Price Discovery in the Futures and Cash Market for Sugar

by

Delroy A. Armstrong

January 10, 2003

Corresponding Authors:

Hector O Zapata

T. Randall Fortenbery

Selected Paper prepared for presentation at the
Southern Agricultural Economics Association Annual Meeting,
Mobile, Alabama,
February 1-5, 2003

[1] *Delroy A. Armstrong and Dr. Hector Zapata, are research assistant and Professor respectively. Department of Agribusiness and Agri-Economics, Louisiana State University, Baton Rouge, Louisiana. Dr. T Randall Fortenbery, Associate Professor, at the Department of Agriculture and Applied Economics, University of Wisconsin, Madison, Wisconsin.*

Introduction

Quite often the issue of price risk management is foremost in business decisions of managers, producers, speculators, and especially traders of storable commodities because of unpredictable factors within commodity markets. Because of this inherent risk in price movement, financial analysts, economists and evaluators of financial derivatives are always investigating ways to minimize this risk. One method generally employed is the practice of hedging; this is "the process of shifting price risk in the cash market to the futures market by simultaneously holding opposite positions in the cash and futures markets" (Catlett et al 1999).

Futures and cash prices present an interesting case for application of cointegration-type relationships. One might expect, a priori, that a predictive relationship may exist between these two market prices. If one considers the futures prices at time t for delivery at time t + k as the expectation held at time t of the cash price in period t + k, then the relationship between futures price and cash price is defined by the order of integration of cash price (Bessler, and Covey 1991). Because of this, it is interesting to investigate the relationship (cointegration) between both price series in order to ascertain which series provides an indication of the other in the future, that is if futures prices can be used to predict cash prices or *vice-versa*. If this is so then cash market participants can use futures position as a risk minimization tool for world #11 sugar.

The pricing function of world sugar futures (WSF) has received limited research interest. One unique aspect of the WSF (sugar # 11) contract is the specification of cane sugar delivery, stowed in bulk, *fob* from any 28 foreign countries of origin as well as the U.S. Previous work suggests that futures markets price the cheapest quality of a commodity deliverable on a contract.

This paper investigates whether a statistical relationship (cointegration) exists between price movements in the cash (or spot) market and futures market for world #11 sugar. As such it will identify the components that drive the temporal and spatial price relations between these two markets for sugar, and identify the relevance of the futures market to cash market traders of world #11 sugar. This type of information is of significant importance to owners of inventory that continuously trade the physical commodity since it is storable, and investors who deal in both transaction of both physical commodities and derivative contracts. This information further could be of immeasurable value in predicting future sugar prices since sugar ranks as one of the most volatile of all internationally traded commodities.

Review of Literature

Various authors using a wide range of commodities have given this subject area much attention. Garbade and Silber examined the characteristics of price movements in cash markets and futures markets for storable commodities, using a model of simultaneous price dynamics. One aspect focuses on an analytical model of simultaneous price dynamics, which suggest that, over short time intervals, the correlation of price changes is a function of the elasticity of arbitrage between the physical commodity and its counterpart futures contract. Greater elasticity fosters more highly correlated price changes, and thereby facilitates the risk transfer function.

The elasticity of supply arbitrage services is constrained by, among other things, the storage and transaction costs. Thus, futures contracts will not, in general, provide perfect risk transfer facilities over short-run horizons. The essence of the price discovery function of futures markets depends on whether new information is reflected first in changed futures prices or in changed cash prices.

Theoretical results suggest that the degree of market integration over short horizons is a function of the elasticity of supply of arbitrage services. Empirical results are reported for seven commodities. While all markets are integrated over a month or two, there is considerable slippage between cash and futures markets over shorter time intervals, especially for grains (corn, wheat and oats). Gold and silver are highly integrated even over one day. Results indicate that there is nontrivial risk exposure to hedgers over short time intervals (e.g., a week) in the futures markets for grains and to a lesser extent, copper and orange juice.

Whether the price discovery function of futures markets exists hinges on whether price changes in futures markets lead price changes in cash markets more often than the reverse. The authors found that in general futures dominate cash market price changes. The evidence suggests that the cash markets in wheat, corn, and orange juice are satellites of the futures markets for these commodities, with about 75% of new information incorporated first into futures prices then flowing to cash prices. This seems to be the case for gold although data limitations prevent a conclusive statement. The pricing of silver and especially oats and copper are more divided between the cash and futures markets.

Bessler and Covey studied two price series (futures and cash prices for slaughter cattle) using daily settlement price for the nearby live cattle futures contract for August 21, 1985 through August 20, 1986 and daily average cash price (per cwt.) for direct sale of choice 900-1300lbs. slaughter cattle steers for the Texas-Oklahoma market over the same period (LS-214s, USDA). This provides a direct rather than auction sales market for slaughter cattle and as such, sales are conducted throughout the entire five-day business week. Previous day's observations are used in place of missing observations, such as occasional holidays, for both price series since these represent the most recent information available to the market participant. The literature suggests that models of cointegration should show improved long-ranged forecasts relative to models that don't impose the cointegration restrictions. These models are applied to 261 data points on daily live cattle prices. Results are mixed. First, within sample fits (conducted on the first 130 data points) indicate that both cash and futures prices are generated by processes not statistically distinguishable from a random walk. Tests for cointegration based on residuals from a static regression (based on the same 130 data points), show marginal support for the cointegration hypothesis between cash prices and the nearby futures contract. No cointegration is discovered between cash prices and the distant contracts. The evidence of a weak cointegration relationship between cash and nearby futures suggests some dependency between the two price series, which may arise when cash traders use the nearby futures price as a means of predicting short-run price movements in the cash market. These results plus the clear absence of any cointegration relationship between cash prices and futures contracts, confirms prior work that suggests the greater the distance over time, the greater the degree of independence.

