandan et al., 2014; Stoll & Whaley, 1990; Tu, Hsieh, & Wu, 2016; Vipul, 2008; Yadav & Pope, 1990).

#### **2.4. Determinants of Arbitrage Opportunities**

Numerous factors are said to be responsible when explaining arbitrage opportunities in futures. Previous related works help to derive important determinants of mispricing.

*Time to contract expiration/maturity*, according to Yadav and Pope (1990), can be related to the higher absolute magnitude of mispricing due to uncertainty about dividends, relative pattern of interest rates, and stock prices. Theoretically, the price of an SSF is greater than spot price in the period far from contract expiration and gradually it starts declining until the expiration day arrives; at which the fair price of futures becomes exactly equal to the spot price.

Mispricing is also affected by *spot volatility* and there are different opinions of researchers about it. One opinion is that higher volatility is a result of greater price movements and consequently, it increases the mispricing.

The other is that market participants rebalance their portfolio due to higher volatility which changes the expected returns of futures and spot market. It attracts other participants to take advantage of this and increases the arbitrage activity, thus decreasing the mispricing. However, Chang and Lin (2015) found that volatility generally serves to increase the spread. Tu et al. (2016) suggested that even during the period of financial crises, concurrent or spot volatility is capable of explaining futures mispricing.



*Liquidity* of futures and spot markets, as indicated by trading volume, is another important determinant of mispricing. Different arguments are found behind the relationship between liquidity and mispricing in related studies. Fassas (2010) states that if arbitrage transactions are initiated by the arbitrageur then it leads to narrowing of price deviations. Chang and Lin (2015), however, finds a positive relationship between liquidity of futures and mispricing and explained this effect as a result of speculator's trading who widen the spreads by dominating the market and exacerbating the arbitrage. *Open interest* is also used by Misra et al. (2006) and Vipul (2008) to check if the opening of new contracts or closing of older contracts affects mispricing.

Finally, a set of commonly studied determinates of mispricing is obtained that can be used to explain the mispricing in DFCs at PSX as well. Figure 1 illustrates it.

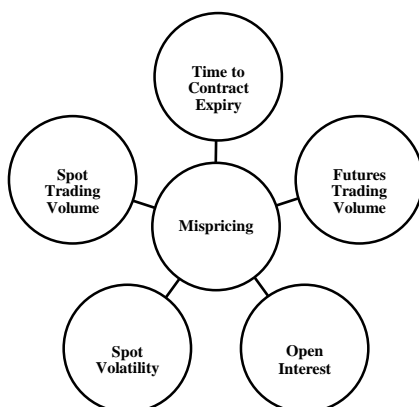


Figure 1: Determinants of Mispricing in DFCs

## 2.5. Research Hypotheses

Based on the affirmed framework, the study poses the following hypotheses:

**H1:** Number of days to contract expiry has a significant relationship with mispricing.

**H2:** Price volatility of underlying stock has a significant relationship with mispricing.

**H3:** Trading volume of the futures contract has a significant relationship with mispricing.

**H4:** Trading volume of the underlying stock has a significant relationship with mispricing.

**H5:** Open interest in the futures contract has a significant relationship with mispricing.

### 3. Research Methodology

This section describes the Variables, Data, and the Econometric model.

#### 3.1. Variables and Data

Data for this research is available online at the data portal of PSX. Data is collected from January 2015 to December 2015 DFCs on daily basis for twenty-two stocks, selected through purposive sampling technique. Selected stocks are listed in Table 1.

**Table 1**

*List of Selected Stocks for Study Sample*

| Sr | Symbol | Complete Name of the Company       | Sr | Sym-<br>bol | Complete Name of the Company               |
|----|--------|------------------------------------|----|-------------|--|
| 1  | AICL   | Adamjee Insurance Company Limited  | 12 | NCL         | Nishat Chunian Limited                     |
| 2  | BOP    | The Bank of Punjab                 | 13 | NML         | Nishat Mills Limited                       |
| 3  | CHCC   | Cherat Cement Company Limited      | 14 | OGDC        | Oil & Gas Development Company Ltd          |
| 4  | DGKC   | D.G. Khan Cement Company Limited   | 15 | PAEL        | Pak Elektron limited                       |
| 5  | EFOODS | Engro Foods Limited                | 16 | PIOC        | Pioneer Cement Limited                     |
| 6  | ENGRO  | Engro Corporation Limited          | 17 | PPL         | Pakistan Petroleum Limited                 |
| 7  | FCCL   | Fauji Cement Company Limited       | 18 | PSO         | Pakistan State Oil Company Limited         |
| 8  | FFBL   | Fauji Fertilizer Bin Qasim Limited | 19 | PTC         | Pakistan Telecommunication Company Limited |
| 9  | FFC    | Fauji Fertilizer Company Limited   | 20 | SNGP        | Sui Northern Gas Pipelines Limited         |
| 10 | KEL    | K-Electric Limited                 | 21 | SSGC        | Sui Southern Gas Company Limited           |
| 11 | MLCF   | Maple Leaf Cement Factory Limited  | 22 | UBL         | United Bank Limited                        |

