Exchange Traded Contracts for Difference: Design, Pricing and Effects[*]

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ABSTRACT

Contracts for Difference (CFDs) are a significant financial innovation in the design of futures contracts. Over-the-counter trading in the UK is significant and has created controversy, but there is no published academic research into the design, pricing and effects of CFDs. This paper analyzes CFD contract design and pricing. It uses a unique database of trades and quotes on exchange traded equity CFDs introduced by the Australian Securities Exchange to test theoretical pricing relationships, and draws out implications for successful design and trading arrangements for the introduction of new derivative contracts.

Contracts for Difference (CFDs) are an innovative financial futures contract designed such that its price should equal that of the underlying security. CFDs enable market participants to achieve leveraged positions, hedge existing positions, implement strategies involving short positions, and possibly avoid stamp duty or other taxes on transactions in the underlying assets.[3]

CFDs were originally introduced in the London market in the early 1990s as over the counter (OTC) products aimed at institutional investors. They have since become popular with retail investors and have been introduced in many countries. While they are prohibited in the USA, OTC CFDs on US stocks are offered by providers based outside the USA to non-residents.

The OTC CFD market in the UK has grown substantially since 2003. The value of transactions is estimated to have increased from around 10 per cent of the value of London Stock Exchange equity transactions in 2001, to around 35 per cent in 2007 (FSA 2007). Most UK CFD providers have counterparties who are hedge funds, other financial institutions or corporates (FSA, 2007). The average contract size ranges from 30,000 to 1.3 million pounds and is held for 3 to 6 months. CFD providers most often hedge the resulting exposure in the underlying asset.

In November 2007, the Australian Securities Exchange (ASX) became the first exchange to design and list exchange-traded CFDs. At May 31, 2008 there were contracts available on 49 leading stocks. The Australian OTC market has also grown substantially

[3] In the UK, stamp duty is levied on physical share transactions, but not on CFD transactions or share transactions by registered financial intermediaries (such as CFD providers) hedging derivative transactions. This creates a tax incentive for position taking by hedge funds and other investors via CFDs. Oxera (2007) provides more details on stamp duty arrangements.

with most participants being individual investors.[4] According to the Financial Standard (2008), there were around 20 providers of OTC CFDs in Australia in 2008, and a survey of providers indicated around 30,000 active traders.

OTC CFD markets have not been without controversy. First, unsophisticated investors can easily take highly leveraged positions, causing concerns about investor protection. Second, traders with open positions are potentially exposed to adverse pricing by their CFD provider when seeking to close a position. There is also counterparty exposure should the CFD provider fail. Third, is the accumulation of non-disclosed significant economic interests in companies by way of CFD positions.[5] Although long CFD positions do not provide voting rights, the hedging practises of CFD providers (buying shares in the physical market) provide an indirect linkage and the possibility of readily available conversion of a CFD position into a physical position without affecting market prices.[6] Alternatively, an investor could acquire voting rights in a company by purchasing stock and avoid price risk by hedging that position with a short CFD position. Fourth, some commentators have suggested that speculative OTC CFD trading may contribute to increased volatility in the underlying market as CFD providers make

[4] Internationally, hedge funds and institutional investors have typically been able to do "equity swaps" (Chance 2004) if they wish to take leveraged long or short positions with their prime brokers, and thus not required the services of CFD providers.

[5] See FSA (2007). In July 2008 the FSA announced that a holding in excess of a 3 per cent stake in a company through CFDs (or other derivative transactions) would be required to be disclosed from June 1 2009 (FSA, 2009).

[6] The trader with a long CFD position could close out that position and buy the physical stock concurrently being offered in the market by the CFD provider unwinding their hedged position.

corresponding trades in the physical market to hedge their CFD exposures. Despite these important issues and the significant use of CFDs in international financial markets, there has been no academic research published to date.

This paper makes a number of important contributions. First, the conditions under which an arbitrage pricing relationship holds are derived. Second, the paper explains how contract design and trading arrangements preclude pure arbitrage pricing, but should generate CFD prices close to parity with the price of the underlying security. Third, the paper tests whether such parity pricing prevails, and examines how bid-ask spreads on CFDs are linked to those on the underlying security using data on exchange traded CFDs introduced by the ASX. Finally, the paper highlights the potential impact of exchange traded CFDs on broader financial market structure, such as short selling and margin lending arrangements. It is also, to our knowledge, the first academic paper examining both theoretical and empirical aspects of CFDs, although there are a number of practitioner publications providing guides to CFD trading, such as Norman (2009) and Temple (2009).

Our results and analysis provide insights into important features of contract design and trading arrangements relevant for successful introduction of new derivatives. The nature of the trading platforms used and consequent ability of market makers to hedge risks are important potential determinants of spreads, pricing, liquidity and ultimate success of innovative derivative contracts such as these. Our work should thus be of interest to securities exchanges and regulators contemplating introduction of such products, as well as to academics interested in microstructure.

In Section 1 we provide a brief description of the characteristics of CFDs, derive an arbitrage pricing relationship for a particular type of CFD and discuss how approximate "parity" pricing results from contract design and market practises in the OTC markets. In Section 2 we outline the contract specifications of the ASX exchange traded CFDs and argue that contract design and trading arrangements facilitate approximate "parity pricing" but preclude a pure arbitrage pricing relationship. We also discuss the potential implications for financial markets from successful introduction of exchange traded CFDs. Section 3 reviews related literature that informs development of specific hypotheses about CFD parity pricing and the relationship between bid-ask spreads in the CFD and underlying market. Section 4 describes the data, and investigates aspects of the trading and pricing of exchange listed CFDs and their relation to the underlying market. Section 5 concludes with some observations on the potential future development of exchange traded CFDs in competition with individual share futures and OTC CFDs, together with suggestions for future research.

1. CFD Structure

Contracts for Difference (CFDs) are futures-style derivatives designed such that their theoretical price, absent transactions costs, should be equal to the price of the underlying security. They provide the opportunity for investors to take highly levered, margined, "effective" positions in stocks or other traded financial instruments without taking actual physical positions.

It is helpful to initially assume that the CFD contract has no margin requirements and a defined expiry date T at which time instantaneous arbitrage forces the CFD price (P_T) and underlying stock price (S_T) to equality. This may occur either by a requirement for physical delivery of the stock or a cash settlement equal to the price difference. (In practise, as discussed later, an infinite expiry date, margin requirements, and transactions costs complicate the analysis). The buyer and seller of this hypothetical CFD at date 0 < *T* at price P_0 enter a contract with the following cash flow obligations: (a) at date 0 there are no cash flows; (b) at date *T* there is a cash flow from seller to buyer of $\left(P_T - P_0\right) = \left(S_T - P_0\right)$; (c) at each date *t* until expiry the buyer pays the seller a contract interest amount of rS_{t-1} where *r* is the contract rate of interest per day; (d) at any date *t* prior to expiry on which a dividend (D_t) is paid on the stock, the seller pays the buyer an equal amount.

It can be shown by induction that this contract design leads to equality of the CFD and contemporaneous stock prices ($P_t = S_t$). Consider the arbitrage strategy established at date *T*-1 which involves short selling the stock for one day (and investing the proceeds at an interest rate of *r* per cent per day until date *T*) and buying the CFD at date *T*-1. The short sale position involves paying the equivalent of any dividend D_T paid on day *T* to which a holder of the stock on day *T*-1 becomes entitled. It also requires purchase of the stock at date *T* to close the short position. Table 1 sets out the cash flows involved. It is clear that absence of arbitrage opportunities requires that $P_{T-1} = S_{T-1}$. $P_t = S_t$ for any $t < T$ follows by induction.

(Insert Table 1)

This pricing relationship can also be understood by reference to the well known cost of carry relationship between spot (*S*) and futures (*F*) prices on a dividend paying stock. Considering only date *T*-1, this can be written as

$$F_{T-1} = S_{T-1}e^{r} - D_T \qquad (1)$$

where the basis difference ($F_{T-1} - S_{T-1}$) arises because of the income stream paid on the underlying asset and the opportunity cost of interest foregone on a physical stock position relative to a futures position. CFDs differ from futures because the buyer pays contract interest $S_{T-1}\left(e^{r}-1\right)$ and receives the dividend, D_T. Hence:

$$P_{T-1} = F_{T-1} - S_{T-1}\left(e^{r}-1\right) + D_T = S_{T-1}. \tag{2}$$

As the cash flows in Table 1 suggest, the purchase of a CFD is essentially equivalent to borrowing to purchase the underlying stock (but without acquiring ownership of the stock, and where the amount borrowed changes daily in line with the underlying stock price). Conversely, the sale of a CFD is equivalent to a strategy of short selling the stock each day, investing the proceeds, and closing out the previous day's short position.

In practice, CFDs differ from the hypothetical CFD considered above. They were initially introduced as OTC products by financial firms (referred to as CFD providers) which provide bid-ask quotes for traders. No settlement date is specified, and traders close out positions at dates of their discretion by offsetting trades at the price quoted by the CFD provider. That price is not contractually tied to the underlying stock price, creating potential basis risk for the trader (in addition to counterparty risk). CFD providers manage their counterparty risk by requiring traders to post margin accounts to which profits and losses are added (making long CFD positions basically equivalent to a margin loan arrangement). The ASX CFD contract essentially mimics the OTC variety, but with novation of trades to the clearing house.

These practical features mean that the pure arbitrage based pricing argument, involving a fixed expiry date when CFD and physical prices converge, does not immediately hold. There are two other explanations for a parity pricing relationship. The first is competition and reputational risk. CFDs are a substitute for margin lending and short sale facilities offered by stockbrokers and investment banks. This is only the case if CFD prices quoted by the OTC providers closely track the underlying stock prices. The second explanation is the cost of risk management by CFD providers. A CFD provider who quotes low prices will attract mainly buyers and hedging the net short position involves buying an equivalent volume of physical stock at a higher price. There is thus a negative cost of carry (greater interest expense on funds borrowed to finance physical hedging than interest income from long CFD positions). Conversely quoting high CFD prices attracts sellers and involves paying more interest to those customers than received on short hedging positions in the physical market. In practise, some CFD providers simply “pass through” CFD orders from customers as buy/short sell orders directly to the physical market on their own account to ensure a hedged position, thereby linking CFD prices quoted directly to the underlying. This is sometimes referred to as Direct Market Access (DMA).

2. The ASX Exchange Traded CFD Contract

2.1 Details of the contract

The ASX CFD Market began trading on 5 November 2007, with the listing of CFD contracts on 16 stocks with a further 33 contracts on stocks listed later that month.[7] Contracts on a number of AUD bilateral exchange rates, gold, and the Australian equity index (S&P ASX 200) have also been listed. CFDs replaced Individual Share Futures which had failed to sustain significant trading activity.

[7] Subsequent mergers have seen two contracts delisted, and in early 2009 four further stock CFD contracts were listed.

The ASX CFD contract is based on a mixed limit-order book and designated price maker (DPM) electronic trading system structure operating through the SYCOM trading platform.[8] The small number of approved DPMs (initially eight) provide bid and ask prices, and traders can submit market or limit orders (through brokers) advising whether they are position opening or closing transactions. The CFD price is quoted per unit of the underlying equity security (one contract equates to one share).

To illustrate the design of the contract, consider the case of a buyer of CFD units on company XYZ at date 0 at a price of $\$P_0$ per unit for a contract value of $\$P_0$. If she sells the CFD units at some later date T at a price of $\$P_T$, she will have a net gain ignoring interest payments of $\$(P_T - P_0)$.[9] On each day over the life of the contract, the buyer must pay *contract interest* given by

$$CI_t = r_t S_{t-1}$$

[8] This is not linked directly to the ITS platform used for the underlying stocks. This creates potential complications for instantaneous hedging by DPMs as discussed later. In June 2008, the London Stock Exchange announced (London Stock Exchange 2008; Sudbury 2008) plans to introduce exchange traded CFDs involving a combined order book with the underlying stock. However, in April 2009 it was announced that this project had been indefinitely put on hold due to the impact of recent market conditions on customers' development capacity (Sukumar 2009). This issue of links between trading platforms for derivatives and the underlying security and implications for market development is one we return to in the concluding section.

