Futures Market Efficiency: Evidence from Iran

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Abstract

Futures market plays three major roles, namely, hedging, price discovery and alternative investment vehicle. This paper studies gold coin futures market in Iran in terms of two important issues that determine how well a futures market may perform its functions. First, the long-horizon regression is used to study causal relationship between volatility of gold coin prices and capital flows to gold coin futures contracts. The results reveal that capital flows to futures contracts do not destabilise spot and futures prices of gold coin. We then test market efficiency at both long-run and short-run levels using multiple forecast horizons. The futures market is said to be efficient in the long run if futures prices are unbiased estimators of future spot prices. The bulk of evidence confirm that gold coin futures market has so far provided relatively fair estimates of future spot prices. The short-run efficiency requires that the basis should contain all relevant information to predict next-period changes in spot price. The findings on short-run efficiency are mixed in the sense that the basis sometimes fails to fully account for subsequent changes in spot price.

Keywords: capital flows, volatility, cointegration, unbiasedness, long-horizon regression and error correction model

JEL classifications: G13, G14

1. Introduction

Inception of coinage in Iran dates back to the 6th Century BC when electrum which is an alloy of gold was used to strike coins. In the ancient era, gold coin was popular as a medium of exchange. Nowadays, gold coins are purchased for investment purposes and used as gifts. Each of these coins has a fineness of 90 percent, equivalent to 21.6 karats, and has an actual gold weight of 0.2354 troy ounces.

Derivatives markets were nonexistent in Iran until a decade ago. The Iran Mercantile Exchange (IME) launched gold coin futures contracts in November 2008. The gold coin futures market has rapidly grown in recent years such that the contract is now one of the most traded financial instruments in Iran. This paper aims to assess performance of gold coin futures market in terms of two major questions: (1) do capital flows to futures market destabilise gold coin prices? And (2) does futures market function efficiently to predict future spot prices?

These questions are crucial because they determine the social utility of futures market. For example, effectiveness of hedging depends on how well information is reflected in prices of underlying assets. In an efficient market, futures price is the optimum forecast of future cash price in the sense that random forecast errors will, on average, be equal to zero. Also, if investments in futures markets destabilise prices of underlying assets, the economy as a whole could suffer. For instance, people may find it difficult to park their savings with a low-risk asset in turbulent times if futures market impairs the safe-haven property of gold. The consequences could be worse in agricultural and energy markets because excess volatility in prices of consumption commodities may hit consumer confidence and expenditure, and subsequently economic growth would weaken.

A large number of studies have been carried out to answer aforementioned questions in advanced economies. Stoll and Whaley (2010) study agricultural commodities and find that capital flows from index investors do not affect commodity futures prices. Also, Xiong and Tang (2012) show that concurrent with rapid increases in weekly investment flows from commodity index traders since the early 2000s, prices of indexed non-energy commodities have become more correlated with oil price. They believe this evidence reflects the fact that capital flows to commodity futures markets may help explain large increase in price volatility of non-energy commodities around 2008. The results from tests of futures market efficiency are mixed, too. For instance, Chow (1998) documents that futures prices are not unbiased estimators of future spot prices in gold, platinum, silver and palladium markets. In contrast, Chinn and Coibion (2014) find evidence in favour of market efficiency for energy and agricultural futures but precious and base metals fail unbiasedness tests.

The rest of this paper is organised as follows. Section 2 briefly reviews theoretical arguments and explains our data and methodology. Section 3 presents empirical results and their interpretations. Section 4 sums up all discussions and makes a conclusion. Finally, appendix contains tables which are cross-referenced within the text.