Criteria for selection of stocks listed in table 1 are as under:

- 1) Security must be currently eligible<sup>5</sup> for deliverable futures trading.
- 2) Contracts on each security must be available throughout the year 2015. Securities with at least twelve<sup>6</sup> one-month contracts are selected only.
- 3) Securities must have non-zero trading volume throughout the study period.

The year 2015 is selected in order to get an insight in to this issue with recent data. Observations for first five days or overlapping period of each new contract are dropped<sup>7</sup> Data on 252 trading days for 22 stocks was considered for further analysis. Detail of selected trading days of January 2015 to December 2015 DFC is exemplified in table 2.

**Table 2**

***Example of Total Trading Days in Year 2015 per DFC***

| Sr. | DFC        | Trading Days Considered for Analysis |
|-----|------------|--------------------------------------|
| 1   | SYMBOL-JAN | 29                                   |
| 2   | SYMBOL-FEB | 19                                   |
| 3   | SYMBOL-MAR | 19                                   |
| 4   | SYMBOL-APR | 20                                   |
| 5   | SYMBOL-MAY | 24                                   |
| 6   | SYMBOL-JUN | 20                                   |

<sup>5</sup>Securities Eligible for SSF Trading from March 2016

<sup>6</sup> DFCs on all eligible stocks for a month remain available for the same period e.g. DFC February, 2015 was available from 26-01-2015 to 23-02-2015 on eligible stocks. Contracts are sometimes split on cum-dividend and ex-dividend basis. This gives rise to more than twelve contracts per stock in a year. However, trading period of such futures remains same as DFCs on other stock for that specific month.

<sup>7</sup> Contract for the next month is opened a few days before the expiry of the near month contract. This, according to Vipul (2008), reflects that the open interest, volatility, and volume of future during this overlapping period belong to the existing or near month contract. Therefore, data on overlapping days need to be removed for new contracts. This also applies to the cum-dividend and ex-dividend contracts.

| Sr.                | DFC        | Trading Days Considered for Analysis |
|--------------------|------------|--------------------------------------|
| 7                  | SYMBOL-JUL | 22                                   |
| 8                  | SYMBOL-AUG | 19                                   |
| 9                  | SYMBOL-SEP | 18                                   |
| 10                 | SYMBOL-OCT | 24                                   |
| 11                 | SYMBOL-NOV | 20                                   |
| 12                 | SYMBOL-DEC | 18                                   |
| Total Observations |            | 252                                  |

A balanced panel dataset with 5544 observations is finally obtained. Variable wise details of collected data and methods of calculation are discussed here.

### 3.1.1. Mispricing M

It is deviation of fair price from the actual price of futures. Mispricing leads to arbitrage by simultaneously changing the positions in the ready and futures market. Vipul (2008) defined mispricing as the difference of actual price of futures from its theoretical fair price. Following Burger and Smit (1997) mispricing is estimated by the following formula:

$$M=FA-FTh$$

Where FA is the actual futures price and it is taken as the closing price<sup>8</sup> of a particular DFC on day t. FTh is the theoretical fair price calculated using the cost of carry model given by Cornell and French (1983). Following Ackert and Tian (2001), commission costs and short-selling restrictions are ignored to capture maximum violation of spot-futures parity. Therefore, FTh or the Theoretical fair price of a futures contract is calculated as:

$$FTh=(S-D) e^{r(t-T)}$$

“S” is spot price of the underlying stock and it is taken as the closing price of the stock on day t. D is the present value (PV) of

<sup>8</sup>Fassas (2010) used settlement prices for index futures series in empirical analysis. According to the regulations governing DFCs of PSX, the daily settlement price is the closing price in DFC market.

cash dividends<sup>9</sup> expected on the underlying stock until the maturity of the contract. Dividends are excluded from contracts available on the cum-dividend<sup>10</sup> basis for which a company has announced its book closure dates. Khatri (2016) provides following formula to calculate fair price with dividend adjustments whenever a dividend is expected till the maturity time.