[9] As the contract value changes, margin payments and receipts will be made to the trader's account, such that when the contract is closed out by the trader, her net gain or loss will be reflected in the account balance. Initial margins required by the Exchange are set as a cash amount and ranged from 5.5 to 27.2% of the settlement price with an average of 13.8% as at 1 September 2008 (based on margins set at current levels on 5 June 2008)

where r is the daily contract interest rate (the Reserve Bank of Australia's (RBA) target overnight cash rate), and where S_{t-1} is the previous day's daily settlement price (DSP) defined by the ASX as the closing underlying share price. The CFD buyer must also pay an *open interest charge* each day given by

$$OIC_t = r_t^* S_{t-1}$$

where r_t^* is a daily charge rate set by the exchange and which has been 1.50% p.a. from the date of initial trading.

The seller of the contract receives the equivalent contract interest amount each day, but must also pay an open interest charge. The OIC charged to both buyers and sellers is an interest rate spread levied by the ASX on positions. The buyer also receives, and the seller pays, amounts equal to any cash dividend paid on the underlying stock. (A contract design complexity arising from the treatment of dividend tax credits is outlined in Appendix 1). These transactions occur on the ex-dividend day, such that no difference arises between entitlements to cash dividend amounts on the CFD and the underlying stock (although there is a cash flow timing difference, given the gap between ex-dividend and payment dates).

The rationale for CFD design involving an infinite maturity is two-fold. First, this is the structure found in the successful OTC market and makes the exchange traded version a virtually perfect substitute. Second, compared to ISFs which they replaced , retail investors wishing to maintain a CFD position for a long period of time do not have to roll their positions whenever the current contract expires (as occurs with ISFs), providing a virtue of simplicity.

2.2 Arbitrage or parity pricing?

The possible existence of an exact one-for-one relationship and lack of basis risk is obviously valuable for marketing of the CFD contract to traders interested in taking synthetic positions in the underlying stock using CFDs. Also relevant, since they can limit the exploitation of arbitrage opportunities, is the size of transactions costs in the market. This consists of bid-ask spreads and fees and charges imposed by the exchange and by brokers through whom clients trade.

Arbitrage activities by DPMs are more likely than by individual traders, given their lower transactions costs. They are rebated the OIC as part of incentive arrangements with the ASX, face very low transactions fees, and as financial institutions should be able to access short term interest rates close to the RBA target cash rate. However, pure arbitrage (rather than "risk arbitrage") strategies are not possible. The absence of a terminal date at which some no-arbitrage relationship exists between the derivative contract price and that of the underlying precludes the development of an arbitrage pricing relationship for earlier dates.[10] (Mandated netting-off of DPM positions on the ex-div date at the ASX determined DSP (see Appendix 1) provides one potential link, but there is no guarantee that any netting-off will occur if for example all DPMs are in short positions at that time).

The ASX (2008) suggests that use of the DSP for determining variation margins (and open interest cash flows) may contribute to "arbitrage" pricing. However, as shown in Appendix 2, this only affects the pattern of cash flows over the life of the contract and not

[10] An infinite expiry date does not necessarily preclude deriving an exact arbitrage pricing relationship as Merton (1973) and Chung and Shackleton (2003) have shown for American calls with no (ie infinite) expiry date. However, in that case the exercise of the option generates a payoff which is explicitly linked to the underlying stock price which is not the case for closing out a CFD.

the eventual profit or loss. Hence it is not a factor that will drive the CFD and stock price to equality.

Other relevant factors include competition for business between DPMs and their hedging activities. Because the CFD is a close substitute for leveraged stock positions, but only if CFD prices maintain a near-parity relationship with underlying stock prices, DPMs will find it necessary to maintain a near parity relationship if they are to attract traders into the CFD market. Their ability to do so is aided by the relative ease of hedging CFD positions created by immediate transactions in the underlying market. However, because trading arrangements mean that hedging and CFD transactions are not necessarily able to be effected instantaneously, and a risk that non-parity pricing may prevail when the hedge is unwound, there is some risk associated with implementing the hedge. Also, spreads in the underlying market create a cost of hedging as do differences between the contract interest rate on CFDs and interest rates DPMs can access in the market for funding (investing proceeds) of long (short) stock hedging positions. But at some sufficiently large basis difference, the opportunity would exist for significant net interest earnings on a “risk arbitrage” position. It is also likely that confidential commercial arrangements between the ASX and DPMs provide incentives for quoting prices which keep the basis small.

2.3 Potential implications of exchange traded CFDs

The introduction of exchange traded CFDs by the ASX has been marketed as overcoming some of the possible problems of OTC CFDs. This includes a reduction in counterparty risk and exposure to adverse pricing. But, more generally there are potentially significant implications for the operations of equities markets and the future of margin lending.

First, CFDs enable traders to take short positions on traded stocks by selling the CFD, without having to short sell the physical stock. With a well developed CFD market it would be possible, in principle, to ban short selling on the physical market (other than by designated price makers in the CFD market who are hedging positions), and have short selling occurring through an arguably more transparent OTC CFD market. Since a well designed CFD contract will ensure that CFD prices track those of the underlying, there may be little if anything to be gained by market makers cross hedging long CFD positions in the physical market rather than directly in the CFD market. However it is an open question as to whether a close link between CFD and underlying stock prices would exist if physical short selling were generally prohibited or restricted only to DPMs. Whether the traded CFD market could achieve the depth required to facilitate within market hedging by market-makers is also an open question. (The concluding section will return to these issues and consider how alternative trading platforms may answer some of these questions). Since transactions costs are relevant considerations in hedging decisions, a comparison of the transactions costs (including bid-ask spreads) in the CFD and underlying markets is an important area for study.

Second, a long ASX CFD position is an alternative to purchasing stock using a margin loan facility provided by a financial institution (see Appendix 2). The funding is indirectly provided by those with short CFD positions, who receive interest on the implicit loan, while the counterparty for both long and short positions is the exchange clearing house. (The clearing house in effect becomes a financial intermediary with matched assets and liabilities). Consequently, the growth of a traded CFD market provides a significant source of potential competition for participants in the margin loan market. The extent of competition depends upon the interest rate charged on the positions.

Third, as a close substitute for individual share futures, the ability to design a successful exchange traded CFD contract would have implications for the future of individual share futures. Finally, exchange traded CFDs are a competitive threat to the more well developed OTC CFD market.

3. Prior research

In the absence of prior literature on financial market CFDs, studies of individual share futures (ISFs) and research on the relation between spreads in options markets and spreads in the underlying asset market form the basis of our empirical analysis in Section 4.

3.1 Individual share futures (ISFs)

Whilst there are important differences between CFDs and ISFs they have many common features and are potential substitutes. Most research has focused on the relationships between the ISF and the underlying asset. These studies broadly fall into three categories. First, a number of studies examine the cost of carry and violations in the no arbitrage conditions. Jones and Brooks (2005) found that daily ISF settlement prices at One Chicago contradicted the cost of carry model, with a number of ISFs settling at prices below the underlying. Brailsford and Cusack (1997) found frequent, small pricing errors before transaction costs on Australian ISFs, however after allowing for transaction costs, pricing errors were rare. More recently, Fung and Tse (2008) have found that ISF (single stock futures) traded on the Hong Kong exchange are more likely to be underpriced than overpriced.

The second category of research examines the impact of ISFs on the volatility of the underlying. Mazouz and Bowe (2006) found that the introduction of ISFs had no impact on the volatility of the underlying stocks traded on the LSE. Dennis and Sim (1999) found a similar result for the ISFs on the Sydney futures exchange.

Third, Lien and Yang in a series of papers examined the impact of changes in the settlement of ISFs on the Australian market. Lien and Yang (2004a) showed that a switch from cash settlement to physical delivery resulted in an increase in the futures, spot and basis volatilities. The switch also resulted in an improvement in futures hedging effectiveness. Other research found that the introduction of ISF contracts reduced the option expiration effects on the underlying (Lien and Yang 2003; 2005).

Another strand of research examines the low trading volumes of ISFs. Jones and Brooks (2005) found that for all nearby contract days at One Chicago, 41% had zero trading volume. See also Brailsford and Cusack (1997), McKenzie and Brooks (2003), Ang and Cheng (2005) and Lien and Yang (2004b).

3.2 Spreads

Madhavan (2000) provides a review of market making and bid-ask spreads focusing on the physical rather than a derivative market. He suggests that price, risk, volume as a measure of market activity and market capitalization explain most of the cross-sectional variation in stock spreads, leading to the following model for bid-ask spreads in the stock market

$$SS = \beta_0 + \beta_1 (1/P) + \beta_2 \ln(1+V) + \beta_3 \sigma + \beta_4 \ln(M). \qquad (3)$$

SS is (percentage) stock spread, P is price, V is trading volume, σ is stock volatility and M is market capitalization. Price inverse is used because the minimum tick induces convexity in the percentage spreads. Madhavan (2000) and Mayhew (2002) provide empirical evidence that the effect of volume and price may be non-linear. Inventory based models of the bid-ask spread (see for example Stoll (1978), Amihud and Mendelson (1980) and Ho and Stoll (1983)) predict a negative relation with trading volume, a negative relation with the inverse of price and a positive relation with stock volatility. Adverse selection models (see for example Glosten and Harris (1988) and George, Kaul, and Nimalendran (1991)) predict a negative relation between market capitalization and spread. This is because low-priced low market capitalization firms will have less analyst following and greater information asymmetry.

It is reasonable to expect market activity in the underlying asset market to play an important role in determining spreads in a derivative market. Cho and Engle (1999) and Kaul, Nimalendran and Zhang (2001) develop models of market making in options markets where the cost of hedging provides the link between spreads in the derivative market with those in the underlying asset market. Typically in these models the spread in the option market is found to depend on the spread in the underlying stock plus a number of control variables such as volume and price in the option market and the volatility of the underlying stock, similar to the model specified in equation (3). de Fontnouvelle, Fishe and Harris (2003) model bid-ask spreads using pooled regressions similar to equation (3) and find that the spread in the options market is significantly related to the spread in the underlying stock.

4. Empirical Analysis

4.1 Data

The main source of data is the SIRCA Taqtic data base and comprises trade and quote data and market depth data for the period November 5, 2007 (the commencement of the market) through to December 31, 2008. The data consist of all trades and quotes and the best bid and ask price on ASX equity CFDs and their underlying stocks. Information is also provided on the open interest at the close of each trading day.

To examine the relation between the CFD and underlying markets, each CFD trade was time matched to the spot trades that occurred both before and after the CFD trade. (Each trade comprises a number of contracts). This resulted in a data set that consisted of 190,450 observations. Data cleaning removed a further 462 observations. To compare liquidity in the two markets we use the market depth data to calculate the spreads in each market. This data consists of 201,430,727 observations of the bid-ask price pairs giving the best bid and best ask in the market at any point in time. A new quote occurs in this dataset when the best bid or the best ask is changed or a trade has occurred.

4.2 Descriptive Statistics

Table 2 presents summary statistics for the full sample and for a select group of companies. The companies chosen include two more heavily traded CFDs – BHP (a large mining company) and TLS (the national telecommunications company), two thinly traded CFDs – CSR and CSL, and two CFDs with trading volumes that are close to the mean trading volume - FXJ and QBE. Most of the statistics are self explanatory. The time between CFD trades (minutes) within the day only considers trades within the day and therefore excludes days with only one trade. The $ difference between the CFD trade price (P_t) and the subsequent stock trade price (S_t) may be considered a pricing error. The % difference between the CFD price and the subsequent stock price is calculated as a percentage of the observed CFD price. Finally the percentage of trades where the CFD volume equals the subsequent stock volume, provides a crude measure of the percentage of CFD trades that are immediately hedged by DPMs.[11]

(Insert Table 2)

The results highlight the infancy of the listed CFD market in Australia. The mean (median) daily trading volume over the period was 9023 (4645) shares per CFD with the mean (median) number of CFD trades per day being 8.93 (4.00). The illiquidity of the market is reflected in the mean (median) time between trades of 22.41 (2.65) minutes. Even a relatively heavily traded CFD like BHP has a mean (median) time between CFD trades of 10.75 (3.07) minutes. The small mean (median) trading size of 1010 (500) reflects the fact that the listed CFD market has been targeted at the retail investor. The time between the CFD and the subsequent stock trade is more a reflection of the liquidity in the underlying assets with a mean (median) of 0.068 (0.006) minutes or 4.1 (0.4) seconds.

