Price Discovery in the Indian Gold Futures Market

Piyamas Chaihetphon • Pantisa Pavabutr*

Abstract This paper examines the price discovery process of the nascent gold futures contracts in the Multi Commodity Exchange of India (MCX) over the period 2003 to 2007. The study employs vector error correction models (VECMs) to show that futures prices of both standard and mini contracts lead spot price. We find that mini contracts contribute to over 30% of price discovery in gold futures trade even though they account for only 2% of trading value on the MCX. Our finding reveals that trades initiated in mini contracts are much more informative than what the size of their market share of volume suggests.

Keywords: Gold futures, Price discovery, Information share
JEL classification: G14; G15

1. Introduction

Futures markets perform two important roles, hedging of risks and price discovery. The efficacy of the hedging function is dependent on the price discovery process or how well new information is reflected in price. In general, futures markets are found to respond faster to new information than spot markets since the transaction cost is lower and the degree of leverage attainable is higher.

Another important issue on market quality is the contribution to price discovery when the trading of an underlying asset is dispersed over multiple trading systems or different contract specifications, usually based on size.[1] Standard contracts are typically larger in size and intended for institutional customers. Mini contracts are smaller sized

* Corresponding author: Department of Finance, Faculty of Commerce and Accountancy, Thammasat University, 2 Prachan Rd. Bangkok 10200, Thailand. Tel: +662-225-2107,
e-mail: pantisa@gmail.com

Piyamas Chaihetphon
Merrill Lynch Securities (Thailand) Limited, 87/2 Wireless Rd. Bangkok 10330
e-mail: Piyamas_Chaihetphon@ml.com

[1] Mendelson (1987) defines a fragmented market as one where orders are decomposed into a number of disjoint subsets and when an asset is traded in a number of different locations.

contracts that are designed to appeal to retail customers who cannot afford standard contracts.[2] Opponents of contract separation argue that introduction of multiple contracts may result in fragmented liquidity and impede price efficiency. Besssimbinder and Kaufman (1997) and Mendelson (1987) show that stock trading in multiple markets results in lower liquidity and higher volatility. Wang et al. (2007) find that the introduction of E-mini futures contracts for S&P500 and NASDAQ 100 indices lead to a deterioration of market depth and an increase in bid-ask spreads of standard futures contracts. Other authors (Chowdhry and Nanda (1991) and Theissen (2002)) find that price discovery is positively related to volume market shares as liquidity and informed trading are expected to concentrate in one market.

This paper examines the price discovery process of standard gold futures contract and mini gold futures contracts in the Multi Commodity Exchange of India (MCX) over the period 2003-2007.

Our analysis provides strong evidence that futures prices lead spot prices. In addition, mini contracts account for approximately 37% of the price discovery process even though they represent only 2% of the trading value on the MCX. The finding suggests that these smaller contracts allow efficient transmission of information as retail investors are known to trade more frequently and often engage in spread trading to take advantage of mispricing in futures contracts leading to timely price responses.

In their studies using US market data, Hasbrouck (2003) and Tse and Xiang (2005) also find that mini contracts contribute to substantial portion of price discovery despite their relatively small trading value compared to the standard contracts. While Hasbrouck (2003) explore the price dynamics on S&P 500 and NASDAQ 100 equity

[2] For example, the Chicago Board of Trade (CBOT) offers full (100 ounce) and mini gold (33.2 ounce) futures contracts. The MCX offers standard (1 kilogram) and mini gold futures (100 grams) contracts.

futures, Tse and Xiang (2005) conduct comparisons on regular and mini contracts on natural gas and crude oil. However, their comparisons are made across two different trading platforms, the dealership system where standard contracts are traded on the exchange floor and the electronic system where the so-called “E-mini” contracts are traded via an automatic order matching system. Thus, it is uncertain whether price discovery in E-mini contracts are attributable to superior speed of execution and price transparency of electronic trading or to efficient transmission of information among traders in small contracts. This concern can be alleviated in this study because both standard and mini contracts are traded on an electronic platform on the MCX.

The empirical results of this study offer useful insights into the design and development of gold futures trading in other Asian markets as they share similar characteristics.[3] Our analysis suggests that trading value market share may not always be a proxy for share of price discovery and mini-sized contracts not only provide affordability to retail investors but also aid price discovery.

.