2. Data and methodology

2.1. Do capital flows to futures market destabilise prices of underlying assets?

To examine whether capital flows to futures contracts destabilise gold coin prices, we need a model that evaluates the causal relationship between volatility of gold coin prices and capital flows. Using the generic form of long-horizon regressions specified by Valkanov (2003), the following model is utilized to test whether capital flows to gold coin futures contracts make spot and futures prices of gold coin more volatile:

(1) $$\sum_{i=0}^{k-1} VOL_{t+i} = \beta_1 + \beta_2 \sum_{i=0}^{k-1} CF_{t+i-1} + \varepsilon_{t+i}, \quad t = 1,2,3,\ldots,T$$

where k denotes level of aggregation and VOL and CF stand for volatility and capital flows, respectively. In this model, volatility of gold coin prices is regressed on 1-period lag of capital flows. The capital flows are calculated with weekly frequency as follows:

(2) $$CF_t = (OP_t - OP_{t-1}) \times FP_{t-1}$$

where OP and FP stands for open interest and futures price, respectively. According to this equation, capital flow to gold coin futures market over current week is equal to change in open futures positions over current week times closing futures price of previous week. As Stoll and Whaley (2010) and Xiong and Tang (2012) argue, above equation separates capital flows from price changes and provides an estimate of weekly money flow to futures contracts that is not affected by changes in futures price within the week under consideration.

Two measures of volatility are used, namely, historical volatility and Parkinson's high-low volatility (Parkinson, 1980) that estimate volatility of gold coin prices from different perspectives. The former measures dispersion of growth rates of daily closing prices within a week and the latter captures price range within a week. These two measures of volatility are calculated for both spot and futures prices. Thus, four variants are defined for equation (1) that have the same explanatory variable, which is capital flows, but differ in terms of the dependent variable as follows:

- Variant 1: dependent variable is historical volatility of gold coin spot prices;

- Variant 2: dependent variable is high-low volatility of gold coin spot prices;
- Variant 3: dependent variable is historical volatility of gold coin futures prices; and
- Variant 4: dependent variable is high-low volatility of gold coin futures prices.

The objective is to examine whether capital flows to gold coin futures market have significant power to predict volatility of gold coin prices. The level of aggregation determines forecast horizon of the test. The long-horizon regression is estimated for levels of aggregation from 1 to 8. Given that our sample data has weekly frequency, setting level of aggregation equal to 1 implies that $\hat{\beta}_2$ estimates the causal relationship between volatility and capital flows over the 1-week horizon. Similarly, the slope coefficient in a regression with level of aggregation of 2 estimates the causal relationship between volatility and capital flows over the 2-week horizon, and so on.

Furthermore, capital flows and volatility of gold coin futures price are calculated on the basis of data from the nearest-to-expiration futures contracts. The sample covers the period from January 2011 to March 2017. For each week, five measures are calculated, namely, capital flow, historical volatility of spot prices, high-low volatility of spot prices, historical volatility of futures prices and high-low volatility of futures prices. Then, these measures are used to construct long-horizon series for each level of aggregation. Also, we use the method recommended by Hjalmarsson (2011) to estimate equation (1). Specifically, long-horizon series include overlapping observations and least squares t-statistics are divided by square root of level of aggregation in order to correct for effects of informational overlap in long-horizon series. The reason to re-scale t-statistics by square root of forecast horizon is that overlapping observations generate such strong serial correlation in residuals that autocorrelation-consistent estimation of standard errors (e.g. Newey and West, 1987) tends to perform poorly, and consequently wrong inferences could be made.

If slope coefficient in equation (1) is significantly positive, it means that capital flows to gold coin futures market increase volatility of gold coin prices. In contrast, if slope coefficient is significantly negative, it implies that capital flows help stabilise gold coin prices. Thus, insignificant slope coefficient indicates that capital flows do not affect volatility of gold coin prices. Also, a comparison of slope coefficients across regressions with different levels of aggregation allows us to figure out how long the causal relationship between volatility and capital flows, if any, may persist over time.

2.2. Does futures market function efficiently to estimate future spot prices?

Futures market is said to be efficient if futures prices are unbiased predictors of future spot prices. Testing futures market efficiency requires time series that match futures prices with future spot prices. According to Crowder and Hamed (1993), future spot price for a particular futures contract is cash price on the last trading day of the contract. Each futures contract is open for a relatively large period of time and each daily futures price reflects market expectations about termination spot price given all publicly available information. Among many daily futures prices, only one of them should be selected and matched with termination spot price for a particular contract. This selection depends on forecast horizon that is under examination. In this study, efficiency of gold coin futures market is tested using forecast horizons of 5, 15, 25 and 40 days. Thus, futures prices for a particular contract are picked out by working backwards 5, 15, 25 and 40 days from contract termination date.