It is also apparent that the development of the CFD market has been uneven, with a number of contracts exhibiting little activity. Figure 1 presents a histogram of the mean daily number of CFD trades per stock. There are less than 5 trades per day on average for over 50 per cent of the contracts, with many of the remainder having less than 10 trades per day on average. Only the BHP CFD contract has elicited significant trading interest. Table 3 presents the distribution of daily CFD trades. On average only 60.5 percent of CFDs trade on any given day, with trading concentrated in a small number of CFDs. The three

[11] This clearly suffers from a number of limitations. For example, it will not identify those hedges where a CFD position is hedged through more than one stock trade. This will have the effect of understating the hedging activities in the market.

most popular contracts on any day account for just over 50 per cent of the total daily value of trades on average.

(Insert Figure 1) (Insert Table 3)

Figure 2 shows that total trade value and open interest have languished through the turbulent economic environment of 2008. This raises the question of whether exchange listed CFDs will prove to be viable, or whether they will join the long list of failed financial innovations on futures exchanges (Johnson and McConnell, 1989, Tashjan, 1995). It is worth noting however that the decline in value of OI and trades overstates the volume decline due to the significant decline in stock prices from a peak in November 2007. Moreover, turnover and open interest has increased substantially, post-sample in 2009.[12] Also important to note, is the fact that a general prohibition on short selling of stock on the ASX was introduced on September 22, remained generally in force until November 13, but was continued past the end of 2008 for financial stocks. The effect of this is considered in the next section.

4.3 CFD Bid-ask Spreads

This section examines the relation between CFD spreads and the spreads on the underlying. Section 4.3.1 approximates the maximum CFD spread which would still entice clients into the CFD market, rather than the physical. This result provides justification for the higher spreads in the CFD market which is confirmed empirically. Section 4.3.2 then estimates a model of CFD spreads using panel data.

4.3.1 CFD spreads and the spreads on the underlying

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[12] For example, in the week ending 2 Oct 2009, turnover was 3.63 million contracts and open interest was 5.4 million contracts, compared to 0.798 million and 2.1 million respectively for the week ending 5 Dec 2008.

Because DPMs are rebated the OIC and face very low trading costs, the zero profit spread from market making activities resulting from competition should, in the absence of hedging risks, be not much wider than those in the underlying market. However, for customers, there is a potentially much wider spread which is consistent with them being willing to take positions in the CFD rather than in the underlying using margin loans, short selling, or trading the physical.

This arises because the effective interest cost on long CFD positions is lower than that associated with margin loan purchases and the interest return is higher than on investing proceeds from short positions in the physical. Incorporating the Open Interest Charge on positions levied by the ASX of 1.50% p.a., the effective interest cost (return) on CFD positions is r +0.015 or r -0.015 p.a., where r is the RBA target cash rate. Over the period of our study, the indicator margin lending rate averaged 3.4% higher than the RBA cash rate. The interest paid on bank cash management accounts (in excess of $50,000), which would be an upper bound on returns paid by brokers to retail clients on cash generated from short sales, was 1.1% lower than the RBA cash rate.

These figures can be used to estimate an indicative maximum CFD spread which would still entice clients into the CFD market rather than trading the physical (ceteris paribus). Assume that CFD bid and ask prices are $S_t - d$ and $S_t + d$, where for simplicity the bid-ask spread in the underlying share is zero. Let m be the amount borrowed using a margin loan and x be the amount by which borrowing/investment interest rates are greater/less than the RBA cash rate. A margin loan purchase involving cash outflow of $(1-m)S_0$ at date 0 would generate a cash inflow of $S_1 - mS_0\left[1+(r+x)/n\right]$ when the share is sold at date 1 (1/nth of a year later). A CFD long position at $S_0 + d$ requiring a margin account deposit of $(1-m)S_0$ involves the same cash outflow at date 0. If the interest paid on the margin account is the same as that charged on the long CFD position (ie r + 0.015 p.a.), the net cash flow at date 1 when the CFD position is closed out is $S_1 - 2d - mS_0\left[1+(r+0.015)/n\right]$.[13] A trader would be willing to purchase a CFD in preference to the margin loan purchase if:

$$\frac{d}{S_0} < \frac{m}{2n}(x-0.015).$$

Assuming margin requirements such that m = 0.8, a retail interest rate spread of x = 0.03, and an anticipated holding period of one month (n =12), a bid-ask spread of $(2d/S_0) < 0.1\%$ would make the CFD transaction preferable (where zero spreads are assumed in the underlying market). For longer anticipated holding periods the critical spread value is higher.[14] The degree of competition between DPMs, together with their operating costs will determine the extent to which the quoted spreads in the market approach such a critical value rather than reflecting the lower spreads in the underlying. These arguments lead us to state our first hypothesis

Hypothesis 1: The bid-ask spreads in CFDs will be significantly greater than in the underlying stock for each stock at all times.

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[13] The CFD gain/loss is (S_1-d)-(S_0+d)-S_0(c+0.015)/n and the initial margin account plus interest returned is (1-m)S_0(1+(c+0.015)/n)).

[14] For an anticipated holding period of four months, the critical CFD spread is around 0.4% higher than that in the underlying market, which is compatible with the spreads observed in the CFD market prior to the market disruption in September 2008.

This paper employs an absolute (*Spread1=Ask price – bid price*) and percentage spread ($Spread2 = 100 \times \left(Ask\ price - Bid\ price \right) / \left[\left(Ask\ price + Bid\ price \right) \div 2 \right]$. Most of the analysis however focuses on the percentage spread.

The average number of quote revisions per day for the stocks (CFDs) is 10,965 (2,587) with the average time difference between quote revisions 2.75 (29) seconds. We use a time-weighted average across all spreads in a given contract on a given day to give a daily measure of *Spread1* and *Spread2* for each company's stock and CFD, thus reducing the effects of any intra-day patterns.

The average percentage stock and CFD spreads are plotted for each company in Figure 3. Figure 4 takes the average of the percentage spread across companies for stocks and CFDs for each day and then plots these cross-sectional averages through time. Two features of the CFD spreads are apparent. First, there has been a general upward movement in the average percentage spread through time. Second, a major disruption to the spread levels occurred on Monday 22 and Tuesday 23 September 2008. This followed an announcement of a ban on short-selling of all stocks on the prior weekend. On those days the spreads on CFDs for several companies jumped to levels significantly above the average spread for the time period.[15] Even though the short-selling ban continued for all stocks until November 13 and for financial stocks past the end of our study period, there

[15] The absolute spreads for 11 CFDs were greater than $1.00 on either one or both days. The largest absolute spread on 22 September is $2.97 for Woodside Petroleum's CFD, whereas the mean absolute spread is 14.99 cents and the standard deviation is 17.54 cents.

was clarification on September 23rd that DPMs hedging CFD positions (as well as other market makers hedging derivatives position) were exempt from the ban.

(Insert Figure 3) (Insert Figure 4)

The absolute spreads and percentage spreads for each company's stock are significantly less than the corresponding spreads for its CFD. There is no day in the sample period where the average CFD spread is less than the average stock spread for any company. The average across all company stocks (CFDs) across time of *Spread1* is 1.8406 (6.3470) cents and of *Spread2* is 0.2014% (0.7293%). In conclusion, there is strong support for Hypothesis 1.

4.3.2 A regression model of the CFD spread

This section estimates a regression of percentage CFD spreads on spreads in the underlying market plus a number of other explanatory variables. Following de Fontnouvelle, Fishe and Harris (2003) and Cho and Engle (1999), we argue that the cost of hedging in the CFD market for DPMs is directly related to the bid-ask spread in the stock market. For example, to hedge a short position in the CFD market a DPM would take a long position in the stock at the ask price and close the position by selling the shares at the bid price. Thus the bid-ask spread in the stock market, together with any spread between wholesale interest rates paid for funding the stock purchase and the RBA target cash rate received by DPMs on the short CFD position, represents the cost of the hedge.

The percentage spread is modelled using the following specification

$$\begin{aligned} CFDS_{i,t} = \beta_0 + \underset{+}{\beta_1} SS_{it} + \underset{-}{\beta_2} \ln\left(M_{i,t}\right) + \underset{+}{\beta_3} \left(1/P_{i,t}\right) + \underset{+}{\beta_4}\, \sigma_{s,t} + \underset{+}{\beta_5}\, \sigma_{m,t} \\ + \underset{-}{\beta_6} \ln\left(1+V_{i,t}\right) + \underset{+}{\beta_7}\, IS_t + \underset{+}{\beta_8}\, D_t \end{aligned} \qquad (4)$$

where the subscripts *i* and *t* refer to contract *i* and time *t* respectively, and the signs under the coefficients reflect their expected signs. CFDS (SS) is the percentage spread of the CFD (the corresponding stock) at time *t*. We also include a number of control variables. The inverse of the end of day underlying stock price (1/*P*) reflects the effect of minimum tick size, and as discussed earlier the coefficient is expected to be positive. (Note *P* is also the settlement price for the CFD). Liquidity in the CFD market, measured by open interest and/or trading volume, is also a potentially relevant determinant of spreads.[16] However, given that DPMs hedge in the underlying market, it is more likely to be liquidity in that market than in the CFD market which is more relevant. We thus include both the daily dollar volume of trading in the CFD (*V*), (measured as the log of one plus trade volume to overcome the problem of a significant number of zero observations)[17] and the (log of the) value of trades (*M*) in the underlying. The coefficient on *M* is expected to be negative reflecting a liquidity effect of greater trading activity in the underlying at a particular point in time leading to narrower spreads in the derivative. Idiosyncratic stock volatility may already be impounded in the stock spread, but we also include it as a control variable. This is because the separate trading platforms for the CFD and the underlying stock create a problem of latency and the risk for the DPM not completing the hedge before prices change. In addition, overall market volatility is included as a proxy for general market

[16] Ding and Charoenwong (2003) examine thinly traded futures markets and suggest that on days when a trade occurs in thinly traded futures markets, the spread becomes lower. They also consider the relationships between the spread, volatility and transactions volume as well as whether a high activity level as reflected in more quote revisions is associated with a lower spread.

[17] Use of lagged OI did not generate significant results, and incomplete data for this variable led to a significant drop in the number of useable observations.

uncertainty. This is particularly relevant given the time period over which CFDs have been trading. Stock (market) volatility $\sigma_{s,t}$ ($\sigma_{m,t}$) is measured as the natural logarithm of the ratio of high over low price for the previous day. IS_t is an interest rate credit risk spread – the 30 day bank bill rate minus the 30 day Overnight Interest Swap (OIS) rate. This should capture changes over time in the funding cost of hedging positions for DPMs. D_t is a dummy variable equal to unity on September 22 and 23, otherwise zero.

The data set consists of a panel with the number of days *T*=245, and the number of cross-section units *N*=46.[18] The literature examining panels with large *N* and *T*, where time series properties are relevant, is relatively new. Banerjee (1999), Phillips and Moon (2000), Coakley, Fuertes and Smith (2006) provide reviews, and as noted by Smith and Fuertes (2008) there are still many gaps.

The issues associated with large *T* and *N* data sets are complex, with panels differing in the degree of heterogeneity of the parameters, the orders of integration with the possibility of cointegrating relations over time and across variables in the cross-section, the number of factors influencing the dependent variables, as well as cross-sectional dependence between residuals, and or residuals and regressors. The considerable challenges have meant that no clear consensus on the most appropriate econometric methods has emerged to date. Our preliminary analysis focuses on the orders of integration of the variables and the existence of cross-sectional dependence.

[18] As well as deletions from the population of all CFDs introduced due to mergers, one company, St George Bank was removed from the analysis due to a large number of missing observations. The panel is also slightly unbalanced with the total number of observations being 11,248 (A fully balanced panel would have 46x245=11270 observations).

4.3.2.1 Stationarity of variables

Table 4 summarises the results of the Augmented Dickey Fuller (ADF) test and the KPSS tests on each of the variables. The results are far from definitive. CFD spreads, stock spreads and the inverse of the stock price are likely to be I(1), however there are a number of time series that would appear to be I(0). The KPSS test suggests that stock value, stock volatility, market volatility and CFD volume are generally I(1). The ADF test however suggests that these variables are generally I(0).[19]

(Insert Table 4)

A visual inspection of the data reveals that many spreads significantly increased in magnitude and volatility after September 2008. This shift occurred more abruptly in some spreads than others. For illustrative purposes, Figure 5 displays the CFD percentages spreads for BHP, NWS and TAH. These three CFDs were chosen because they are representative of many of the other CFD spreads. BHP shows a spike in the spread on September 22 and 23. From this point forward, the mean and the variance in the spread appears to increase. NWS shows no significant increase in the spreads in September; however the mean and variance of the series over the entire sample appear to be increasing with time. TAH shows an increase in the spread on September 22 and 23. The spreads increase and are more volatile subsequent to that date, however there is a general trending downwards towards the end of the sample.