The rest of the paper is organized as follows. Section 2 provides a brief literature survey. Section 3 describes market background and data overview. Sections 4 through 5 explain the empirical methods and discuss results. Section 6 concludes the paper.

2. Literature survey

Existing literature adopt two different approaches to measuring price discovery. The first approach uses lead-lag return regressions, vector autoregressive models (VARs), or vector error correction models (VECMs) to explore the temporal precedence or bivariate relationship between paired returns, i.e. futures returns and spot market returns.

[3] As the world’s second largest retail consumer of gold, China has recently introduced gold futures trading earlier in 2008.

In the equities market, Kawaller et al. (1987), and Stoll and Whaley (1990) find that S&P500 futures price lead spot price. Chan et al. (1991) and Pizzi et al. (1999) observe bi-directional causality between S&P500 futures and stock index, but note that the futures market has a stronger lead effect. Min and Najand (1999) report similar empirical findings in the case of Korean stock index futures.

Likewise, commodities futures prices are found to lead spot prices. Silvapulee and Moosa (1999) and Karande (2006) find that the futures prices of crude oil and castor seed lead spot prices. The most common explanation why a lead-lag relationship between the two markets is observed is that it is less costly for traders to exploit information in the futures market since transaction cost is lower and the degree of leverage attainable is higher. A lead in the futures prices implies that price is being discovered first in that market.

The second approach presumes that securities that are based on the same underlying assets must share one or more common factors and thus it is possible to determine the proportion of contribution to price discovery of one security over another.

This concept is first discussed in Garbade and Silber (1982) where the authors examine seven types of agriculture and precious metals commodities and show that futures markets account for 75% of new information and dominate spot markets in price discovery. Hasbrouck (1995) use this idea to develop the concept of "information share," which is determined by the proportion of innovation variance that is attributable to a security. The information share approach has been adopted in a number of existing studies, which we list next.

Hasbrouck (2003) shows that price discovery occurs in the E-mini futures market of the US S&P500 and NASDAQ100 index. Martens (1998) compares open outcry and electronic trading and concludes that the latter contributes to a larger (smaller) portion of information share when the market is in low (high) volatility state. Tse and Xiang (2005) find that NYNEX E-mini futures contracts on gas and crude contribute more than 30% of price discovery even though they account for less than 1% of the volume of standard contracts. They argue that the significant portion of price discovery in E-mini futures is attributable to the efficiency of electronic trading.

3. Market background and data description

3.1 Market Background

India is the world's largest consumer of physical gold. Dempster (2006) estimates that as of 2005 India accounted for 22% of global gold jewellery demand and 35% of all net retail investments (coins and bars). Although an active market for physical gold buying and selling has been in existence in India for a long time, the use of gold as a financial product has been a more recent phenomenon. The introduction of gold futures trading allows integration of demand and supply of market participants, i.e., gold and jewellery manufacturers, exporters and importers, and investors, in organized markets. Two local exchanges-the MCX, and the National Commodity Derivatives Exchange (NCDEX) introduced gold futures contracts in late 2003. The focus on the MCX is due to its dominance in gold futures trading in India.[4]

MCX was established on 10 November 2003 as an independent demutualized multi-commodity exchange. MCX's business focuses on globally traded commodities such as gold, silver, copper, crude oil and natural gas to serve a large cross-section of

[4] MCX accounts for over half of gold futures trading in India. Both MCX and NCDEX have similar structures. However, activity on NCDEX is largely driven by regional domestic crops whereas activity on MCX revolves around precious metals and crude oil.

participants including producers, traders, importers, and exporters among others.[5] The market is opened from Mondays through Saturdays. The MCX uses an electronic platform to match incoming orders. Trading sessions begins 10.00 a.m. to 11.30 p.m on Mondays to Fridays and from 10.00 a.m. to 2.00 p.m. on Saturdays. Trading of standard and mini gold futures on the MCX requires a 4% initial margin. All open positions are marked-to-market at the end of the day. A special margin in case of additional volatility can be imposed as deemed fit.

Gold futures contracts on MCX are settled with physical delivery. Quality specification for gold trading on MCX is at 99.5% purity. The gold must be serially numbered gold bars supplied by London bullion market association (LBMA) approved suppliers or other suppliers with quality certificates approved by MCX. We provide details of standard and mini contracts in the appendix.