Longer forecast horizons are not tested because Hansen and Hodrick (1980) argue that if previous contract is still being traded when matching spot and futures prices for next contract, wrong inferences about market efficiency might be made. In other words, when matching spot and futures prices for a particular futures contract, it should be ensured that the contract under consideration is the nearest-to-expiration contract among all open contracts with the same underlying asset. The first gold coin futures contract that was traded in the IME had the delivery month of January 2009. In this paper, the sample taken to test market efficiency comprises all gold coin futures contracts whose expiration dates were within the period from November 2009 to March 2017.

2.2.1. Long-run efficiency of futures market

Fama (1991) argues that to test whether prices properly reflect information, we need a model that depicts the meaning of "properly." According to Fujihara and Mougoue (1997), the conventional approach to examine futures market efficiency requires establishing presence of cointegration between futures prices and termination spot prices, and then testing whether futures price at a specific forecast horizon is the unbiased estimator of spot price at contract termination date. Hence, a cointegrating regression is specified as follows:

(3) $$s_T = \alpha_1 + \alpha_2 f_{T-\tau} + \varepsilon_t$$

where s_T is natural logarithm of spot price at the last trading day of the contract and $f_{T-\tau}$ is natural logarithm of futures price at a specific forecast horizon. As stated earlier, this regression is estimated for multiple forecast horizons. The long-run efficiency of futures market is based on the Unbiased Expectations Hypothesis that states futures price is the unbiased estimator of future spot price. The futures market is efficient if $\alpha_1 = 0$, $\alpha_2 = 1$ and residuals are stationary. If residuals of the cointegrating regression have no unit root, it means that futures prices and termination spot prices have a cointegrating relationship that implies presence of a long-run equilibrium between them. If joint restrictions $\alpha_1 = 0$ and $\alpha_2 = 1$ are rejected but single restriction $\alpha_2 = 1$ is not rejected, it indicates that termination spot price is equal to futures price plus a constant. This situation does not necessarily give evidence against market efficiency because the postulated one-for-one relationship between futures prices and termination spot prices still holds in the long-run equilibrium.

To assess futures market efficiency according to above framework, the first step involves testing for unit root in futures and termination spot prices, and then confirming presence of cointegration between them. The Augmented Dickey-Fuller and Phillips-Perron tests are used to perform unit root tests on prices, and then the Johansen's maximum eigenvalue and trace tests are applied to detect cointegration. Having established cointegration as a precondition for long-run efficiency, the second step requires testing both joint and single restrictions imposed on parameters of the cointegrating regression in order to determine whether futures price is the unbiased predictor of termination spot price. This procedure is implemented for each forecast horizon.

2.2.2. Short-run efficiency of futures market

The presence of long-run efficiency does not suffice short-run efficiency in futures market. Besides, the approach adopted to test long-run efficiency just determines whether futures market is efficient or not and it does not measure the degree of inefficiency. Therefore, ability of the basis, which represents the long-run equilibrium, to explain next-period changes in spot price should be examined as well. The method to test short-run efficiency in futures market is based on the Granger Representation Theorem (Granger, 1986) that states if random variables X_t and Y_t are I(1) but there exists a linear combination of them in the form of $Y_t - bX_t$ that is I(0), an error correction representation of these cointegrated variables could be specified as follows:

(4) $$\Delta Y_t = \beta_1 + \beta_2 \Delta X_t + \beta_3 (Y_{t-1} - bX_{t-1}) + \varepsilon_t$$

where the term $(Y_{t-1} - bX_{t-1})$ is 1-period lag of linear combination of X_t and Y_t. The linear combination of X_t and Y_t is called cointegrating relationship and it represents the long-run equilibrium in the form of

$Y_t = bX_t$ where coefficient b denotes the cointegrating parameter. The slope coefficient β_3 in equation (4) is called adjustment coefficient that measures how Y adjusts to error in previous period. The error correction model explains short-run changes in Y by short-run changes in X, as well as the error correction term that measures lagged deviations of Y from the long-run equilibrium.