$$F=(S-PV \text{ of dividend}) * e^{rt}$$

Here the present value of the dividend is at the applicable rate for the duration at the end of which dividend is received or expected. Fassas (2010) also excluded the present value of dividends from the spot price to get the fair prices of futures. “e” is exponent and its value is 2.718. “r” is risk-free interest rate and taken as the daily KIBOR for one month tenure. By following Fassas (2010), interbank offer rate is used as the risk-free rate of interest. Time till maturity of the contract is taken in fraction of a year i.e.  $t-T/365$ . Where “t” is the day for which fair price of futures is to be calculated and T is the day at which contract will close. By following related studies (Fassas, 2010; Misra et al., 2006), absolute mispricing |M| is used for further analysis because mispricing on either side gives rise to an arbitrage opportunity.

Data on daily futures and spot prices (Last day closing price, Open, High, Low, and Close), days to contract maturity, dividend payments, and daily KIBOR published by State Bank of Pakistan for one month tenure is collected from the official data portal of PSX for the selected stocks.

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<sup>9</sup>As dividend payments are usually discrete events, it is not viable to use a constant dividend yield (Fassas, 2010; Vipul, 2008).

<sup>10</sup>Contracts that are entitled to receive dividends. At PSX stocks are sometimes split on cum dividend and ex dividend basis, and a revised schedule for trading is announced. Whenever Deliverable Futures trading schedule is announced, it is also mentioned which contracts are entitled to receive dividends and which contracts will be traded on ex-benefit basis even if the company has announced its closure of books. This information is available under the PSX Notice & Updates section and the information on dividends and book closure dates is available under the financials of each stock.

### 3.1.2. Time to Contract Expiry FMAT

FMAT<sub>t</sub> is the time till maturity of the futures contract on day t. Theoretically, the price of an SSF is greater than spot price in the period far from contract expiration and gradually it starts declining until the expiration day arrives; at which the fair price of futures becomes exactly equal to the spot price. FMAT<sub>t</sub> is calculated by taking the number of days until contract expiry in fraction of a year i.e.  $t - T/365$  (Burger & Smit, 1997). T is the day on which a DFC is going to expire and this information is available in daily quotations and announcements on PSX data portal.

### 3.1.3. Volatility of Underlying Stock SV

The volatility of share price is a measure of uncertainty about future share price movements (Burger & Smit, 1997). Chang and Lin (2015) found that volatility generally serves to increase the mispricing spread. Tu et al. (2016) suggested that even during the period of financial crises, concurrent or spot volatility is capable of explaining futures mispricing. Following Vipul (2008), formula provided by Parkinson (1980) for calculation of variance with extreme value method is used to estimate volatility in the price of the underlying stock on day t as:

$$\sigma_{st} = 0.601 \left\{ \ln \left( \frac{S_{ht}}{S_{lt}} \right) \right\}$$

Where  $S_{ht}$  is the maximum price and  $S_{lt}$  is the minimum price of a share on day t. 0.601 is random walk factor<sup>11</sup>. Extreme value

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<sup>11</sup>The diffusion constant D that characterizes that random walk for each stock is estimated by the extreme value method in Parkinson (1980). The study says that the extreme value method is very easy to apply in practice, since daily, weekly, and in some cases, monthly highs and lows are published for every stock. The change using D to measure variance V could be of specific significance in studies that assume the dependence of V upon time and to get a given precision in V. As compared to the traditional method, around 80% less data and as a result, 80% smaller time interval is required for extreme value method. The study concluded that the extreme value method is 2.5 to 5 times better than the traditional method. The diffusion constant estimated by this study is:

$$D = \frac{1}{4 \ln 2} \cdot \frac{1}{n} \sum_{i=0}^n l_i^2 \quad \text{Or} \quad D_l = \frac{.361}{n} \sum_{i=0}^n l_i^2$$

method is given by Parkinson (1980) to estimate the variance. According to this, if  $S$  is the price of a stock, then  $\ln(S)$  will follow a random walk (at least to a very good approximation). Vipul (2008), used the formula for variance originally developed by Parkinson (1980).

$$\sigma^2 = \frac{.361}{n} \sum_{i=0}^n l_i^2$$

Where  $l_i = \ln S_h - \ln S_l$

Vipul (2008) transformed this formula for the estimations based on single day's high-low prices (i.e  $n=1$ ).

$$\sigma^2 = 0.361 \left\{ \ln \left( \frac{S_{ht}}{S_{lt}} \right) \right\}^2$$

Thus, volatility has been estimated using:

$$\sigma_{st} = 0.601 \left\{ \ln \left( \frac{S_{ht}}{S_{lt}} \right) \right\}$$

Data on daily high low prices of the underlying stock is collected from the PSX data portal.