3.2 Data Description

The data set, which consists of daily closing futures price and trading volume of standard gold futures contracts (F^S) and mini gold futures contracts (F^M) between November 2003 to December 2007, is obtained from the MCX through their web-site www.mcxindia.com. As the MCX does not offer an archive of spot prices, we obtain spot prices from their vendor, TickerPlant Infovending Limited from the website www.tickerinfo.com. Two types of contracts are available based on size. A standard contract has a trading unit of 1 kilogram or 1,000 grams, while a mini contract has a trading unit of 100 grams.[6] Our sample period covers 24 standard contracts and 40 mini contracts, in total amount of INR 20,479 billion or 23,012 tons of gold. To create a

[5] Among the three major national commodity exchanges, MCX account for almost 60% of total commodity trading.

[6] Large size gold futures contracts, known as High Net worth Individual contracts for trading unit of three kilograms was available earlier. However, due to limited interest, these contracts only existed only for a short period of time. To target smaller traders, MCX also launched an even smaller contract size of 8 grams called the “Gold Guinea” on May 8, 2008.

continuous series we cut-off the most immediate contract at the start of its delivery month and concatenate the next most immediate contract to the series.

Table 1 presents the summary statistics of daily price, return, volume, and value of standard gold futures contracts and mini contracts and daily price and return of spot gold for the entire sample period. The daily futures returns, ΔF_t, are derived from the natural log of the ratio F_t / F_{t-1}, expressed in percentages. As shown in Table 1, the daily return of futures and spot prices are approximately 0.05%. Daily standard deviations of return for standard and mini contracts are around 0.8%. The average daily trading value of standard contracts is INR 13.73 billion whereas the average daily trading value of mini contracts is INR 0.23 billion.

Panel A of Table 2 reports the contemporaneous correlation matrix between the natural log of standard gold futures contracts (*VOLS*), the natural log of volume of mini gold futures contracts (*VOLM*), return of standard contracts (ΔF_t^S), return of mini contracts (ΔF_t^M) and return of spot gold (ΔS_t). The correlations between the return of standard contracts and mini contracts and between their volumes are 0.95 and 0.78, respectively. Correlations between futures return and volume are small and negative for both standard contracts and mini contracts. Spot gold return has positive correlations with the return of standard contracts and the return of mini contracts. The correlation analysis indicates that there is a strong linkage between standard and mini contracts and between futures and spot returns.

Panel B of Table 2 reports the result of the Johansen Trace Test for cointegration of futures and spot prices and between standard and mini futures prices where *r* denotes the number of cointegrating vectors. In our case, the number of cointegrating vectors can be at most one because there are only two series in each test. Since the test statistic exceeds its critical value (5%) when the null is $r = 0$, but less than its critical value (5%) when the null is $r \leq 0$, we can conclude that one cointegrating vector is present and that futures and spot prices are cointegrated. It then follows that standard and mini contracts are also cointegrated. The test for cointegrating vectors confirms that each series can be represented by an error correction model, which will be used to examine the source of price discovery and the contributions to price discovery of standard and mini contracts.

4. Measuring price discovery and information share

4.1 Price discovery

In a frictionless market, security prices on the same underlying asset price should be perfectly correlated and that no lead-lag relationship should exist. When the price of security *1* leads the price of security *2*, we say that price is discovered in security *1* as it is the first security to respond to new information. Moreover, the price should be cointegrated, meaning that despite short-term deviations from each other, market forces will bring them back together in the long-run because the random walk component in their efficient prices are driven by the same fundamentals. Engle and Granger (1987) show that two cointegrated series have a VECM representation shown next,

$$\Delta p_t = \alpha z_{t-1} + A_1 \Delta p_{t-1} + \ldots + A_r \Delta p_{t-r-1} + \varepsilon_t \qquad (1)$$

where Δp_t is a vector of log returns, and z_t is the error correction term, which measures the differences in prices between the two securities,

$$\Delta p_t = \begin{bmatrix} p_{1,t} - p_{1,t-1} \\ p_{2,t} - p_{2,t-1} \end{bmatrix} \qquad (2)$$

$$z_{t-1} = p_{1,t-1} - \beta_t p_{2,t-1} \qquad (3)$$

A_i's are 2×2 matrix of parameters, r is the lag length determined by Schwarz information criterion (SIC), ε_t, is a 2×1 vector of serially uncorrelated residuals with a covariance matrix, Ω, $\alpha = [\alpha_1\ \alpha_2]$ and $\beta = [1, -1]$ are 2×1 matrices consisting of error correction and cointegrating vectors.