(Insert Figure 5)

[19] The tests for the AOI volatility are also mixed with the ADF test supporting an I(0) process and the KPSS test supporting an I(1) process. Tests for the interest rate spread suggest that it is I(0).

Whether these features of the data should be treated as evidence of a structural break after September or of non stationarity is unclear. This is further complicated by the fact that unit root tests have difficulty in distinguishing unit roots from structural changes (Perron 2006).[20] We initially examine the time series behavior for evidence of a unit root for two reasons, and subsequently examine the implications of assuming a structural break. First, there are a number of CFD spreads that are similar to NWS, which visually shows no signs of a break. Secondly, as discussed below, the impact of heterogeneity in the levels of integration across panel data is relatively easy to deal with. The effects on parameter estimation are also reasonably well understood.[21]

The potential non-stationarity of the variables raises the question of cointegration and spurious regression. If the variables and errors are I(1), then the individual OLS regression results from Equation 4 are spurious. Univariate tests on the OLS residuals revealed that the residuals were generally I(0). The ADF (KPSS) test suggested that the residuals were I(1) for only two (eight) regressions (at 5% level of significance).[22] A

[20] The power of these tests depends on the time span of the data, suggesting that these procedures may suffer from low power. Further, over a longer time span, one would expect that the CFD spreads will be I(0) processes. The non-stationarity of the data is therefore a statistical issue that needs to be adequately dealt with to ensure reliable inference.

[21] A range of panel unit root tests were also performed also generating inconsistent results and are available on request.

[22] Panel unit root tests also supported the stationarity of the residuals.

methodology that allows for the possibility of integration in the variables and the residuals is required.[23]

4.3.2.2 Cross-sectional dependence

The existence of cross-sectional dependence seems likely given that stock spreads across assets are likely to move together. Further, it does not seem unreasonable to suggest that a common factor could drive CFD spreads, stock spreads and stock and market volatility. The more recent panel literature has emphasised the importance of allowing for latent common factors that induce cross-sectional dependence. Ignoring this dependence may lead to inconsistent parameter estimation if the common factors are correlated with the regressors (Coakley, Fuertes and Smith 2006).

Table 5 examines the presence of cross-sectional dependence. The table reports the average cross-sectional correlation measure between each of the variables and from the OLS residuals from Equation 4. Given that there are 46 cross-sections, each average correlation measure represents the average of 1035 correlations. Each of the variables (with the exception of CFD volume) exhibit reasonably high levels of cross-sectional correlation, ranging from 0.34 to 0.50.[24] The null hypothesis that all contemporaneous correlations between residuals are zero was rejected at the 1% level of significance against the

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[23] Whilst individual equations may exhibit cointegration, the mixed results of the unit root testing for the variables and residuals suggest that cointegration across the entire panel is unlikely. See Ashworth and Byrne (2003) for an application and discussion of panel cointegration methods.

[24] CFD volumes for many CFD often had a zero volume of trading for the day. This explains the lower levels of cross-sectional dependence in this variable.

alternative that *at least one correlation is non zero.*[25] Table 5 also reports the proportion of variability explained by the *p*th principal component (p = 1, 2) from the relevant correlation matrix. This also supports cross-sectional dependence and a common factor structure.

(Insert Table 5)

4.3.2.3 Model estimation

The preliminary results suggest that a panel regression model of CFD spreads using the variables in equation 4 needs to be robust to: i) heterogeneous orders of integration, where each variable in the panel may be an I(1) process for some of the N units and an I(0) process for the remaining units; ii) the possibility of integrated residuals, and iii) the presence of cross-sectional dependence. It is difficult to identify the most appropriate estimator given the uncertainty surrounding the stationarity of the variables and residuals, the appropriate latent factor structure(s) that drive the cross-sectional dependence, and the extent of heterogeneity across the units in the panel. It is therefore prudent to consider a range of estimators and examine the sensitivity of the results (Smith and Fuertes 2008). This section applies five estimators that can handle non stationary time series and cross-sectional dependence: 1) Pooled OLS (POLS) as suggested by (Phillips and Moon 1999), 2) an OLS estimator of a cross-section regression (CS) as suggested by (Pesaran and Smith 1995), 3) Two way fixed effects (2FE), 4) the Mean Group (MG) estimator of (Pesaran and Smith 1995) and 5) the Common correlated effects mean group (CCMG) estimator of

[25] The test statistic for $H_0 : \rho_{12} = \rho_{13} = \rho_{14} = ... = 0$, is $\lambda = T\left(\rho_{12}^2 + \rho_{13}^2 + \rho_{14}^2 + ...\right)$, with a critical value of $\chi^2_{N(N-1)/2}$, where N is the number of equations (N = 46).

(Pesaran 2004). (See Appendix 3 for more detail and Coakley, Fuertes and Smith (2008) for the finite sample properties of the estimators).

Table 6 Panel A presents the results. They are generally robust to the alternative estimators and consistent with expectations. Most parameters subject to some exceptions discussed below are stable across estimators. Price inverse, stock volatility and CFD volume are statistically significant for all estimators. Stock spread is statistically significant for all estimators except for the CS regression, where the results in Panel B indicate that this is due to high collinearity with the stock price in the cross-section. Stock trading value is not significant in any of the regressions. The September dummy generally supports an increase in spread at that time of 1.5 to 2%. The signs of all variables are also consistent with expectations.

(Insert Table 6)

The insignificance of the market volatility and interest spread variables in the CCMG estimator suggests that the inclusion of the latent factor proxies (the cross sectional averages of the stock spread, stock value, price inverse, stock volatility and CFD volume which seek to capture the cross-sectional dependence) has rendered these market wide variables insignificant. This suggests that the market volatility and interest spread variables in the pooled OLS and MG regressions act as common factors, partly capturing the cross-sectional dependence.

Given the robustness of the results to the alternative estimators, we focus on the Pooled OLS results for detailed discussion. Table 7 presents those results both for the full sample and for subsamples prior to (subperiod1: 2 Jan.08 - 19 Sep 08) and after the announcement of the short selling ban (subperiod2: 22 Sep 08 -31 Dec 08). Tests for a structural break at that time were performed using a Chow breakpoint and Chow forecast test using both the MG and CCMG estimators which estimate equations for each CFD. In only a very small number of cases (eg 5 of 46 for the CCMG estimator for the breakpoint test and 2 of 46 for the CCMG estimator for the forecast test) was the null hypothesis of no structural break not rejected. The table also reports a 2 tailed t test of the differences in the coefficient estimates between the two sub-samples.

For subperiod1 the coefficient on the stock spread is insignificantly different from unity, but it is significantly above unity for subperiod2 when the shortselling ban was in operation. While in subperiod1, the CFD spreads are higher than stock spreads (Fig 4), this is attributable to factors other than a "proportional mark-up" on the underlying stock spread. The intercept term of 0.35 (35 basis points) is of similar order of magnitude to the average difference between CFD and stock spreads over this period. Since other explanatory variables have been argued to capture the effects of costs and risks involved in hedging, it is tempting to interpret this coefficient estimate as indicating either exploitation of the wider feasible spread for customers by DPMs or reflecting cost recovery associated with development and implementation of trading algorithms and systems.

In subperiod2 when CFD spreads jump (Fig 4), there is also greater sensitivity to stock spread. The dummy variable for the period of market turmoil on September 22 and 23, 2008 is significant, with its value indicating that spreads were around 2 percentage points higher than usual on those days. The sensitivity of the spread to the inverse of the stock price falls significantly in subperiod2. Higher priced stocks had lower spreads and while that was still so after the shortselling ban, the effect was somewhat muted. There is also significantly greater sensitivity of CFD spreads to short term market volatility in subperiod2 and some suggestion of increased sensitivity to individual stock short term volatility. The larger effect of stock market volatility on the CFD spread (relative to individual stock volatility) is most likely due to the effect of individual stock volatility being reflected in the stock spread which is highly significant. These results are suggestive of responses to a perceived increase in hedging risks by DPMs.

(Insert Table 7)

4.4 Mispricing

This section examines the existence of any CFD mispricing relative to the underlying. Interest differentials mean that retail customers may be willing to trade CFDs rather than the underlying at relatively wide spreads. This is relevant for examining the possibility of mispricing. CFD trades may occur at some distance from parity with the underlying either because contract design and trading deficiencies prevent "near-arbitrage" pricing, or because imperfect competition between DPMs means that they are able to exploit the wide spreads within which customers are willing to trade. This section tests whether contract design, competition, ASX incentives to DPMs, and the other factors described in Sections 1 and 2 are sufficient to keep CFD and underlying prices aligned in the absence of an exact arbitrage result.

The descriptive statistics presented in Table 2 examining the $ and % difference between the CFD and the next spot trade suggest that the average $ and % mispricing are approximately zero in total and for all stocks. However it is important to establish whether any mispricing is beyond those attributable to transaction costs. We therefore consider the following hypothesis.

Hypothesis 2: There is no difference in price of contemporaneous trades of CFDs and underlying stock, beyond that attributable to transactions costs.

The determination of the appropriate transaction costs is difficult. The transaction costs associated with one round trip for the CFDs must be added to the transaction costs associated with taking the appropriate position in the underlying. To the extent that quotes by DPMs exploit the relatively large spread within which customers will trade, it is likely that trades will occur in the CFD market at potentially large deviations from concurrent trades in the underlying market. Our spread calculations suggest that deviations of greater than 0.5 per cent would (after allowing for additional transactions costs) be suggestive of mispricing or full exploitation by DPMs of the feasible retail trader spread. (The willingness of retail traders to deal at non-parity prices arises because of the interest advantages compared to alternative trading strategies). But it should also be noted that in some cases (discussed below) the time lag between CFD and subsequent stock trades is several minutes. This implies that not all CFD trades are immediately hedged and gives rise to the possibility of parity violations due to non-synchronous trading.

We adopt an approach similar to Chung(1991) and Klemkosky and Lee (1991) and examine mispricings that exceed predetermined thresholds. Accordingly, Table 8 examines the mispricings that exceed the transaction cost bounds of 1% (Panel A) and 0.5% (Panel B). The table presents the results for all CFDs along with the six individual CFDs presented in Table 1. We conclude that CFD pricing is generally efficient, with violations in the transaction cost boundary occurring 0.68% (2.97%) of the time for transaction costs of 1% (0.5%). Across all stocks, mispricings are more likely to be negative (CFDs are more likely to be underpriced). This is reflected in the negative and statistically significant mean and median values of -0.33% and -1.04% in Panel A and -0.10% and -0.51% in Panel B. It is also reflected in the number of negative violations being greater than the number of positive violations. The Wald-Wolfowitz runs test also finds that mispricings are not generally randomly spaced over time.

(Insert Table 8)

Figure 6 presents histograms of the number of companies whose CFDs exhibit violations in the price bounds of various frequencies. Figure 6 (Panel a) considers transaction costs of 1%, revealing that 31 CFDs (72% of CFDs) exhibit boundary violations less than 2% of the time. When transaction costs are set at 0.5% (Panel b), 26 CFDs (60% of CFDs) exhibit boundary violations less than 6% of the time. Five CFDs experience boundary violations more than 30% of the time when transaction costs are 0.5%. Each of these CFDs has a relatively long average time between the CFD trade and the subsequent spot trade. They also have a very low number of trades per day with means (medians) ranging from 1.9 to 3.1 (1 to 2).

(Insert Figure 6)

Four CFDs exhibit statistically significant negative (and four with positive) mispricing for transaction costs of 0.5 and 1% (results available on request). Notably the pricing of the most traded CFD (BHP) has mispricings occurring only 0.18% (0.37%) of the time for transaction costs of 1 and 0.5% respectively. This suggests that if adequate market depth and liquidity develops, pricing will reflect parity relationships, despite the inability to undertake riskless arbitrage in CFDs.