Above error correction specification is applied to gold coin futures market in order to test whether the basis contains all relevant information to predict subsequent changes in spot price. To ensure that results from tests of short-run and long-run efficiency are comparable, equation (4) is estimated for each forecast horizon of 5, 15, 25 and 40 days, provided that restriction $\alpha_2 = 1$ is not rejected in equation (3). Hence, the following quasi-error correction model is specified:

(5) $$s_T - s_{T-\tau} = \beta_1 + \beta_2(f_{T-\tau,} - s_{T-\tau}) + \varepsilon_t$$

where the term $(f_{T-\tau} - s_{T-\tau})$ is the basis at a particular forecast horizon. In this model, the basis represents the cointegrating relationship between futures and spot prices and the cointegrating parameter is set equal to unity due to the unbiasedness hypothesis. The short-run efficiency means that restrictions $\beta_1 = 0$ and $\beta_2 = 1$ should hold in equation (5). In other words, futures market is efficient in short run if the basis, which implies the long-run equilibrium, is the unbiased estimator of change in spot price over the forecast horizon.

The test of short-run efficiency could be taken further using the method recommended by Newbold, Kellard, Rayner and Ennew (1999). They argue that if futures market is efficient in the short run, the basis should contain all relevant information to optimally predict subsequent changes in spot price. Therefore, information additional to the basis in the form of lagged changes in spot and futures prices should not be useful to forecast next-period changes in spot price. Accordingly, they add lags of $(s_T - s_{T-\tau})$ and $(f_T - f_{T-\tau})$ as regressors to equation (5) and specify the following model:

(6) $$s_T - s_{T-\tau} = \beta_1 + \beta_2(f_{T-\tau,} - s_{T-\tau}) + \sum_{i=1}^{k} \lambda_i (s_{T-i} - s_{(T-\tau)-i}) + \sum_{i=1}^{k} \gamma_i (f_{T-i} - f_{(T-\tau)-i}) + \varepsilon_t$$

where change in spot price over the forecast horizon is explained by the basis at the forecast horizon, as well as lagged changes in futures and spot prices over the forecast horizon. According to Newbold et al. (1999), regression coefficients for lags in equation (6) should be nonsignificant if futures market is efficient in the short run.

Moreover, they devise a ratio that quantifies the degree of short-run inefficiency in futures market. This measure, denoted by ϕ, is the ratio of forecast error variance of equation (6) to forecast error variance of futures price as the estimator of termination spot price:

(7) $$\phi = \frac{(n-2k-2)^{-1} \sum_{t=1}^{n} \hat{\varepsilon}_t^2}{(n-1)^{-1} \sum_{t=1}^{n} \left[(s_T - f_{T-\tau}) - E(s_T - f_{T-\tau})\right]^2}$$

where the term $2k+2$ is the number of parameters estimated in equation (6). The short-run efficiency ratio is equal to unity if futures market is completely efficient in the short run. This measure assesses relative merits of two predictors of short-run spot price changes, namely, the basis and a forecast obtained from equation (6). When efficiency ratio equals unity, it means that inclusion of lagged changes of spot and futures prices in equation (6) does not provide useful information to predict change in spot price over the forecast horizon, and hence the basis contains all relevant information to estimate subsequent changes in spot price. In contrast, the ratio would be less than unity if futures market is not fully efficient in the short run. Also, the value of zero would indicate complete short-run inefficiency. Therefore, $1-\phi$ measures the degree of short-run inefficiency.