The VECM in equation (1) is comprised of two components, the first term measures how the left hand side variable adjusts to the previous period's deviation from long-run equilibrium. The error correction vector, $\alpha = [\alpha_1\ \alpha_2]$ measures the speed of the long-run adjustment. In a bivariate VECM, one of the coefficients α_1 or α_2 is expected to be non-zero and statistically significant, implying that the prices of the two securities are responsive to last period's equilibrium error. The remaining terms in equation (1) represent short-run adjustments of the left-hand-side variable to the previous period's change in price. From the VECM, security *1* leads security *2* if α_2 and the lagged first differences of security *1* have predictive power on the movement of security *2's* returns.

4.2 Information share

In order to determine the proportion of price discovery of standard and mini futures contracts, we adopt a model of information share developed in Hasbrouck (1995). The intuition behind Hasbrouck (1995) is that when two price series are cointegrated, their price innovations share a common component. The information share is defined as the proportion of contribution of one market's innovation to the innovation in the implicit common price.

To elaborate this concept, the VECM in equation (1) can be expressed in the form of a vector moving average (VMA):

$$\Delta p_t = i\psi\left(\sum_{\tau=1}^{t} \varepsilon_\tau\right) + \Psi(L)\varepsilon_t \qquad (4)$$

where i is a column vector of ones, $\psi = (\psi_1, \psi_2)$ is a row vector, and Ψ is a matrix polynomial in the lag operator. The first term in equation (4) captures the random-walk component that is common to all prices. The second term is the transitory component with zero-mean and stationary covariance.

The information share of a price series *1* is defined as the proportion of market contribution to the total variance given by,

$$IS_1 = \frac{\psi_1^2 \Omega_{11}}{\psi \Omega \psi'} \tag{5}$$

Equation (5) is a case when price innovations across markets are uncorrelated. If price innovations are correlated, Baille et al. (2002) demonstrate that the upper bound and lower bounds can be obtained by performing a Cholesky factorization of $\Omega = MM'$. There are many possible factorization, the lower triangular factorization shown in equation (7) will maximize (minimize) the information share on the first (second) security. By permuting the elements in *M*, we can create an upper (lower) bound for the second (first) security.

$$\Omega = \begin{bmatrix} \sigma_{1,\varepsilon}^2 & \rho\sigma_{1,\varepsilon}\sigma_{2,\varepsilon} \\ \rho\sigma_{1,\varepsilon}\sigma_{2,\varepsilon} & \sigma_{2,\varepsilon}^2 \end{bmatrix} \tag{6}$$

$$M = \begin{bmatrix} \sigma_{1,\varepsilon} & 0 \\ \rho\sigma_{2,\varepsilon} & \sigma_{2,\varepsilon}\left(1-\rho^2\right)^{1/2} \end{bmatrix} \tag{7}$$

We follow the approach of Baille et al. (2002) in deriving the information share from the error-correction coefficients α and the elements of the covariance matrix $\Omega = MM'$. The upper and lower bounds of the first and second security, IS_1, IS_2, are given in equations (8) and (9).[7]

$$IS_1 = \frac{\left(\alpha_2\sigma_{1,\varepsilon} + \alpha_1\rho\sigma_{2,\varepsilon}\right)^2}{\left(\alpha_2\sigma_{1,\varepsilon} + \alpha_1\rho\sigma_{2,\varepsilon}\right)^2 + \left(\alpha_1\sigma_{2,\varepsilon}\left(1-\rho^2\right)^{1/2}\right)^2} \tag{8}$$

$$IS_2 = \frac{\left(\alpha_1 \sigma_{2,\varepsilon}\left(1-\rho^2\right)^{1/2}\right)^2}{\left(\alpha_2 \sigma_{1,\varepsilon} + \alpha_1 \rho \sigma_{2,\varepsilon}\right)^2 + \left(\alpha_1 \sigma_{2,\varepsilon}\left(1-\rho^2\right)^{1/2}\right)^2} \tag{9}$$

Equations (8) and (9), indicate that the upper bound of the first security's information share is comprised of the first series' innovations from $\sigma_{1,\varepsilon}$ and its correlation with another series $\rho\sigma_{2,\varepsilon}$, whereas the lower bound of the second security only consists of the second series' innovations $\sigma_{2,\varepsilon}\,(1\text{-}\rho_2)^{1/2}$.