4.4.1 Factors explaining mispricing

With the volume of trade in the CFD a significant determinant of the spread, it is likely that any mispricing will be related to the number of contracts traded. So following the approach of Brailsford and Cusack (1997) the absolute value of the pricing error is regressed on the number of contracts traded and a dummy variable that captures the higher level of pricing errors on introduction of a new contract. The following regression is estimated

$$\left|e_t\right| = \alpha + \beta_1 D_{start,t} + \beta_2 D_{sept,t} + \beta_3 Vol_t + \beta_4 D_{sept,t} Vol_t + \beta_5 \left|e_{t-1}\right| + \varepsilon_t \qquad (5)$$

where e_t is the mispricing at time t defined as the difference in cents between the CFD trade at time t and the subsequent stock trade, $D_{start,t}$ is a dummy variable equal to 1 if trading occurs in the first 7% of the data sample (an approximation for the first month of trading) otherwise zero, $D_{sept,t}$ is a dummy variable equal to 1 for days after and including September 22, 2009, otherwise zero, Vol_t is the number of CFD contracts traded at time t, and ε_t is the residual at time t. Further, where outliers for the dependent variable were observed, intercept dummy variables were employed (at most only 2 to 3 dummies were required). The regressions are estimated via OLS with Newey West standard errors to ensure that inference was robust to heteroscedasticity.

Table 9 presents the results for a sample of CFDs. First, there is some evidence that the mispricing was actually lower in the first month of CFD trading but this result, whilst statistically significant, appears economically insignificant. The significant intercept dummy β_2 indicates that mispricing was higher in the period after September 22, 2008 for four of the six stocks considered. Second, for two of the stocks there is a negative relation between CFD volume and mispricing reinforcing the earlier conclusion that high volume levels facilitate a liquid and efficient market in which mispricing is mitigated. Third, the significant lagged dependent variable for most CFDs suggests that pricing errors are persistent. This is consistent with the Wald-Wolfowitz runs test in Table 8, which suggests that violations in the transaction costs bounds tend to occur in clusters.

(Insert Table 9)

A further regression (using data for all CFDs) of the percentage of boundary violations (from Table 8) against the average number of trades (from Table 2) also reveals a statistically significant negative relation between mispricing and trading activity (although regressing the percentage of violations against the average volume per day did not give significant results). See Table 10 for the results.

(Insert Table 10)

In summary our findings are consistent with the research examining the pricing of ISFs. The overall negative mispricing is consistent with Jones and Brooks (2005), who find that ISF prices tend to be underpriced relative to their fair value. The negative relation between CFD trading levels and mispricing in Table 10 is consistent with the findings in Table 3 and with Brailsford and Cusack (1997) who find that for ISFs, after transaction costs, pricing errors are rare except on illiquid contracts.

5. Conclusion

Contracts for difference (CFDs) are an important innovation in financial futures markets, that to date have not been studied in the literature. We have described the nature of CFDs and provided details on the nature of the first exchanged-traded stock CFDs. An interesting feature of a CFD is that it has no explicit maturity date, which should enhance its appeal to retail investors (relative to ISFs where contracts need to be rolled if a long term position is desired). Instead the CFD position can be closed out at any time at a price equal to the CFD price at that time. There is thus no explicit price link between the CFD and its underlying stock that can be used to derive an arbitrage-free price for the CFD. However, we argue that there are other market factors such as competition and close substitutes that will result in the CFD trading at a price close to the underlying. We show this to be the case in our empirical tests, where we explore the characteristics of the stock CFDs trading on the Australian Securities Exchange. We also demonstrate however that spreads are significantly wider in the CFD market (partly reflecting its relative infancy) than in the underlying market.

For policy makers and securities exchanges, the ability to create an exchange traded CFD which demonstrates efficient pricing has a number of implications. For exchanges, listed CFDs warrant consideration as a possible replacement for individual share futures which have been introduced in a number of countries over the past decade. They also provide a possible opportunity for development of a transparent market for short-selling. The recent experience and regulatory actions suggests that this warrants further examination. While a close link between CFD and underlying stock prices requires DPMs to be able to hedge long CFD positions by shorting the underlying stock, there may be merit in forcing traders (both retail and wholesale) to short-sell through such a derivative market. Here only DPMs would be able to short-sell in the physical market to hedge positions.

In that regard, the future design of CFD trading platforms and market arrangements is an important issue. The consideration of an integrated order book model by the London Stock Exchange is indicative of potential developments (and its deferral of introduction also indicative of logistical difficulties). As our results indicate, the separation of the CFD market and its underlying on trading platforms creates difficulties for instantaneous risk-free hedging. This leads to wider spreads in the CFD market which retard market development. It is, in principle, possible to combine CFD and underlying stock orders in the one limit order book, which would force equality between their prices. To do this, novation of CFD trades would be required. For example a trade involving a CFD purchase and underlying stock sale, would lead to the clearing house or DPM being the novated buyer of stock and seller of the CFD. A trade involving a CFD sale and underlying stock purchase would involve the clearing house or DPM being a novated seller of stock, and thus having to draw on its inventory holdings or borrowing stock to deliver. Precluding short sales, other than by DPMs, and forcing traders wishing to take short positions to do so via selling CFDs may be more transparent than current short-selling arrangements. Thus, both securities exchanges and regulators should find the results of our empirical analysis of the first attempt at design of an exchange traded CFD market of interest.

Also important is the role of listed CFDs as a potential competitor for margin lending facilities from financial institutions. A successful exchange traded CFD leads to the clearing house becoming, in effect, a financial intermediary with a matched book of assets and liabilities. Here CFD sellers indirectly extend credit to CFD buyers through contracts with the clearing house as counterparty. Provided that margining arrangements successfully keep the counterparty risk to the clearing house low, the potential exists for the clearing house to provide more attractive interest rate terms to both CFD buyers and sellers than may be available elsewhere. And as with margin lending and OTC CFDs, there are public policy concerns regarding retail investor understanding of the risks and costs involved and appropriate investor protection regulation.

Areas for future empirical research can be readily identified. A number of studies referenced earlier have examined the nature of lead-lag relationships between individual share futures and share prices. Others have considered how changes in contract terms affect volatility of the futures, the spot and the basis as well as futures hedging effectiveness and option expiration effects. While the thinly traded nature of CFDs (and ISFs as well) limits the lessons which can be gained from such studies, there is scope for further work in this area. More generally comparison of the performance of CFDs versus ISFs on a number of different metrics is warranted given the potential for choice between these alternative contracts by organized exchanges. There is also potential, availability of data on OTC CFDs permitting, for further work investigating the OTC market in CFDs and the extent to which the size of exchange fees and broker costs may be relevant for explaining spreads in, and limited growth of, the exchange traded CFD market relative to the OTC market.

Finally, a more detailed examination of market maker behavior is warranted. Our analysis of trade data indicates that a significant proportion of CFD trades are replicated soon after in the physical, suggestive of DPM hedging. This is supported by our examination of the spread in the CFD market, which we find to be determined by the spread in the underlying stock, consistent with the hedging models suggested by Cho and Engle (1999) and de Fontnouvelle, Fishe and Harris (2003). Given relative spreads in the two markets, the question of the relation between DPM profits and risk bearing is an important one in the context of the potential future growth and development of the CFD market.

Figure Legends

FIGURE 1: Distribution of Mean CFD Trades per Day by Company: November 5, 2007 – December 31, 2008

FIGURE 2: Total Trade and Open Interest

FIGURE 3: Distribution of percentage spreads for stocks and CFDs across companies.

FIGURE 4: Average percentage spreads for stocks and CFDs across time

FIGURE 5: CFD Spreads (%) for selected stocks

FIGURE 6: Distribution of the price boundary violations by company

Appendix 1 – Tax Credit Cashflow Arrangements

Because Australia has a dividend imputation tax system, many companies pay *franked dividends* which carry a tax credit for Australian taxpayers.[26] Equivalence between CFD and underlying stock positions would thus require an additional "franking credit payment" of cash equivalent to the tax credit. However, Australian tax law precludes use of such tax credits where the shareholder has not held the shares for at least 45 days around the ex-date, or has engaged in hedging transactions involving the stock. Consequently, in designing the CFD contract, the ASX has exempted DPMs with short CFD positions (likely to be hedged by long positions in the stock) from the requirement to make franking credit payments. DPM positions are mandatorily netted- off at ex-div date to determine their net short (or long) position in order to calculate tax-credit cashflows. This creates an asymmetry for traders with positions at the ex-div date, with short positions requiring payment of the franking credit equivalent, but long positions receiving only a fraction of the franking credit equivalent dependent upon the proportion of short positions which are held by DPMs.

These specific arrangements imply that open interest should decline substantially at the ex-div dates, particularly for franked dividends and this result is observable in the data.

[26] Cannavan , Finn and Gray (2004) consider the implications of franked dividends for the pricing of individual share futures in Australia (which were delisted by the ASX with the introduction of CFDs).

Appendix 2 – Cash Flows, Pricing and Margining

Table A1 illustrates the daily cash flows for a CFD margin account (row 4) as a result of daily gains or losses and the daily interest charge on a long CFD position. For simplicity of exposition we assume there are no dividends, no initial margin and no "open interest charges" of the form levied by the ASX. The long CFD position is opened at price CFD_0 at the end of day 0. The daily rate of interest charged on the long position is *r* applied to the DSP of the previous day.

1	Day	0	1	2	….	n
2	Stock price (DSP)	S_0	S_1	S_2	….	S_n
3	CFD price	CFD_0				CFD_n
4	Margin account gain/loss		$S_1 – CFD_0 – rS_0$	$S_2 – S_1(1+r)$		$CFD_n - S_{n-1}(1+r)$
5	Day i gain/loss (compounded to day n)		$(S_1 – CFD_0 – rS_0)(1+r)^{n-1}$	$[S_2 – S_1(1+r)](1+r)^{n-2}$	….	$CFD_n – S_{n-1}(1+r)$

Table A1: Daily cash flows on a long CFD position.

For example, at the end of day 1, the gain/loss to the margin account on the long CFD is the difference between the day DSP (S_1) and the opening CFD price (CFD_0) minus the interest that must be paid on the long position (calculated using the day 0 DSP, S_0). This is given by

$S_1 – CFD_0 – rS_0$.

On day 2 the gain/loss is given by

$S_2 – S_1 – rS_1$.

In row 5 the daily profit/loss is assumed to accrue at rate *r* in the margin account until the sale of the CFD at day *n* at price CFD_n.

The sum of the row 5 entries is the cumulative gain/loss on the position when it is closed out at day *n* and is given by

$$\Sigma_{CFD} = CFD_n – CFD_0(1+r)^{n-1} – rS_0(1+r)^{n-1} \qquad \text{(A1)}$$

which if the initial CFD price equals the share price, simplifies to

$$\Sigma_{CFD} = CFD_n - CFD_0(1+r)^n = CFD_n - S_0(1+r)^n, \qquad \text{(A2)}$$

If an initial margin of M is required and earns interest at *r* per cent the gain or loss becomes

$$\Sigma_{CFD} = S_n - S_0(1+r)^n + M(1+r)^n - M$$

$$= (S_n - M(1+r)^n) - (S_0 - M) \qquad \text{(A3)}$$

Note the following. First the ultimate profit/loss does not depend on share prices over the intervening period (or how the DSP is determined other than for date 0), as expected for a futures contract with deterministic interest rates (Cox, Ingersoll and Ross 1981). Because the initial margin and ASX open interest charge of 1.5% per annum are fixed charges, including these does not alter this conclusion. Second, the CFD gain/loss in (A2) is the same as that on a long forward position in the stock (since the forward price is $S_0\ (1+r)^n$). Third, equation (A3) illustrates the equivalence of a long CFD position to a margin loan financed stock position.

Appendix 3 – Panel Regression Methods

For notational purposes let the parameter vector $\beta = (\beta_1, \beta_2, ...\beta_6)$ denote the slope coefficients for the regressors in Equation 4 above. The pooled OLS (POLS) approach ignores any parameter heterogeneity and estimates

$$CFDS_{it} = \beta_0 + \beta x_{it} + \varepsilon_{it}, \quad \varepsilon_{it} \sim iid\left(0, \sigma^2\right), \quad i = 1, ..., N, \; t = 1, ...T \qquad \text{(A3.1)}$$

If the variables are non stationary and cointegrate, the estimator is consistent. Phillips and Moon (1999) showed that the estimator is still consistent even when the errors are I(1).[27] This result is of importance here, given that the residuals from the OLS regressions above showed very mixed results, with some regressions suggesting the residuals were I(1). If however cross unit cointegration is present (in the dependent and independent variables) and ignored, Banerjee *et al* (2004) show via simulation that inferences using the pooled approach can be terribly misleading. Further, if cross sectional dependence between the regressors and residuals exists and is driven by the same factor, the estimator is inconsistent.[28]

The cross section (CS) regression of Pesaran and Smith (1995) estimates

$$\overline{CFDS}_i = \beta_0 + \beta \bar{x}_i + \varepsilon_i, \quad \varepsilon_i \sim iid\left(0, \sigma^2\right), \quad i = 1, ..., N \qquad \text{(A3.2)}$$

where $\overline{CFDS}_i = T^{-1}\sum_{t=1}^{T} CFDS_{it}$ and $\bar{x}_i = T^{-1}\sum_{t=1}^{T} x_{it}$ are the unit means. This procedure obviously removes any unit root issues. If cross-sectional dependence between the errors and regressors is driven by a common factor, under certain circumstances the estimator may still be consistent.