3. Results and interpretations

3.1. Do capital flows to futures market destabilise prices of underlying assets?

Table I reports results for variants 1 and 2 of equation (1). Since slope coefficients are not significant at any forecast horizons, capital flows to gold coin futures market do not affect historical volatility and high-low volatility of gold coin spot prices. However, it may be noted that slope coefficients are negative at all forecast horizons. The results for variants 3 and 4 of equation (1) are shown in Table II. Similar to spot market, slope coefficients in futures market are negative at all forecast horizons. However, the distinguishing fact is that $\hat{\beta}_2$ is significant at 1 percent in the case of the 1-week forecast horizon for historical volatility. Putting all results together, we conclude that capital flows do not increase historical and high-low volatilities of gold coin spot and futures prices. It could also be inferred that capital flows have a short-run stabilizing effect on historical volatility of futures prices that fades away as forecast horizon gets longer.

Black (1986) and Fama (1991) classify traders into two groups of informed traders and uninformed traders. They argue that informed traders, also known as the smart money, trade on market fundamentals, contribute to market efficiency and stabilise prices by trading against mispricing. In contrast, uninformed trades are based on noise rather than signal and cause a divergence between market prices and intrinsic values of securities. These theoretical arguments reflect the notion of market efficiency and imply that arbitrageurs contribute to efficiency and stability of asset markets. Therefore, a negative slope coefficient in equation (1) could indicate that majority of futures traders in gold coin market use arbitrage strategies.

Table I
Results for Long-horizon Regression: Spot Price Volatility

Forecast Horizon (weeks)	Historical Volatility		High-low Volatility	
	β_1	β_2	β_1	β_2
1	0.2007** (8.3722)	-4.2048 (-1.4254)	0.1120** (9.4441)	-1.3021 (-1.0358)
2	0.4021** (9.8900)	-1.6534 (-0.3362)	0.2242** (12.1090)	-1.9079 (-0.8522)
3	0.6039** (9.1504)	-3.9760 (-0.5287)	0.3366** (10.7916)	-3.6616 (-1.0302)
4	0.8061** (8.6876)	-6.9620 (-0.6805)	0.4494** (10.0069)	-5.1591 (-1.0418)
5	1.0092** (8.2857)	-10.1906 (-0.7799)	0.5625** (9.3882)	-6.6870 (-1.0403)
6	1.2134** (7.9571)	-14.8200 (-0.8792)	0.6763** (8.8864)	-8.1327 (-0.9668)
7	1.4182** (7.6924)	-24.9002 (-1.1052)	0.7906** (8.4770)	-11.5052 (-1.0096)
8	1.6226** (7.4423)	-32.5311 (-1.1938)	0.9042** (8.1502)	-15.3605 (-1.1077)

Figures in parentheses are t statistics;
* Denotes statistically significant at 5% level;
** Denotes statistically significant at 1% level; and
See equation (1) and section 3.1. for details.

Table II
Results for Long-horizon Regression: Futures Price Volatility

Forecast Horizon (weeks)	Historical volatility		High-low Volatility	
	β_1	β_2	β_1	β_2
1	0.1955** (10.8489)	-5.2688** (-3.2421)	0.1568** (10.5876)	-1.1756 (-0.7529)
2	0.3916** (13.9700)	-1.5308 (-0.4516)	0.3135** (14.4828)	-2.1672 (-0.8280)
3	0.5879** (12.4695)	-2.4793 (-0.4614)	0.4703** (12.5568)	-4.6667 (-1.0934)
4	0.7846** (11.4746)	-4.8181 (-0.1629)	0.6274** (11.3733)	-6.8428 (-1.1250)
5	0.9815** (10.7457)	-7.9312 (-0.8093)	0.7848** (10.5223)	-8.4209 (-1.0523)
6	1.1793** (10.1308)	-12.5917 (-0.9785)	09431** (9.8913)	-11.5530 (-1.0962)
7	1.3766** (9.6870)	-20.2170 (-1.1642)	1.1018** (9.4331)	-17.9348 (-1.2566)
8	1.5737** (9.3247)	-28.1778 (-1.3359)	1.2593** (9.0741)	-24.2867 (-1.4001)

Figures in parentheses are t statistics;
* Denotes statistically significant at 5% level;
** Denotes statistically significant at 1% level; and
See equation (1) and section 3.1. for details.