5. Empirical results

To determine whether price discovery takes place in both standard and mini futures prices, we estimate two sets of VECMs between standard futures and spot prices and between mini futures and spot prices. Table 4 presents the parameters from VECMs estimations. A lag length of four is used for both series.[8] The results of the VECMs support the presence for cointegration found earlier in the Johansen test. The size of error correction of spot returns, α_s's are positive and significant in both estimations. This means that an increase in the previous period's equilibrium error leads to an increase in the current period spot prices. In contrast, the size of error correction for futures returns, α_f's are negative and significant. A negative α_f implies that an increase in the previous period's equilibrium error is followed by a decrease in the current period futures prices. Both error correction coefficients suggest that a sustainable long-term equilibrium is attained by closing the gap between futures and spot price. In other words, spot prices rise to meet increases in futures prices while futures prices revert to spot prices. As shown, the error correction coefficients of α_s are 0.135 for standard contracts and 0.128 for mini

[7] See details of proof in Baille et a. (2002).

[8] To determine the appropriate number of lags, we first consider specifying a VAR order p, and obtain the optimal number of lags equal to five according to Schwarz information criterion (SIC). This criterion is applicable for choosing the number of lagged differences in a VECM because $p-1$ lagged differences in a VECM correspond to a VAR order p. (See Lütkepohl (2005)). Hence, for consistency and comparability, our VECMs will use the lag length of four throughout the paper.

contracts but the error correction coefficients of α_f are only -0.08 for standard contracts and -0.09 for mini contracts.

The short-run dynamics between futures and spot prices is measured by the coefficients on the lagged difference terms. We find that the change in yesterday's and the previous day's standard and mini futures returns has significant influence on spot returns, but past spot returns have no influence on current futures returns.

Overall, the results provide evidence that both standard and mini futures contracts exhibit a stronger influence over spot prices both in the short-run and long-run. This finding is consistent empirical evidence in previous research. As noted earlier, most studies of spot-futures relationships in equities market and commodity futures markets find that the two markets are closely related, with futures often leading spot markets in price discovery. What is surprising is the strength of mini contracts, despite their notably smaller contract size and trading value, in leading spot prices that appears to match that of standard contracts. Next, we examine price leadership between standard and mini futures contracts and determine each of their contributions to price discovery.

Table 5 presents the test results of VECM between standard and mini futures prices. The parameter estimates reveal that the return of standard contracts exert stronger influence in the adjustment process of the return of mini contracts as the error correction term α_m is 0.423 and statistically significant. In contrast, the error correction term on standard contracts α_s is -0.24 and insignificant implying that the return of standard contracts is less responsive to the previous period's pricing error. We also find that short-term disturbances up to the second lag from standard contracts have influence on the current return of mini contracts.

Table 6 reports the information share and trading share of standard and mini futures contracts. We find that mini contracts contribute up to 37% of the price discovery process, even they account for only 2% of trading value during the sample period. This estimate is based on the mid-point between the lower and upper bounds information share of mini contracts, which are 12% and 62%, respectively. We expect the fairly large contribution to price discovery of mini contracts to be a consequence of frequent trading by mini futures traders. Although mini contracts account for a very small portion of total trading value in INR and total trading volume in gold weight, the amount of participation in terms of the number of contracts is about 17%[9] of the accumulative total number of contracts (standard and mini contracts combined), changing hands over the sample period. The frequency of trade implies frequent update of new market information. In addition, mini contracts traders are expected to observe the dynamics of larger trades on the standard contracts in making informed trades.[10] Such learning is beneficial in the process of price discovery as Blume et al. (1994) demonstrate by applying a model where traders use trading volume to help infer an efficient price since their private information signals are noisy. Kurov and Lasser (2004) empirically show how exchange locals of S&P500 and NASDAQ 100 index futures take advantage of the information from large trades they observe in their own trading of mini futures.

6. Conclusion

Existing studies compare the contributions to price discovery of regular standard futures contracts in floor trading and mini futures in electronic trading. The studies attribute the execution speed of the electronic trading system to mini futures' efficient price adjustments. This study compares the contributions to price discovery of standard

[9] Note that the trading unit of mini gold futures is 100 grams per contract. Based on the cumulative gold trading volume of 460,543 kilograms for the mini contracts, this works out to be approximately 4.61 ((460,543 kilograms x 1000 grams)/100 grams) million contracts or 17% of total contracts traded over the sample period.