The well known two way fixed effects (2FE) estimator is

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[27] This result is at odds with the univariate time series literature, where it is well known that an I(1) error results in a spurious regression. By using a panel however, the strong noise of the residuals is reduced by the pooling of data, thereby enabling a consistent estimate of the beta vector to be obtained.

[28] Urbain and Westerlund (2006) complement these results analytically showing that the statistics diverge with the size of the cross section. If however at least one variable does not cointegrate across units, normality is again possible, with the centre of the distribution located at the long run average coefficient.

$$CFDS_{it} = \beta_{0i} + \beta_{0t} + \beta x_{it} + \varepsilon_{it}, \quad \varepsilon_{it} \sim iid\left(0, \sigma^2\right), \tag{A3.3}$$

where the intercepts differ by unit and time. If a common factor causes the errors and regressors to be contemporaneously correlated, the estimates remain consistent as long as the loadings attached to the factors are independent.

The mean group (MG) estimator allows for different slopes and separately estimates the following regression for each unit by OLS

$$CFDS_{it} = \beta_0 + \beta_i x_{it} + \varepsilon_{it}, \quad \varepsilon_{it} \sim iid\left(0, \sigma_i^2\right). \tag{A3.4}$$

The overall coefficient for each explanatory variable in the panel is then calculated as the average of the N estimates. i.e $\hat{\beta} = N^{-1}\sum_{i=1}^{N}\hat{\beta}_i$. The standard errors are calculated as $s.e = \sqrt{1/N\left(N-1\right)\sum_{i=1}^{N}\left(\hat{\beta}_i - \overline{\beta}\right)^2}$. Like POLS, even if the errors are I(1), the individual OLS regressions will be spurious, however the averaging will reduce the effects of the noise in the residuals and allow a consistent estimate for large *N*.

Finally, the Common Correlated effects mean group (CCMG) estimator estimates the following

$$CFDS_{it} = \beta_{0i} + \beta_i x_{it} + c_{1i}\overline{CFDS_t} + c_{2i}\overline{x_t} + \varepsilon_{it}, \quad \varepsilon_{it} \sim iid\left(0, \sigma_i^2\right) \tag{A3.5}$$

where $\overline{CFDS_t}$ and $\overline{x_t}$ represent the cross section averages which act as proxies for the latent factors. Like the MG estimator, individual OLS regressions are estimated and the coefficients are calculated as the average of the estimates. Standard errors are also calculated in the same way as the MG estimator.

TABLE 1: Arbitrage Portfolio cash flows for CFD purchase and stock short sale.

This Table shows the cash flows associated with establishing an arbitrage portfolio at date T-1 involving a long position in a hypothetical CFD contract which expires at date T and a short position in the underlying stock, assuming that the CFD contract interest rate and that available on the proceeds of the short sale are equal. Absence of arbitrage implies that at date *T*-1 the stock price (S_{T-1}) and the CFD price (P_{T-1}) must be equal. Proof of price equality for earlier dates is by induction, substituting proceeds of market sale of the CFD on the next day for CFD settlement cash flows.

	Date T-1	**Date T**
Short sell stock at date *T*-1	$+S_{T-1}$	
Invest proceeds of short sale	$-S_{T-1}$	$+S_{T-1}(1+r)$
Pay any dividend D_T		$-D_t$
Buy and deliver stock at date *T*		$- S_T$
Buy CFD at date *T*-1		
Pay contract interest		$-rS_{T-1}$
Receive dividend		$+D_T$
CFD settlement		$+(S_T - P_{T-1})$
Net Cash Flow	0	$S_{T-1} - P_{T-1}$

TABLE 2: Descriptive Statistics: CFD Trading, November 2007 – December 2008

		Daily CFD trade volume	Number of CFD trades per day	CFD trade size	Time between CFD trades (mins)	Time between CFD & next stock trade (mins)	$ price diff between CFD & next stock trade	% price diff between CFD & next stock trade	% of CFD trades where CFD vol equals next stock vol
All	Mean	9023	8.93	1010	22.41	0.068	-0.0018	-0.01%	19.31%
	Median	4645	4.00	500	2.65	0.006	-0.0000	-0.00%	
	Std dev	13399	12.63	1729	47.53	0.230	0.0839	0.36%	
	Min	0	0.00	1	0.00	0.000	-8.9500	-31.30%	
	Max	280000	288.00	83000	351.35	18.061	5.1900	29.70%	
BHP	Mean	33791	34.23	987	10.75	0.035	-0.0012	-0.00%	12.64%
	Median	28110	31.50	750	3.07	0.007	-0.0000	-0.00%	
	Std dev	24499	17.89	1203	20.09	0.076	0.0574	0.16%	
	Min	2800	4.00	1	0.00	0.000	-2.6700	-7.44%	
	Max	150510	94.00	15000	269.88	1.283	0.3700	1.02%	
TLS	Mean	21609	2.46	8788	62.47	0.104	-0.0004	-0.01%	21.49%
	Median	12000	2.00	5000	20.86	0.011	-0.0000	-0.00%	
	Std dev	32497	2.37	10026	85.22	0.217	0.0132	0.31%	
	Min	1	1.00	1	0.00	0.000	-0.0500	-1.15%	
	Max	280000	16.00	83000	303.89	1.822	0.0600	1.37%	
FXJ	Mean	9597	2.29	4191	19.72	0.221	-0.0021	-0.10%	10.58%
	Median	5000	1.00	3000	0.61	0.026	-0.0050	-0.23%	
	Std dev	9569	2.33	3729	53.13	0.430	0.0162	0.61%	
	Min	500	1.00	200	0.00	0.000	-0.0400	-2.13%	
	Max	36000	12.00	21000	251.01	2.282	0.0300	1.02%	
QBE	Mean	6654	7.46	892	28.00	0.055	-0.0008	-0.00%	27.13%
	Median	3000	5.00	500	2.62	0.005	-0.0000	-0.00%	
	Std dev	9499	7.76	1252	56.09	0.141	0.0629	0.27%	
	Min	67	1.00	1	0.00	0.000	-0.8500	-4.18%	
	Max	58305	62.00	8399	335.77	2.260	1.1900	5.22%	
CSL	Mean	2253	5.84	389	37.21	0.094	0.0007	0.00%	14.12%
	Median	1500	4.00	500	6.62	0.011	-0.0000	-0.00%	
	Std dev	2296	5.40	262	65.11	0.224	0.0580	0.16%	
	Min	20	1.00	1	0.00	0.000	-0.2000	-0.52%	
	Max	13750	31.00	3000	345.87	2.246	0.5400	1.65%	
CSR	Mean	4313	1.92	2504	44.08	0.192	0.0004	-0.00%	31.25%
	Median	3000	1.00	2000	0.72	0.011	-0.0000	-0.00%	
	Std dev	5527	1.42	2530	81.14	0.528	0.0238	0.89%	
	Min	200	1.00	200	0.00	0.000	-0.0400	-1.97%	
	Max	41500	8.00	15000	304.49	3.451	0.2100	7.02%	

TABLE 3: Daily Distribution of CFD Trading:

November 19, 2007 – December 31, 2008

Statistic	Percentage of CFD's traded	Share of total value traded of		
		Largest CFD traded	Second largest CFD traded	Third largest CFD traded
Average	60.5%	28.0%	15.9%	10.8%
Minimum	29.8%	11.2%	3.7%	2.6%
Maximum	80.9%	87.0%	31.1%	21.0%

TABLE 4: Summary of Univariate Unit Root tests

This table displays the number of times that the test supported an I(1) variable using a 5% (10%) level of significance. ADF is the augmented Dickey Fuller test, KPSS is the test of Kwiatkowski, Phillips, Schmidt and Shin. SIC and AIC are the Akaike and Schwarz information criteria respectively. The bandwidths for the KPSS test were determined using the method of Newey-West and Andrews. See Eviews v5.0 for details.

	Lag length/ Band-width	CFD Spread	Stock Spread	Stock value	Price Inverse	Stock Volatility	CFD Volume
ADF	SIC	18 (15)	32 (27)	3 (1)	39 (37)	4 (3)	0 (0)
	AIC	27 (23)	41 (37)	9 (7)	40 (38)	18 (17)	7 (5)
KPSS	N-West	40 (44)	44 (45)	27 (34)	38 (40)	43 (45)	28 (29)
	Andrews	32 (42)	37 (44)	24 (35)	12 (33)	45 (46)	29 (30)

TABLE 5: Cross-sectional dependence

Residual is the OLS residual from Equation 4. $\bar{\rho}_{ij}$ denotes the average cross section correlation, $\%V_p$ denotes the proportion of variability explained by the pth principal component (p = 1,2) from the relevant correlation matrix.

	CFD Spread	Stock Spread	Stock Value	Price inverse	Stock Volatility	CFD volume	OLS Residual
$\bar{\rho}_{ij}$	0.47	0.50	0.35	0.50	0.34	0.07	0.19
$\%V_1$	0.52	0.50	0.36	0.60	0.35	0.11	0.27
$\%V_2$	0.10	0.12	0.06	0.17	0.05	0.05	0.13

TABLE 6: Estimation Results

Panel A reports coefficients and t-statistics for five estimation methods. Each of the five estimation methods are robust when the data exhibits non-stationarity (in the variables and the residuals) and cross-sectional dependence. The pooled OLS method pools the data (forming 11,248 daily observations) and estimates one regression via OLS. The Cross section method calculates for each of the N=46 assets, the average value over time for each variable. This creates 46 observations and facilitates the estimation of one regression via OLS. The two way fixed effects estimator is a panel estimator that allows the intercept terms to differ by unit and time. The reported constant is an average intercept with the fixed effects coefficients (not reported) representing deviations from the mean. The mean group (MG) estimator estimates equation 4 separately for each of the N=46 assets. The reported coefficients represent the average. The CCMG estimator adds the cross section averages of stock spread, stock trading value, price inverse, stock volatility and CFD volume to equation 4. The new equation is then separately estimated for each of the N=46 assets. The reported coefficients represent the average across each of the regressions.
Panel B reports the sensitivity (coefficients and t-values) of the cross-sectional regression to the removal of the stock spread and price variables. Stock spread and price are highly correlated in the cross-sectional regression (coefficient of 0.96). As a consequence the table examines the regression results when either the spread or the price variable are removed. The results are consistent with the high levels of correlation between these two variables.
***, **, * denotes significance at the 1%, 5% and 10% levels respectively. n.a denotes not applicable, this is due to the nature of the estimator. For further details see the Appendix. Newey-West standard errors are employed.