### 3.1.4. Volume of Underlying Stock SVOLU

In this study, SVOLU or trading volume of underlying stock is taken as a proxy for the liquidity of underlying stock. It is taken as daily trading volume in a fraction of the total number of shares outstanding for that stock. This method is used to check if liquidity of underlying stock has any effect on mispricing in SSF or not. Theoretically, the liquidity of underlying stock tends to widen or narrow the pricing spreads in speculators or arbitragers dominated market respectively.

### 3.1.5. Futures Market Volume FVOLU

FVOLU or trading volume of futures, taken as a proxy for the liquidity of DFC, is also a determinant of mispricing in it (Ackert & Tian, 2001; Fassas, 2010; Misra et al., 2006; Vipul, 2008). FVOLU is taken as the trading volume of DFC in the percentage of number

of shares outstanding for the underlying stock. Hypothetically, in arbitragers dominated market, mispricing decreases due to increasing liquidity. However, this relationship inverses when the market is in control of speculators.

### 3.1.6. Open Interest OI

Open interest is defined as the number of unsettled futures contracts at any time. Open interest is taken in the percentage of the free float as provided by PSX. OI was used by Misra et al. (2006) and Vipul (2008) to check if the opening of new contracts or closing of older contracts can explain mispricing behavior. Misra et al. (2006) confirmed that mispricing in futures was increasing due to increasing in open interest. Vipul (2008), however, found that change in mispricing was not due to change in open interest.

Data for daily trading volume (in ready and futures market) the total number of shares outstanding and open interest in percentage of free float is available on PSX data portal.

## 3.2. Econometric Model

The relationship between mispricing and its determinants is modelled as follows:

$$|M_{it}| = \alpha + \beta_1 FMAT_{it} + \beta_2 SV_{it} + \beta_3 FVOLUME_{it} + \beta_4 SVOLUME_{it} + \beta_5 OI_{it} + \varepsilon_{it}$$

Where  $|M_{it}|$  is absolute mispricing per share of a company  $i$  on day  $t$  and  $FMAT_{it}$  is the number of days remaining in contract expiry,  $SV_{it}$  is the volatility in the price of the underlying stock,  $FVOLUME_{it}$  is the volume of a futures contract, and  $SVOLUME_{it}$  is the volume of the underlying stock.  $OI_{it}$  is open interest in the futures contract and  $\varepsilon_{it}$  is error term. Random effect Tobit model is used because the dependent variable is censored or unobservable when a pricing relationship holds. Yadav and Pope (1990), Ackert and Tian (2001), and Fassas (2010) used Tobit censored regression to model the factors that explain mispricing.

## 4. Results and Discussion

Single stock futures are being traded in Pakistan since the year 2001. A five-year comparison of performances of ready and futures markets of PSX is provided in Table 3.



**Table 3**  
***Five Year Comparison of Ready and Future Market***

|   | Upto     | Upto      | Upto      | Upto      | Upto     |
|---|----------|-----------|-----------|-----------|----------|
|   | Dec-14   | Dec-15    | Dec-16    | Dec-17    | Dec-18   |
| Total No. of Listed Companies                       | 557      | 554       | 558       | 559       | 546      |
| Average Daily Turnover - Shares in million          | 218.67   | 258.79    | 293.03    | 249.19    | 194.03   |
| Average value of daily turnover - million Rs.       | 9,401.68 | 11,465.25 | 11,637.79 | 12,099.95 | 7,871.28 |
| Average Daily Turnover (Future™) YTD- in million    | 24.34    | 36.46     | 49.48     | 59.77     | 68.28    |
| Average Value of Daily Turnover - YTD - million Rs. | 2,205.34 | 3,142.91  | 3,056.70  | 4,307.03  | 3,021.88 |
| Total No. Companies Involved in DFC Trading         | 36       | 35        | 37        | 28        | 54       |

Source: Pakistan Stock Exchange – 5-year progress report

Futures on stocks are settled both by cash and through physical delivery of the underlying shares. For this research, Deliverable Futures Contracts were selected because of their non-zero trading volume as compared to CSFs. The specifications of DFC are given in Table 4.