[10] Although not shown, we perform VAR models between returns of standard and mini contracts and between the volume of standard and mini contracts and find that the price and volume of mini contracts follow the trend of standard contracts.

and mini futures contracts that are both traded on an electronic platform of the Indian gold futures on the MCX from 2003 to 2007. We find that futures price leads spot price, indicating that price discovery occurs in the futures market. Moreover, our analysis finds that mini contracts help contribute to price discovery despite their relatively smaller trading quantity. We expect this to be a consequence of efficient transmission of information among traders in small contracts as they tend to trade more frequently. The study reveals that market quality need not be compromised with contract separation. Standard gold futures contracts on the MCX remain the key source of price discovery and liquidity. Mini contracts aid price discovery and serve smaller participants.

References

Baille R, Booth, GG, Tse Y, Zabotina T, (2002) Price discovery and common factor models, *Journal of Financial Markets*, 5: 309-321

Bessimbinder H, Kaufman, HM (1997) A cross-exchange comparison of execution costs and information flow for NYSE-listed stocks, *Journal of Financial Economics*, 46: 293-319.

Blume L, Easley D, O'Hara M (1994) Market statistics and technical analysis: The role of volume. *Journal of Finance* 49: 153-181.

Chan K, Chan KC, Karolyi G (1991) Intraday volatility in the stock index and stock index futures market. *Review of Financial Studies* 4: 657−684.

Chowdhry B, Nanda V (1991) Multi-market trading and market liquidity. *Review of Financial Studies*, 4: 483-511.

Dempster N (2006) The role of gold in India. Gold Report, September, World Gold Council.

Engle R, Granger C (1987) Cointegration, and error correction representation, Estimation and Testing. Econometrica, 55: 251-276.

Garbade KD, Silber WL (1983) Price movement and price discovery in futures and cash markets. *Review of Economics and Statistics*, 65: 289-97

Hasbrouck J (1995) One security, many markets: Determining the location of price discovery. *Journal of Finance* 50: 1175-1199.

Hasbrouck J (2003) Intraday price formation in U.S. equity index. *Journal of Finance* 58: 2375-2399.

Karande K (2006) A study of castor seed futures market in India. *Indira Gandhi Institute of Development Research,* Mumbai, India.

Karagozoglu KA, Martell FT (1999) Changing the size of a futures contract: Liquidity and microstructure effects. *Financial Review* 34: 75-94.

Kawaller IG, Koch PD, Koch TW (1987) The temporal relationship between S&P 500 futures and the S&P 500 Index. *Journal of Finance* 42: 1309 – 1329

Kurov A, Lasser D, (2004) Price dynamics in the regular and e-mini futures markets, *Journal of Financial and Quantitative Analysis* 39: 365-384.

Lütkepohl H (2005) New Introduction to Multiple Time Series Analysis. Springer.

Malliaris A, Urrutia JL (1998) Volume and price relationship: Hypothesis testing for agricultural futures. *Journal of Futures Markets*, 18: 53-72.

Martens M, (1998), Price discovery in high and low volatility periods: open outcry versus electronic trading. *Journal of International Financial Markets Institutions and Money,* 8: 243-260.

Mendelson H (1987) Consolidation, fragmentation, and market performance. *Journal of Financial and Quantitative Analysis*, 22: 189-207.

Min JH, Najand M (1999) A further investigation of the lead-lag relationship between the spot market and stock index futures: early evidence from Korea. *The Journal of Futures Markets* 19: 217–32

Moosa IA, Silvapulle P (2000) The price volume relationship in the crude oil futures market: Some results based on linear and nonlinear causality testing. *Review of Economics and Finance* 9: 11-30.

Pizzi M, Economopoulos A, O'Neill H (1998) An examination of the relationship between stock index cash and futures market: A cointegration approach. *Journal of Futures Markets* 18: 297−305.

Stoll HR, Whaley RE (1990) The dynamics of stock index and stock index futures returns. *Journal of Financial and Quantitative Analysis* 25: 441−468.

Silvapulle P, Moosa IA, (1999) The relationship between spot and futures prices: evidence from the crude oil market. *Journal of Futures Markets* 19: 175–93.