Panel A

Method	Constant	Stock Spread	Stock trading value	Price inverse	Stock Volatility	Market Volatility	CFD volume	Interest spread	Sept dummy
Pooled OLS	-0.313* (-1.81)	2.094*** (17.86)	-0.002 (-0.23)	14.350*** (22.13)	3.376*** (9.83)	6.495*** (10.01)	-0.008*** (-4.27)	0.006*** (9.51)	1.755*** (19.41)
Cross section	1.015 (1.10)	0.439 (0.47)	-0.043 (-0.92)	20.518*** (4.05)	5.431** (2.30)	n.a	-0.029** (-2.07)	n.a	n.a
Two way FE	-0.621** (-2.04)	2.947*** (18.42)	0.026 (1.53)	15.732*** (23.19)	1.976*** (5.04)	n.a	-0.007*** (-3.24)	n.a	n.a
Mean Group	-0.451** (-2.00)	1.857*** (6.29)	0.003 (0.21)	20.241*** (2.78)	2.059*** (4.09)	6.624*** (5.91)	-0.009*** (-2.85)	0.007*** (3.02)	1.581*** (7.43)
CCMG	-0.147 (-0.39)	1.594*** (4.99)	0.008 (0.59)	28.106*** (2.48)	1.453*** (3.12)	0.488 (0.56)	-0.006** (-1.86)	3.5e-04 (0.39)	0.039 (0.10)

Panel B

Method	Constant	Stock Spread	Stock value	Price inverse	Stock Volatility	Market Volatility	CFD volume	Sept dummy
Cross section	-1.240 (-1.591)	3.543*** (8.855)	0.065 (1.451)	-	7.142*** (2.752)	n.a	-0.031** (-2.193)	n.a
Cross section	1.325** (2.374)	-	-0.057* (-1.716)	23.152*** (11.033)	5.387** (2.336)	n.a	-0.030** (-2.204)	n.a

TABLE 7: The relation between spreads in the CFD market and those in the underlying stock: Subsample Analysis

This table shows the results of running a Pooled OLS regression for equation (4):

$$CFDS_{i,t} = \beta_0 + \underset{+}{\beta_1} SS_{it} + \underset{-}{\beta_2} \ln\left(M_{i,t}\right) + \underset{+}{\beta_3} \left(1/P_{i,t}\right) + \underset{+}{\beta_4} \sigma_{s,t} + \underset{+}{\beta_5} \sigma_{m,t} + \underset{-}{\beta_6} \ln\left(1+V_{i,t}\right)$$
$$+ \underset{+}{\beta_7} IS_t + \underset{+}{\beta_8} D_t$$

where the subscripts *i* and *t* refer to contract *i* and time *t* respectively, and the signs under the coefficients reflect their expected signs. CFDS (SS) is the percentage spread of the CFD (the corresponding stock) at time t, M is the dollar value of the day's trades in the stock, P is end of day stock price (the settlement price for the CFD), $\sigma_{s,t}$ ($\sigma_{m,t}$) is stock (market) volatility (measured as the natural logarithm of the ratio of high over low price for the day), V is the daily dollar volume of trading in the CFD, IS_t is an interest rate spread – the 30day bank bill rate minus the 30 day OIS and D_t is a dummy variable equal to unity on September 22 and 23, otherwise zero.

[#] The t test is a test of the difference in the means of two independent populations having unequal variances. The t test compares the estimates from the two sub-samples. The critical values for the two tailed test at a 5% level of significance are -1.96 and 1.96.
***, **, * denotes significance at the 1%, 5% and 10% levels respectively.

Period	Constant	Stock Spread	Stock value	Price inverse	Stock Volatility	Market Volatility	CFD volume	Interest spread	Sept dummy
Full	-0.313*	2.094***	-0.002	14.350***	3.376***	6.495***	-0.008***	0.006***	1.755***
	(-1.81)	(17.86)	(-0.23)	(22.13)	(9.83)	(10.01)	(-4.27)	(9.51)	(19.41)
	Adj R square	0.423	F statistic (p value)	1021.06 (0.000)					
2.1.08 19.9.08	0.351***	0.902***	-0.015***	16.434***	1.891***	1.794***	-0.010***	0.002***	n.a
	(5.51)	(12.10)	(-4.39)	(28.05)	(12.09)	(6.51)	(-13.88)	(6.38)	
	Adj R square	0.690	F statistic (p value)	2529.48 (0.000)					
22.9.08 31.12.08	-1.623***	3.850***	0.070**	10.841***	2.522***	9.281***	-0.008	-0.002	1.856***
	(-2.76)	(12.79)	(2.18)	(8.59)	(2.90)	(4.53)	(-1.12)	(-1.00)	(11.50)
	Adj R square	0.337	F statistic (p value)	199.73 (0.000)					
t test of difference in coefficient estimates[#]		-543.6***	-	238.87***	-40.56***	-204.80***	-	-	-

TABLE 8: CFD price boundary violations

CFD	No of violations (% of sample)	No of negative violations (% of sample)	W-W runs test (p value)	Descriptive statistics of % difference between CFD and subsequent spot price for cases of violations					Time between CFD and subsequent spot price (minutes)	
				Avg (t test)	Median (Wilcoxon test)	Std dev	Min	Max	Avg	Median
Panel A: Transaction costs +/- 1%										
All	405 (0.68%)	224 (0.38%)		-0.33% (-1.73)*	-1.04% (-2.53)**	3.84%	-31.30%	29.70%	0.159	0.010
BHP	14 (0.18%)	13 (0.17%)	0.000***	-2.43% (-3.96)***	-1.63% (-3.04)***	2.21%	-7.44%	1.02%	0.026	0.019
TLS	3 (1.01%)	1 (0.34%)	0.000***	0.43% (0.54%)	1.08% (0.53%)	1.13%	-1.15%	1.37%	0.012	0.007
FXJ	6 (7.69%)	5 (6.41%)	0.341	-0.98% (-2.28)**	-1.15% (-1.99)**	0.96%	-2.13%	1.02%	0.065	0.012
QBE	6 (0.42%)	3 (0.21%)	0.021**	0.11% (0.07)	-0.57% (0.10)	3.31%	-4.18%	5.22%	0.041	0.012
CSL	2 (0.18%)	0 (0%)	0.002***	1.63% (53.88)***	1.63% (1.34)	0.03%	1.60%	1.68%	0.001	0.001
CSR	11 (9.24%)	7 (5.88%)	0.001***	0.29% (0.36)	-1.09% (-0.27)	2.49%	-1.97%	7.02%	0.073	0.036
Panel B: Transaction costs +/- 0.5%										
All	1757 (2.97%)	931 (1.57%)		-0.10% (-2.13)**	-0.51% (-2.41)**	1.94%	-31.30%	29.70%	0.164	0.014
BHP	29 (0.37%)	24 (0.31%)	0.000***	-1.30% (-3.57)***	-0.66% (-3.34)***	1.93%	-7.44%	1.02%	0.039	0.020
TLS	14 (4.71%)	7 (2.35%)	0.018**	0.08% (0.35)	-0.01% (0.28)	0.82%	-1.15%	1.37%	0.022	0.009
FXJ	38 (48.72%)	19 (24.36%)	0.000***	-0.12% (-0.91)	-0.03% (-1.56)	0.82%	-2.13%	1.02%	0.213	0.040
QBE	23 (1.60%)	10 (0.70%)	0.005***	0.15% (0.41)	0.56% (1.06)	1.78%	-4.18%	5.22%	0.112	0.017
CSL	10 (0.93%)	1 (0.09%)	0.003***	0.71% (3.69)***	0.60% (2.70)***	0.58%	-0.52%	1.68%	0.095	0.016
CSR	43 (36.13%)	22 (18.49%)	0.030**	0.07% (0.33)	-0.51% (-1.00)	1.40%	-1.97%	7.02%	0.108	0.021

***,**,*, Denotes statistical significance at the 1%, 5% and 10% levels of significance respectively. The t test (Wilcoxon test) was employed to test whether the mean (median) was significantly different from zero.
W-W runs test – denotes the Wald-Wolfowitz runs test for randomness. A statistically significant result indicates that there are clusters of violations which are not caused by random fluctuation.

TABLE 9: Pricing errors regressions

This table reports coefficients and t-values from the following regression

$$\left|e_t\right| = \alpha + \beta_1 D_{start,t} + \beta_2 D_{sept,t} + \beta_3 Vol_t + \beta_4 D_{sept,t} Vol_t + \beta_5 \left|e_{t-1}\right| + \varepsilon_t$$

where $e_t = (CFD_t - S_t) \times 100$ (i.e the pricing error is measured in cents), $D_{start,t} = 1$ if the observation is in the first month of the sample, otherwise zero, $D_{sept,t} = 1$ for dates after and including September 22, 2008, otherwise zero.

***,**,*, Denotes statistical significance at the 1%, 5% and 10% levels of significance respectively. Newey-West HAC standard errors are employed.

CFD	α	β_1	β_2	β_3	β_4	β_5	Adj R squared	F stat (p value)
BHP	1.362***	-0.142	0.921***	-3.4e-05	-1.5e-04	0.285***	0.802	4538.17***
	(20.83)	(-1.61)	(4.67)	(-1.62)	(-1.00)	(9.02)		(0.000)
TLS	0.919***	-0.187*	0.122	-7.5e-06**	-1.2e-05	0.196**	0.046	3.847***
	(8.35)	(-1.67)	(0.91)	(-2.17)	(-0.46)	(2.06)		(0.002)
FXJ	1.149***	-0.214	0.061	-4.1e-05*	-3.7e-06	0.280**	0.061	1.99*
	(4.71)	(-1.64)	(0.18)	(-1.98)	(-0.07)	(2.17)		(0.090)
QBE	2.502***	0.548	2.383***	-4.2e-05	-0.001	0.039	0.639	362.92***
	(17.21)	(1.44)	(4.39)	(-0.90)	(-1.56)	(1.35)		(0.000)
CSL	3.120***	-0.636	2.916**	0.001	-0.004**	0.132***	0.315	84.35***
	(14.90)	(-1.60)	(4.26)	(1.15)	(-2.54)	(4.41)		(0.000)
CSR	1.065***	0.147	0.473**	2.1e-05	-3.6e-05	0.024	0.877	139.82***
	(13.17)	(0.59)	(2.57)	(1.07)	(-1.21)	(0.95)		(0.000)

TABLE 10: Boundary violation regressions

This tables reports coefficients and t-values for the following regression, which is estimated via OLS with Newey West standard errors

$$V_i = \lambda_0 + \lambda_1 Trade_i + \varepsilon_i$$

where V_i is the percentage of mispricing for the CFD of stock *i*, and $Trade_i$ is the average number of trades per day for the CFD of stock *i*.

*** Denotes statistical significance at the 1% level of significance.

Transaction costs	λ_0	λ_1	Adj R squared	F statistic (p value)
1%	0.031*** (5.60)	-0.002*** (-3.35)	0.136	7.76*** (0.008)
0.5%	0.155*** (5.67)	-0.008*** (-3.53)	0.200	10.74*** (0.002)

FIGURE 1: Distribution of Mean CFD Trades per Day by Company: November 5, 2007 – December 31, 2008

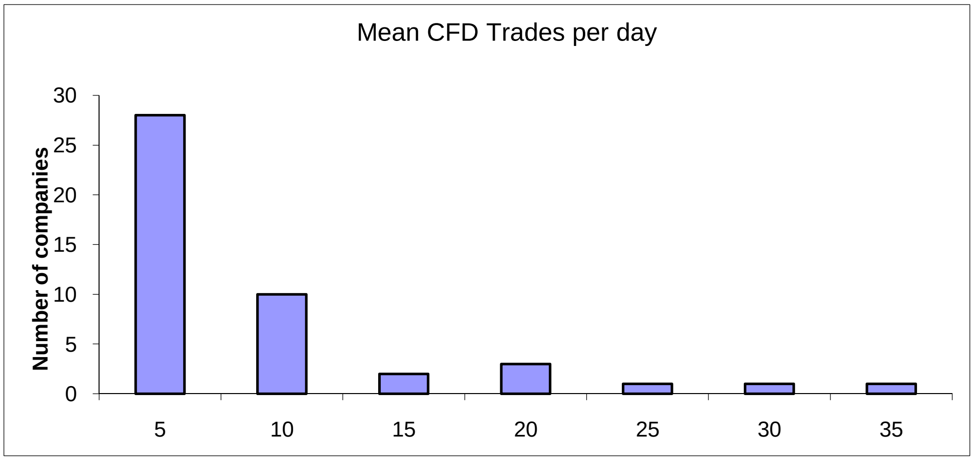


FIGURE 2 Total Trade and Open Interest

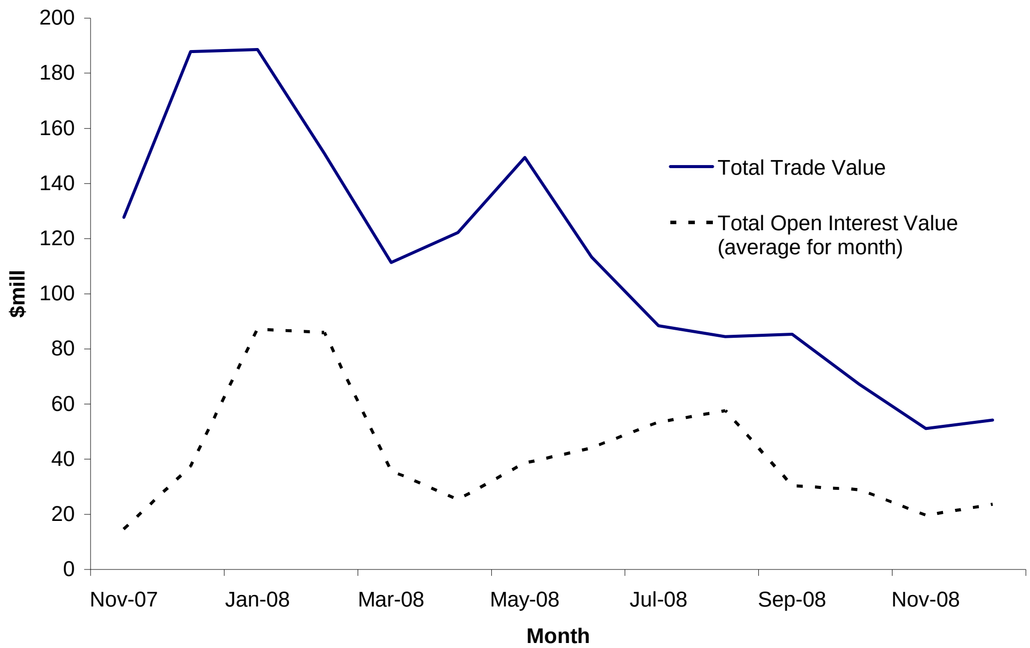


FIGURE 3: Distribution of percentage spreads for stocks and CFDs across companies.