3.2. Does futures market function efficiently to estimate future spot prices?
3.2.1. Long-run efficiency of futures market

We commence analysis of futures market efficiency with results of unit root tests on gold coin prices. As shown in Table III, null hypothesis of unit root cannot be rejected for both futures and termination spot prices because t-statistics of the Augmented Dickey-Fuller and the Phillips-Perron tests are nonsignificant. Thus, both futures and termination spot prices are not I(0).

Table III
Results for Unit Root Tests

Forecast Horizon (days)	Futures Price	
	ADF	PP
5	-1.3491	-1.4168
15	-1.4339	-1.4552
25	-1.6669	-1.6037
40	-1.4615	-1.5086
Unit Root Tests	Termination Spot Price	
ADF	-1.6388	
PP	-1.4144	

ADF stands for Augmented Dickey-Fuller;
PP stands for Phillips-Perron;
* Denotes statistically significant at 5% level;
** Denotes statistically significant at 1% level; and
See section 3.2.1. for details.

Given that gold coin prices are nonstationary, the Johansen's tests are applied to investigate cointegration between them at each forecast horizon. This technique first specifies a vector error correction model (VECM), and then tests the number of cointegrating relationships between the variables. The optimum lag length for the VECM is determined by the Schwarz Information Criterion. A zero rank implies that there is no stationary linear combination of futures prices and termination spot prices, and hence they are not cointegrated. The results of maximum eigenvalue and trace tests are reported in Table IV. For all forecast horizons, null hypothesis of non-cointegration is rejected at 1 percent significance level but null hypothesis of $r = 1$ cannot be rejected. Therefore, the maximum cointegration rank at all forecast horizons is equal to unity.

Table IV
Results for Johansen's Cointegration Tests

Forecast Horizon (days)	$H_0 : r$	Max-Eigen	Trace	Lag Length
5	0	20.1202**	23.1566**	1
	1	3.0364	3.0364	
15	0	16.9413**	19.4212**	1
	1	2.4799	2.4799	
25	0	16.2418**	19.0204**	1
	1	2.7786	2.7786	
40	0	26.1120**	26.3325**	1
	1	0.2204	0.2204	

* Denotes statistically significant at 5% level;
** Denotes statistically significant at 1% level; and
See section 3.2.1. for details.

As described in section 3, examination of long-run efficiency in futures market involves two steps. First, cointegration between futures prices and termination spot prices should be established, and then the unbiasedness hypothesis is tested. Since the Johansen's maximum eigenvalue and trace tests detect 1 cointegrating relationship between futures prices and termination spot prices at each forecast horizon, joint and single restrictions on coefficients of equation (3) are tested. As Table V reports, there exists significant evidence for long-run efficiency of gold coin futures market at forecast horizons of 5, 25 and 40 days. The presence of cointegration implies that there is a long-run equilibrium that binds futures and spot prices together. If a departure from the cointegrating relationship occurs, prices in one or both markets should adjust to remove the disparity. The chi-squared statistics show that joint restrictions $\alpha_1 = 0$ and $\alpha_2 = 1$ cannot be rejected at 5-, 25- and 40-day forecast horizons. Therefore, futures prices have a one-for-one relationship with termination spot prices in the long-run equilibrium, and forecast error is, on average, zero.

However, forecast horizon of 15 days is the only case which is odd one out because both joint and single restrictions are rejected at 1 percent significance level. It means that although 15-day-ahead futures prices and termination spot prices are cointegrated, values estimated for intercept and slope coefficients of the cointegrating regression do not corroborate the unbiasedness hypothesis. The gold coin futures market has no long-run efficiency at this forecast horizon.

Table V
Results for Cointegrating Regression

Forecast Horizon (days)	Unbiasedness Tests	
	$\chi^2(2)$	$\chi^2(1)$
5	2.5211	-
15	12.2801**	12.1249**
25	5.1055	-
40	3.4741	-

$\chi^2(2)$ is the test statistic for $H_0: \alpha_1 = 0$ and $\alpha_2 = 1$;
$\chi^2(1)$ is the test statistic for $H_0: \alpha_2 = 1$;
* Denotes statistically significant at 5% level;
** Denotes statistically significant at 1% level; and
See equation (3) and section 3.2.1. for details.