Theissen E, (2002) Price discovery in floor and screen trading systems. *Journal of Empirical Finance*, 9: 455-474.

Tse Y, Xiang J, (2005) Market quality and price discovery: Introduction of the E-mini energy futures. *Global Finance Journal* 16: 164-179.

Wang Y, Chung H, Yang Y, (2007) The market fragmentation impact of E-mini futures on the liquidity of open-outcry index futures. *International Research Journal of Finance and Economics* 12: 165-180

Table 1 Summary statistics of daily gold futures contracts

This table reports the summary statistics of standard and mini gold futures contracts traded on the Multi Commodity Exchange of India Ltd (MCX) during November 2003 – December 2007. Futures price are closing price of futures contract in INR. Futures returns are calculated from daily log price changes, $ln\ (F_t/F_{t-1})$, expressed in percentages. Spot returns are calculated as daily log price changes, $ln\ (S_t/\ S_{t-1})$, expressed in percentages. The standard contract series includes 1,227 observations, 25 contracts from 10 November 2003 - 31 December 2007. The mini contract series includes 1,220 observations, 40 contracts from 20 November 2003 - 31 December 2007.

	Standard Contracts				**Mini Contracts**				**Spot**	
	Futures price (INR)	**Futures returns** (%)	**Volume** (Kilogram)	**Value** (Million INR)	**Futures price** (INR)	**Futures returns** (%)	**Volume** (Kilogram)	**Value** (Million INR)	**Price** (INR)	**Returns** (%)
Mean	7,706	0.05	15,567	13,736	7,709	0.05	260.21	239.01	7,695	0.05
Median	7,704	0.06	6,831	4,563	7,841	0.06	51.85	38.03	7,725	0.02
Maximum	10,653	3.95	93,857	88,438	10,698	4.11	2,205	2,332	10,710	3.80
Minimum	5,646	-6.52	2.00	1.16	5,663	-6.41	0.10	0.06	5,600	-4.81
Standard Deviation	1,545	0.85	16,626	15,653	1,532	0.85	358.51	343.13	1,517	0.87
No. of obs	1,227				1,220				1,227	

Table 2: Correlation and cointegration test

Panel A of this table provides the Pearson correlation coefficients among return and volume variables. VOLS is the natural log of volume of standard gold futures contracts. VOLM is the natural log of volume of mini gold futures contracts. ΔF_t^S , ΔF_t^M , and ΔS_t are the returns of standard contracts, mini contracts and spot gold, respectively. Panel B of this table reports the results of Johansen Trace test statistics for cointegration of futures and spot natural log prices. Let *r* denote the number of cointegrating vectors. The cointegration test includes five lags length.

Panel A: Pearson Correlation Coefficients

Variable	VOLS	VOLM	ΔF_t^S	ΔF_t^M	ΔS_t
VOLS	1.000	0.783	-0.018	-0.025	-0.012
VOLM		1.000	-0.033	-0.041	-0.021
ΔF_t^S			1.000	0.948	0.327
ΔF_t^M				1.000	0.351
ΔS_t					1.000

Panel B: Johansen trace test for cointegration

Log Price Series	Hypothesis	Trace statistic	0.05 Critical value
Standard and spot	r = 0	47.550	15.495
Standard and spot	r <=1	0.208	3.842
Mini and spot	r = 0	45.509	15.495
Mini and spot	r <=1	0.163	3.842
Standard and mini	r = 0	44.444	15.495
Standard and mini	r <=1	1.061	3.842

Table 4: Error correction model for futures and spot prices

This table reports results of the two bivariate VECMs for daily standard futures contracts and spot prices and for mini futures contracts and spot prices. The model is $\Delta p_t = \alpha z_{t-1} + A_1 \Delta p_{t-1} + \ldots + A_r \Delta p_{t-r-1} + \varepsilon_t$ where Δp_t is a vector of log returns of futures and spot prices. Let $\boldsymbol{\alpha}$ represent the error correction coefficients for futures and spot returns. T-statistics are in parentheses. The VECMs include four lags. Only the parameters of the first two lags of ΔS_t and ΔF_t are reported here.