**Table 4**  
***Contract Specifications of Deliverable Futures Contract at PSX***

|                    |  |
|--------------------|--|
| Contract Size      | 500 Shares   |
| Position Limits    | As prescribed under NCCPL Regulations, as amended from time to time  |
| Daily Price Limits | As provided under chapter 19 of these Regulations pertaining to Risk Management, as amended from time to time. |
| Contract Period    | 1 calendar month   |

|                                      |  |
|--------------------------------------|--|
| Opening of Contract                  | Monday, preceding the last Friday of the month, if Monday is not a trading day, then immediate next trading day. |
| Overlapping Period                   | Maximum Five Days (not less than two days).  |
| Expiration Date/<br>Last trading day | Last Friday of the calendar month, if last Friday is not a trading day, then immediate preceding trading day.    |
| Settlement                           | T+2 settlements falling immediately after the close of the contract.   |
| Depository of underlying security    | Central Depository Company of Pakistan Limited   |

Source: Pakistan Stock Exchange Regulations

Before explaining mispricing with respect to its determinants, the presence of mispricing in DFCs was confirmed by calculating the difference between their actual and theoretical fair prices. Summary statistics of absolute mispricing per share are given in the Appendix: A. Stock-wise minimum, mean and maximum absolute values of mispricing can be seen in percentage per share in this table. Magnitude and frequency of mispricing in positive and negative directions are also given in the next columns. Same is plotted in figure 2 and 3 respectively for a quick glimpse of the reader.

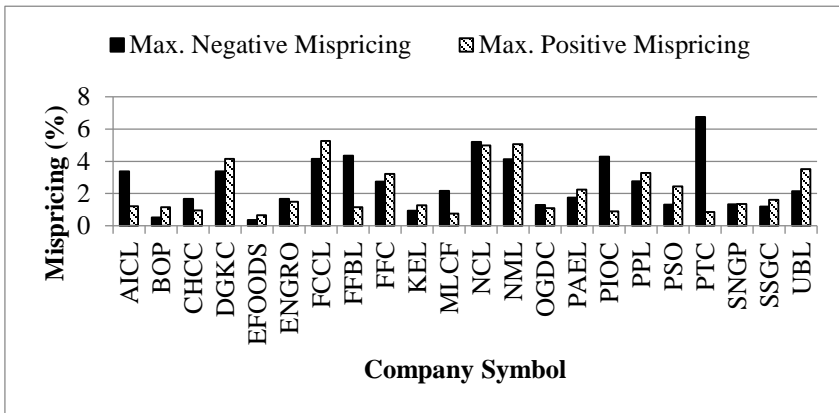


Figure 2: Magnitude of Percentage Mispricing in DFCs

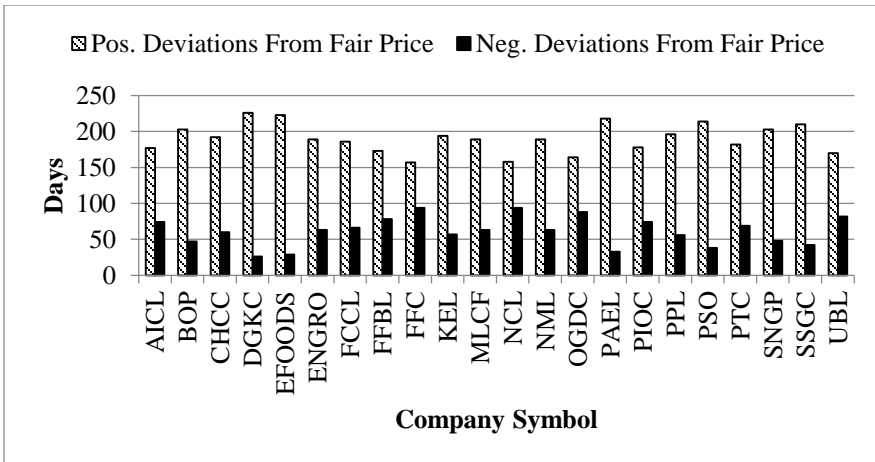


Figure 3: Frequency of Positive and Negative Mispricing in DFCs in Number of Days