3.2.2. Short-run efficiency of futures market

If restriction $\alpha_2 = 1$ in equation (3) is not rejected, then there is not evidence against the unbiasedness hypothesis. In forecast horizons under examination, results show that long-run efficiency holds in all of them excluding the 15-day horizon. Therefore, the basis which is the difference between futures price and spot price represents the long-run equilibrium, and hence it is permissible to specify equation (5) for forecast horizons of 5, 25 and 40 days.

Table VI reports results of testing the unbiasedness hypothesis in equation (5). The slope coefficient in the quasi-error correction model shows how subsequent changes in spot price are adjusted to the error which is deviation from the long-run equilibrium in previous time. Also, the intercept coefficient measures the average forecast error. If joint restrictions are not rejected, it is concluded that the basis is the unbiased estimator of subsequent changes in spot price. In other words, futures market is efficient in the sense that change in spot price over the forecast horizon is explained by the long-run equilibrium relationship between futures prices and termination spot prices. The findings point out that joint restrictions in equation (5) are not rejected at forecast horizons of 5 and 40 days. The analysis of short-run efficiency shows that the 5-day-ahead basis and the 40-day-ahead basis are unbiased estimators of changes in spot price over respective forecast horizons. However, both joint and single restrictions are rejected at forecast horizon of 25 days. Therefore, results give significant evidence against short-run efficiency at this forecast horizon despite the fact that unbiasedness holds in the long run. Although there is an equilibrium that binds 25-day-ahead futures prices with termination spot prices, the 25-day-ahead basis fails to be the unbiased predictor of subsequent change in cash price due to specific short-run dynamics that contradict with those implied by the unbiasedness hypothesis.

Table VI
Results for Quasi-Error Correction Model

Forecast Horizon (days)	Unbiasedness Tests	
	$\chi^2(2)$	$\chi^2(1)$
5	1.5015	-
25	358.6844**	110.8890**
40	2.9009	-

ADF stands for Augmented Dickey-Fuller;
PP stands for Phillips-Perron;
$\chi^2(2)$ is the test statistic for $H_0: \beta_1 = 0$ and $\beta_2 = 1$;
$\chi^2(1)$ is the test statistic for $H_0: \beta_2 = 1$;
* Denotes statistically significant at 5% level;
** Denotes statistically significant at 1% level; and
See equation (5) and section 3.2.2. for details.

The analysis of short-run efficiency so far determines whether gold coin futures market is efficient or not. The test of market efficiency is extended in order to determine the degree of short-run inefficiency at each forecast horizon of 5, 25 and 40 days. Specifically, equation (6) is estimated, and then the degree of short-run inefficiency is calculated accordingly. The results from fitting regression (6) are shown in Table VII. The lag length for equation (6) at each forecast horizon was selected by initially setting k equal to 10 and then removing lags that were insignificant at 10 percent while preserving symmetry on lagged $(S_T - S_{T-\tau})$ and $(f_T - f_{T-\tau})$. Table VII shows that in addition to the basis, lagged changes of spot and futures prices provide significant information to predict change in spot price over the forecast horizon. These results may be interpreted as evidence against complete efficiency in the short run.

Table VII
Results for Quasi-Error Correction Model
with Lagged Changes in Spot and Futures Prices