Series	Obs.	α	ΔS_{t-1}	ΔS_{t-2}	ΔF_{t-1}	ΔF_{t-2}	F-statistic	Adjusted R-square
Standard								
Futures	1,227	-0.080**	-0.085	-0.015	0.034	0.101*	2.024*	0.008
		(-2.022)	(-1.548)	(-0.264)	(0.719)	(1.793)		
Spot	1,227	0.135***	-0.427***	-0.235***	0.723***	0.363***	155.165***	0.488
		(4.891)	(-11.168)	(-6.111)	(21.777)	(9.270)		

Series	Obs.	α	ΔS_{t-1}	ΔS_{t-2}	ΔF_{t-1}	ΔF_{t-2}	F-statistic	Adjusted R-square
Mini								
Futures	1,220	-0.093***	-0.027	0.022	0.038	0.050	2.235*	0.007
		(-2.406)	(-0.509)	(0.415)	(0.813)	(0.915)		
Spot	1,220	0.128***	-0.401***	-0.216***	0.717***	0.327***	130.211***	0.476
		(4.480)	(-10.257)	(-5.480)	(20.716)	(8.134)		

*, **, *** Statistical significance at the 10%, 5%, and 1% levels.

Table 5: Error correction model for standard and mini futures prices

This table reports results of bivariate VECMs for daily standard futures prices and mini futures prices The model is $\Delta p_t = \alpha z_{t-1} + A_1 \Delta p_{t-1} + ... + A_r \Delta p_{t-r-1} + \varepsilon_t$ where Δp_t is a vector of log returns of standard and mini futures prices, (ΔF^S, ΔF^M). Let $\boldsymbol{\alpha}$ represent the error correction coefficients. T-statistics are in parentheses. The VECM models include four lags. Only the parameters of the first two lags of $\Delta F^S{}_t$ and $\Delta F^M{}_t$ are reported here.

Series	**Obs.**	$\boldsymbol{\alpha}$	$\Delta F^S{}_{t-1}$	$\Delta F^S{}_{t-2}$	$\Delta F^M{}_{t-1}$	$\Delta F^M{}_{t-2}$	**F-statistic**	**Adjusted R-square**
Standard Futures	1,227	-0.242	-0.664**	-0.397*	-0.213	-0.280	96.136	0.446
		(-0.742)	(-2.314)	(-1.678)	(-0.760)	(-1.218)		
Mini Futures	1,227	0.428***	0.158	-0.075	-1.056***	-0.644***	99.872	0.456
		(4.642)	(0.574)	(-0.334)	(-3.759)	(-2.608)		

*, **, *** Statistical significance at the 10%, 5%, and 1% levels.

Table 6 Information share of standard and mini futures contracts
This table reports the mid-point, upper, and lower bounds of information share for standard and mini futures contracts.

	Standard contracts	**Mini contracts**
Information share		
Upper Bound	0.883	0.617
Lower Bound	0.383	0.117
Mid-point	0.633	0.367
Trading share (in parentheses)		
Cumulative trading volume	22,551,101	460,543
(Kilogram)	0.980	0.020
Cumulative trading value	20,056,139	422,903
(Million INR)	0.979	0.021
Cumulative number of contracts	22,551,101	4,605,430
	0.830	0.170

Appendix

The table below presents contract specification of three types of gold futures contracts introduced in the Multi Commodity Exchange of India Ltd (MCX). High net worth individual contracts are no longer available due to limited interest.

Contracts	**Standard**	**Mini**	**High net worth individual**
Date of listing	10 November 2003	20 November 2003	27 September 2004 (Last trading contract: 31 May 2006)
Trading unit	1 kg.	100 grams	3 kg.
Quotation/Base value	10 grams	10 grams	10 grams
Maximum order size	10 kg.	10 kg.	12 kg.
Contract months	All even months within a year	- From the date of listing until June 2005, all even months within a year. - From July 2005, monthly contract.	Not in sequence
Price quote	Ex-Ahmedabad	Ex-Ahmedabad	Ex-Mumbai
Delivery Centers	Ahmedabad and Mumbai	Ahmedabad, Mumbai and New Delhi	Mumbai
Tender period	1st to 6th day of the contract expiry month	1st to 6th day of the contract expiry month	1st working day after expiry of contract by 6.00 p.m.
Delivery period	1st to 6th day of the contract expiry month	1st to 6th day of the contract expiry month	1st to 6th day of the contract expiry month

Source: Multi Commodity Exchange of India (MCX)'s website