In line with previous studies, mispricing is found to be common in Pakistani stock futures. With negative mispricing of 6.74% per share price, PTC stock futures are leading. On the other hand, lowest mispricing per share is observed in EFOODS futures where maximum mispricing is 0.65 % per share price on the positive side. FCCL, NCL, and NML also exhibit dominant mispricing pattern, with maximum mispricing of 5.27%, 5.20% and 5.07 % per share price respectively. Overpricing of DFCs is more frequent than under pricing. Results prove that all stocks involved in DFC trading provide sound arbitrage opportunities to the investors who can earn riskless profit by choosing appropriate arbitrage strategy. According to Stoll and Whaley (1990), when the observed futures price is above the theoretical price  $F_{Th}$  a long arbitrage profit, equal to the difference between the actual and theoretical price of futures, can be earned by selling the futures and buying the index portfolio i.e. the underlying asset. An Index portfolio can be purchased by borrowing the money at riskless interest rate. Conversely, if observed futures price is below the theoretical fair price  $F_{Th}$  short arbitrage profit equal to the difference between the actual and theoretical price of futures can be earned by buying the futures and selling the index portfolio. The amount received from selling the underlying asset can be invested at a risk-free rate of interest.

Outcomes of the random effect Tobit model are given in Table 6 to confirm the relationship of mispricing with the factors affecting it.

**Table 5**  
***Results of Tobit Regression for Absolute Mispricing***

| <b>Independent Variable</b>        | <b>Coefficient</b> | <b>Z</b> | <b>P&gt; z </b> |
|------------------------------------|--------------------|----------|-----------------|
| FMAT <sub>it</sub>                 | 2.762941           | 19.86    | 0.000           |
| SV <sub>it</sub>                   | 1.532058           | 3.3      | 0.001           |
| FVOLUME <sub>it</sub>              | 4.419433           | 2.17     | 0.030           |
| SVOLUME <sub>it</sub>              | -4.279144          | -5.44    | 0.000           |
| OI <sub>it</sub>                   | 0.4728405          | 1.29     | 0.198           |
| Constant                           | 0.1743895          | 4.38     | 0.000           |
| ---                                | ---                |          | ---             |
| sigma_u                            | 0.1802887          | 6.56     | 0.000           |
| sigma_e                            | 0.2624149          | 97.62    | 0.000           |
| Rho                                | 0.3206612          |          | ---             |
| Total Observations                 |                    | 5544     |                 |
| Likelihood-ratio test of sigma_u=0 |                    |          |                 |
| chibar2(01)                        | 1728.44            |          |                 |
| Prob>=chibar2                      | 0.000              |          |                 |

Notes: This table provides estimates from the random effect Tobit model. Dependent Variable  $|M_{it}|$  is absolute mispricing per share of a company  $i$  on day  $t$  and FMAT<sub>it</sub> is the number of days remaining in contract expiry, SV<sub>it</sub> is the volatility in the price of the underlying stock, FVOLUME<sub>it</sub> is the volume of a futures contract, and SVOLUME<sub>it</sub> is the volume of the underlying stock. OI<sub>it</sub> is open interest in the futures contract and  $\varepsilon_{it}$  is error term. Daily observations of each variable are collected on 252 trading days for the year 2015. Coefficients of these variables are significant at 5% level and also consistent at 1% level. Panel level variance or between-group standard deviation, sigma\_u, is 0.1802. Overall variance or within-group standard deviation, sigma\_e, is 0.2624. "rho" the Intra Class Correlation coefficient and it is greater than 'zero'. This indicates that the panel estimator is different from pooled estimator. It further tells that 32% of the variation in mispricing is due to the differences between companies. The likelihood ratio test given at the bottom of this table tests the significance of random effects and provides evidence for the goodness of fit of random effect model.

Significant z scores are obtained for all explanatory variables but open interest. H5 is therefore rejected and other hypotheses are accepted. According to the outcomes of this model, mispricing is explained by different factors as follows:

#### **4.1. Time to Contract Expiry $FMAT_{it}$**

According to the results of the Tobit regression,  $FMAT_{it}$  is the most significant variable. Results are similar to Burger and Smit (1997), Misra et al. (2006), Fassas (2010), and Tu et al. (2016). The coefficient is positive and indicates that a one percent change in time to contract expiry increases the magnitude of absolute mispricing by 2.76. Mispricing starts decreasing when the contract is near to its expiry. This is just in line with the pricing theory behind futures i.e. the cost of carry model. When  $t=0$ , the fair price of the futures becomes equal to the spot price of underlying stock and mispricing becomes 0.