Regression Coefficients	Forecast Horizon (days)		
	5	25	40
β_1	-0.0054 (-1.0720)	-0.0108 (-0.5637)	-0.0048 (-0.1489)
β_2	-1.2447 (-0.9323)	0.8250 (29.0099)	1.0963 (1.8392)
λ_1	1.1548 (2. 5200)	0.0549 (1.4598)	1.7809 (1.9123)
λ_2	-1.1644 (-1.6961)	-0.0258 (-1.0523)	-2.3453 (-2.1516)
λ_3	-0.6413 (-0.7578)	-0.0593 (-2.1802)	-2.1994 (-1.7962)
λ_4	-0.0969 (-0.1449)	0.0659 (2.5315)	-0.3412 (-0.4297)
λ_5	-0.3453 (-0.5440)	-0.0568 (-3.4315)	-2.7261 (-2.6119)
λ_6	0.7096 (2.6039)	0.0721 (4.5269)	0.9952 (1.0278)
λ_7	-0.4874 (-2.0659)	-0.0960 (-5.0311)	0.9329 (0.7297)
λ_8	-	0.0365 (5.2969)	-0.1825 (-0.1476)
λ_9	-	-0.0738 (-3.7486)	1.6583 (1.4343)
λ_{10}	-	-	1.7125 (1.8459)
γ_1	-1.0152 (-2.6666)	-0.7255 (-3.1629)	-1.4363 (-1.5435)
γ_2	0.8917 (1.3982)	-0.2783 (-1.0808)	2.4874 (1.9916)
γ_3	0.4840 (0.7283)	0.1043 (0.6410)	1.7809 (1.3489)
γ_4	0.1003 (0.1594)	-0.3237 (-3.0952)	0.2942 (0.3362)
γ_5	0.1397 (0.2263)	0.1082 (1.4333)	3.2583 (2.9433)
γ_6	-0.6838 (-2.4064)	0.4249 (3.0572)	-0.5401 (-0.6100)
γ_7	0.5519 (2.4676)	-0.5982 (-3.0284)	-0.8814 (-0.7498)
γ_8	-	-0.3870 (-3.1042)	0.4872 (0.4022)

γ_9	-	0.1669 (0.9221)	-1.4607 (-1.3531)
γ_{10}	-	-	-1.7066 (-2.0003)
Figures in parentheses are t statistics; and See equation (6) and section 3.2.2. for details.			

Finally, Table VIII reports the degree of short-run efficiency. The findings show that gold coin futures market is more than 90 percent and more than 60 percent efficient at forecast horizons of 5 and 40 days, respectively. However, in the case of the 25-day horizon, gold coin futures market is more than 50 percent inefficient. These results may explain why the unbiasedness hypothesis was rejected in the case of the 25-day-ahead basis but not at the other two forecast horizons. It is concluded that although futures price is the unbiased estimator of termination spot price at forecast horizons of 5, 25 and 40 days, the basis sometimes fails to fully account for short-run changes in spot price, and hence additional information in the form of lagged changes in spot and futures prices may help improve short-run forecasting power.

Table VIII
Results for Degree of Short-run Efficiency

Efficiency Measures	Forecast Horizon (days)		
	5	25	40
ϕ	0.95	0.42	0.64
$1-\phi$	0.05	0.58	0.36
See equation (7) and section 3.2.2. for details.			

4. Conclusion

The purpose of this paper was twofold. The centralised futures market is supposed to aggregate information possessed by market participants and provide unbiased forecasts of future spot prices accordingly. Hence, futures price is assumed to be a leading indicator for the decentralised cash market. As the first purpose, we tested how well gold coin futures market played its price discovery role at both long-run and short-run levels using forecast horizons of 5, 15, 25 and 40 days. The results revealed that, apart from the 15-day horizon, both cointegration and unbiasedness held at all forecast horizons under consideration. We then proceeded to test short-run efficiency. The evidence confirmed that the basis gave fair estimates of changes in spot price over forecast horizons of 5 and 40 days. Therefore, the bulk of evidence supported long-run efficiency of gold coin futures market but results on short-run efficiency are mixed. However, all these conclusions solely relate to forecast horizons tested.

Also, massive capital flows to futures markets in developed economies over the last decade has given rise to a controversy as to whether futures trading distorts commodity prices and causes excess volatility. The second purpose was to examine whether futures investment flows increased volatility of gold coin prices. The findings from long-horizon regressions showed that capital flows to futures contracts did not destabilise spot and futures prices of gold coin. We even obtained some evidence that capital flows had a short-run stabilising effect on historical volatility of gold coin futures prices. Overall, it seems that gold coin futures market has so far proved a positive experience of diversifying financial instruments in Iran economy, and therefore it may serve as a platform to launch futures contracts in other sectors such as agriculture and energy.

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