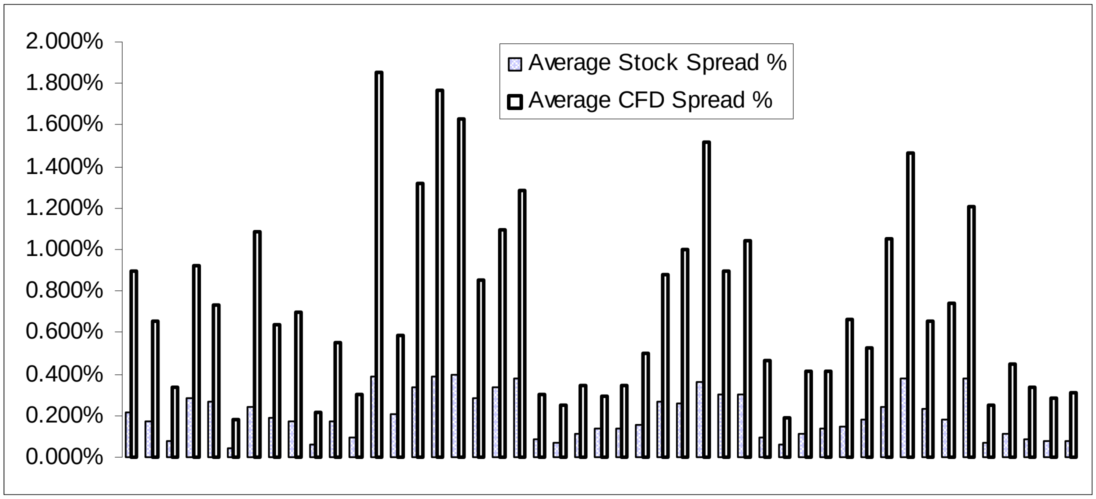


FIGURE 4: Average percentage spreads for stocks and CFDs across time

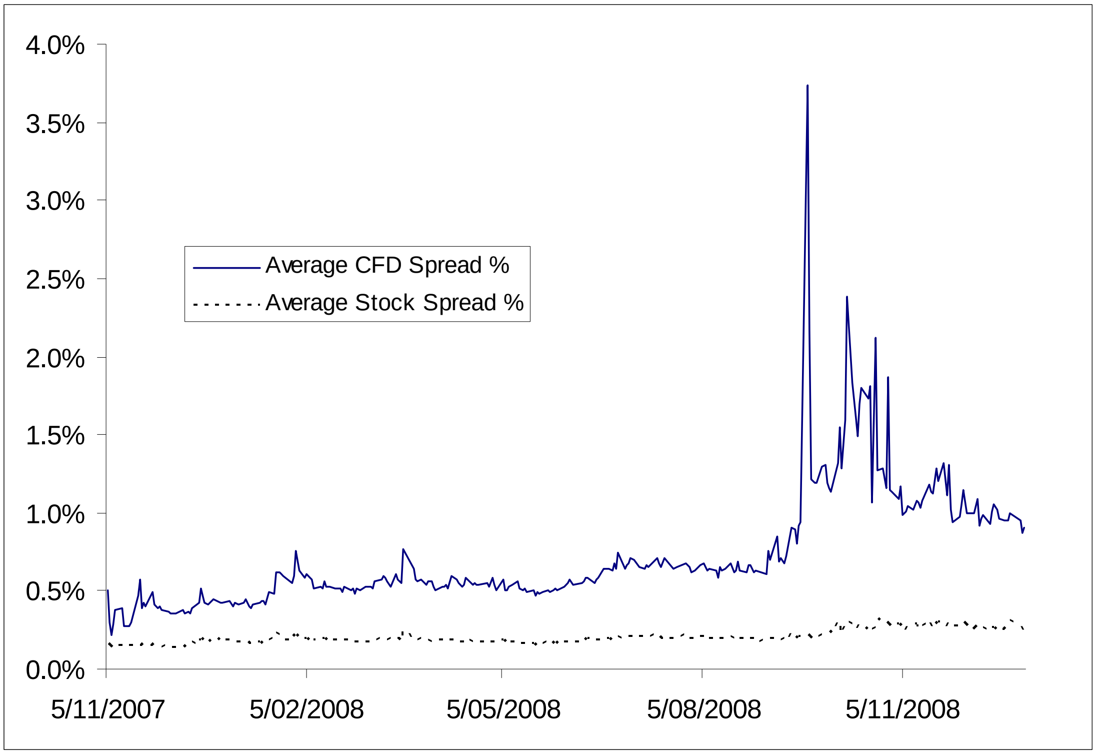


FIGURE 5: CFD Spreads (%) for selected stocks

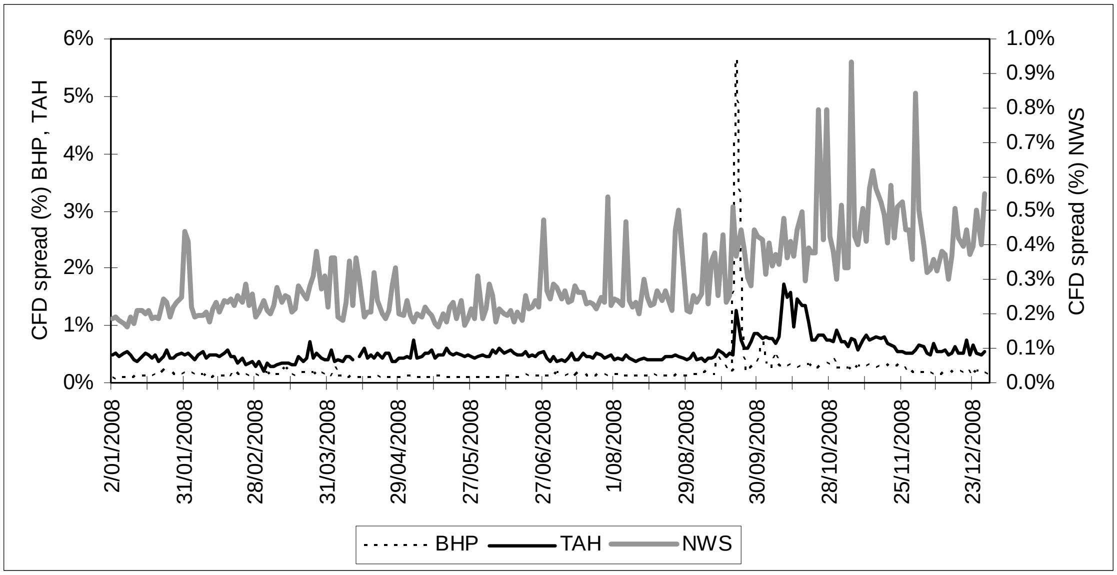
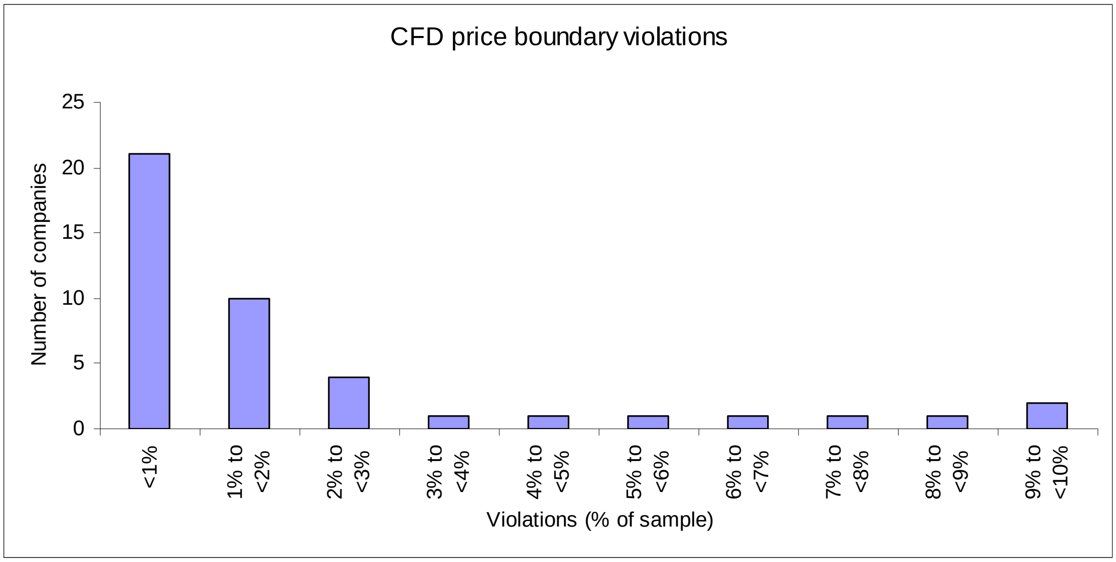
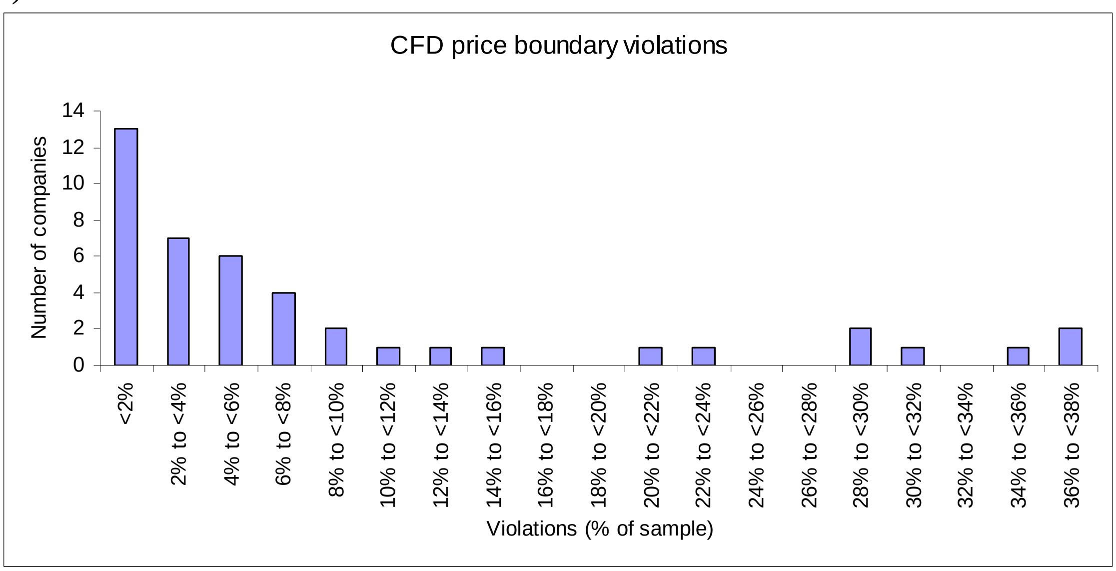


FIGURE 6: Distribution of the price boundary violations by company

a) Transaction costs of 1%



b) Transaction costs of 0.5%



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