#### **4.2. Volatility of Underlying Stock $SV_{it}$**

The volatility of the underlying stock price is positively related to absolute mispricing and highly significant too. A one percent change in volatility on either side leads to a change in the magnitude of absolute mispricing of 1.5 accordingly. Chang and Lin (2015) and Tu et al. (2016) also found a positive and significant effect of concurrent volatility on mispricing. Results are also in line with the findings of Fassas (2010) but are contrary to (Vipul, 2008).

#### **4.3. Futures Market Volume $FVOLUME_{it}$**

The volume of the futures, taken as a proxy for liquidity, is also positively related to absolute mispricing. Results are significant and can be interpreted as a 1% increase in the liquidity of futures increases the mispricing in futures by 4.41 and vice versa. Results are similar to Misra et al. (2006), Chang and Lin (2015) and Tu et al. (2016) as they confirm a significant positive relationship between Liquidity of futures and mispricing.

#### **4.4. Volume of Underlying Stock $SVOLUME_{it}$**

The trading volume of the underlying stock is also taken as a proxy for liquidity. The coefficient is negative and indicates that absolute mispricing is high in futures with less liquid underlying stock. A one percent increase in liquidity decreases the mispricing by 4.27.

Results are in line with Tu et al. (2016) and Chang and Lin (2015) and confirms a negative relationship between the liquidity of

underlying stock and mispricing. This is consistent with the argument that heightened levels of arbitrage trading would tend to lower spreads (Chang & Lin, 2015). Fassas (2010) found a positive association between liquidity of cash market and mispricing. (Vipul, 2008) did not find any such relationship.

#### **4.5. Open Interest $OI_{it}$**

The coefficient of  $OI_{it}$  is positive and indicates that a 1% change in open interest increases or decreases absolute mispricing by 0.47. However, the result is insignificant at both 5% and 10% levels. Contrary to Misra et al. (2006), the result of this study confirms the finding of Vipul (2008) that there is no association between absolute mispricing and open interest.

### **5. Conclusion**

Single stock futures have never been analyzed for arbitrage opportunities since their introduction in Pakistan. This study was dedicated to fill the gap by analyzing arbitrage opportunities in futures in the context of Pakistan. The analysis in this study leads to some significant conclusions in this regard. It is found that DFCs at PSX are frequently mispriced and provide risk-less profit-making arbitrage opportunities. Overpricing of these futures is relatively more common than under pricing. However, negative mispricing spreads are found to be greater in magnitude in some stocks.

As per previous related studies time till contract maturity, volatility and liquidity were found as main contributors of mispricing in DFCs. Effect of open interest was also examined to explain mispricing in earlier studies. In order to explain the mispricing in DFCs at PSX, same variables are used. Apart from open interest, all of these variables have significant explanatory power for mispricing. The magnitude of mispricing is found to be greater during the period far from contract expiration and in the contracts with higher volatility. Negative relationship of spot liquidity indicates the dominance of arbitrageurs in this market who trade to narrow the mispricing spreads. On the other hand, positive relationship between futures liquidity and mispricing is due to speculators' dominance as they trade by widening these spreads. This indicates that speculative mo-

tives may also be a reason behind mispricing. It is possible that mispricing in these contracts is initiated by the speculators, and then arbitragers may start trading to make these spreads narrower.

### **5.1. Recommendations**

Based on the conclusions of this study, some practical recommendations are made here:

- Stocks for trading under the DFC market are selected through uniform selection criteria, approved by SECP. Exchange can select top 100 book-entry securities meeting these criteria. The actual number of securities, selected every six months, is less than even half of this number. It is recommended that keeping in view the benefits of trading under futures market; other listed companies should also try to enter DFC market. Exchange can also relax the criteria in order to gather more companies under the Single Stocks Futures umbrella, where applicable and feasible in the mutual interest of stockholders and stakeholders.
- With a positive association, time to contract expiry is found to be the most significant factor of mispricing. The magnitude of mispricing is greater at the start of the contract when more time is left to contract maturity. PSX can introduce the DFCs with different maturity periods i.e. two months and three months future contracts etc. to attract the arbitragers.
- Arbitrage is a healthy activity that brings efficiency in the market. Results, however, indicated that magnitude of mispricing was increasing with the increasing liquidity of futures. This phenomenon points toward the dominance of speculators in this market. Speculators trading should be discouraged so that arbitrage is not exacerbated by widening these spreads.
- Futures serve to hedge against the risk related to price fluctuation in underlying stocks. On the other hand, higher volatility in underlying stock tends to increase the mispricing band, as indicated by the results of this study. It is suggested that stocks with higher volatility can be introduced in stock futures trading to help the investors to hedge against the risk and to exploit the arbitrage opportunities as well.

## 5.2. Limitations

This study does not cover the effect of transaction cost on price deviations that is left for future research. Moreover, the analysis is conducted on one year daily data. Further research can be done by extending the study period and also by using intraday data.

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**Appendix: A**  
**Summary Statistics for Mispricing in DFCs**

| Sr. | Symbol | Min. (AM) | Mean. (AM) | Max. (AM) | M (SD) | Max. (NM) | Max. (PM) | N (PD) | N (ND) | TD  |
|-----|--------|-----------|------------|-----------|--------|-----------|-----------|--------|--------|-----|
| 1   | AICL   | 0.0012    | 0.4429     | 3.383     | 0.6788 | 3.38      | 1.22      | 177    | 74     | 251 |
| 2   | BOP    | 0.0007    | 0.3127     | 1.1567    | 0.2156 | 0.51      | 1.16      | 203    | 47     | 250 |
| 3   | CHCC   | 0.0004    | 0.3507     | 2.8804    | 0.3732 | 1.66      | 0.95      | 192    | 60     | 252 |
| 4   | DGKC   | 0.0011    | 0.4557     | 4.1555    | 0.9106 | 3.37      | 4.15      | 226    | 26     | 252 |
| 5   | EFOODS | 0.0001    | 0.2309     | 0.6468    | 0.1461 | 0.35      | 0.65      | 223    | 29     | 252 |
| 6   | ENGRO  | 0.0027    | 0.3069     | 1.6609    | 0.3291 | 1.66      | 1.49      | 189    | 63     | 252 |
| 7   | FCCL   | 0.0001    | 0.5755     | 5.2683    | 1.1071 | 4.15      | 5.26      | 186    | 66     | 252 |
| 8   | FFBL   | 0.0017    | 0.4629     | 4.3467    | 0.8274 | 4.35      | 1.15      | 173    | 78     | 251 |
| 9   | FFC    | 0.0008    | 0.4984     | 3.2289    | 0.6824 | 2.74      | 3.22      | 157    | 94     | 251 |
| 10  | KEL    | 0.0022    | 0.5367     | 1.2693    | 0.2545 | 0.93      | 1.27      | 194    | 57     | 251 |
| 11  | MLCF   | 0.0022    | 0.3445     | 2.1637    | 0.3691 | 2.16      | 0.75      | 189    | 63     | 252 |
| 12  | NCL    | 0.0043    | 0.8042     | 5.2095    | 1.2542 | 5.21      | 4.98      | 158    | 94     | 252 |
| 13  | NML    | 0.0001    | 0.4976     | 5.074     | 1.0361 | 4.14      | 5.07      | 189    | 63     | 252 |
| 14  | OGDC   | 0.0042    | 0.3123     | 1.3018    | 0.253  | 1.3       | 1.1       | 164    | 88     | 252 |
| 15  | PAEL   | 0.0033    | 0.3607     | 2.2427    | 0.3799 | 1.74      | 2.24      | 218    | 33     | 251 |
| 16  | PIOC   | 0.0034    | 0.5911     | 4.286     | 0.9768 | 4.29      | 0.9       | 178    | 74     | 252 |
| 17  | PPL    | 0.0014    | 0.4226     | 3.2694    | 0.6697 | 2.76      | 3.27      | 196    | 56     | 252 |
| 18  | PSO    | 0.002     | 0.2996     | 2.4531    | 0.3762 | 1.31      | 2.45      | 214    | 38     | 252 |
| 19  | PTC    | 0.0021    | 0.6745     | 6.7477    | 1.3908 | 6.75      | 0.86      | 182    | 69     | 251 |
| 20  | SNGP   | 0.0043    | 0.3648     | 1.3443    | 0.2716 | 1.33      | 1.34      | 203    | 48     | 251 |
| 21  | SSGC   | 0.0063    | 0.347      | 1.6027    | 0.2458 | 1.2       | 1.6       | 210    | 42     | 252 |
| 22  | UBL    | 0.0023    | 0.4789     | 3.5153    | 0.6499 | 2.15      | 3.51      | 170    | 82     | 252 |

Note: Observations with zero mispricings were ignored. Mispricing is given in percentage per share price. AM = Absolute Mispricing, M(SD) = S.D From Mean, NM = Negative Mispricing, PM = Positive Mispricing, PD = Positive Deviations (From Fair Price), ND = Negative Deviations (From Fair price), TD = Total Deviation

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