Thompson, McNeill and Eales studied the price implications of delivery specifications of the World Sugar Futures (WSF) contract by comparing the price behavior in the WSF contract to price behavior in the cocoa contract during the seven weeks before contract expiration. This study compares price, open interest, and delivery data from WSF market to similar data from the cocoa market to assess the effect of the delivery mechanism and trading period in the WSF contract performance. These two commodity contracts exhibit numerous similarities, except that cocoa contracts differ from sugar contracts in delivery points. Cocoa has three (3) delivery points in the US while sugar that has none. This study functions to provide answers to several related questions regarding the performance of the WSF contract. Does the uncertainty regarding delivery quantities and location force a relative price decline in the expiring contract as longs liquidate their contracts? Are longs thus frequently penalized for maintaining an open position?

Does the volatility of prices increase as expiration approaches? Do changes in open interest near expiration largely reflect longs liquidating rather than shorts covering?

Empirical analysis was carried out using the Paul-Type tests for liquidation bias and changes in volatility. However, this analysis differs from that used by Paul in two ways. Paul examined only the spread between the expiring and next maturity. The spread between the second and third maturities is also utilized by Thompson et.al. since the spread is a ratio, and it is possible that the cause of a price bias could be the behavior of the second maturity rather than the behavior of the maturing contract. The second difference is that Paul calculates weekly average price spreads based on daily closing prices (mostly settlement prices). In this case data used are settlement price data from expiration day, and comparable data from each Thursday up to seven weeks prior to expiration. Since Fridays and Mondays have sometimes been associated with a "weekend effect", Thursdays were chosen and used uniformly throughout the study.

Results-Paul test for Liquidation Bias shows average changes in price spreads and their standard deviations for sugar and cocoa. Volatility of the sugar market appears to consistently increase in the final two weeks of trading in the expiring sugar contract than in previous periods, in the case of cocoa contracts this seems to decrease but not by a statistically significant amount. The variation in the expiration behavior from year to year, may account for such large standard deviations in sugar contracts. No pattern emerges with respect to volatility for either commodity in the second or third maturing futures during these periods.

Regression results-changes in price volatility reveals that a relative decline in the price of the expiring contract and increasing volatility as expiration approaches does not occur simply because the contract is expiring. The driving force behind price behavior in the expiring WSF contract appears rather to changes in the open interest in the expiring contract that, given the relationship between changes in open interest and are generally occasioned by longs liquidating.

Formulating a General Model

A model usually refers to a set of conceptualization employed by the economist to capture the essential features of the phenomenon under consideration. An important aspect of this model is its predictive power. “Prediction means that, a relationship being known to exist between a given variable called the dependent variable, and one or more other variables, called the independent or explanatory variables. It is desired, given some knowledge of the independent variable at some future time, to say something about the behavior of the dependent variable” (Dhrymes, 1978 P.2).

Pricing Model

The financial market pricing theory tells us that market efficiency is a function of how fast and how much information is reflected in prices. The rate at which prices exhibit market information is the rate at which this information is disseminated to market participants. This model can be specified as:

$$\begin{bmatrix} C_t \\ F_t \end{bmatrix} = \begin{bmatrix} \alpha_c \\ \alpha_f \end{bmatrix} + \begin{bmatrix} 1-\beta_c & \beta_c \\ \beta_f & 1-\beta_f \end{bmatrix} \begin{bmatrix} c_{t-1} \\ F_{t-1} \end{bmatrix} + \begin{bmatrix} e_t \\ e_t \end{bmatrix}$$

where t refers to day, and C and F are the logarithms of the cash and futures prices, respectively. The coefficients $\$_c$ and $\$_f$ reflects the impact of the previous day’s price in one market on the other market’s price. In this light it is expected that $\$_c \$ 0$ and $\$_f \$0$. The constant terms $''_c$ and $''_f$ reflect any trends in the price series. The ratio $\$_c / (\$_c + \$_f)$ provides an indication of the level of price discovery occurring in each market. If the ratio is equal to one, implying that $\$_f = 0$, then the cash price follows the future price, and price discovery originates in the futures markets. In this case, the cash market is referred to as a pure satellite of the futures market (Garbade and Silber, 1983). If $\beta_c = 0$, the ratio between zero and one imply mutual adjustment and feedback of the two market's prices to each other.

The Econometric Model

An econometric model, specifically, involves a mathematical formulation, this mathematical form is rather specific and an attempt has to be made to estimate (make inferences about) the models' parameters"(Dhrymes, P.J. 1978 P. 6). By observing the futures contract closest to maturity, the temporal span between the cash price (which is for immediate delivery) and the futures price for later delivery is minimized.

If the equilibrium relationship exists between cash and futures prices then $y_t = (C_t\ F_{t-k})'$ is cointegrated with $Cy_t = z_t$, where z_t is a stationary error term about a mean of zero, suggesting that in equilibrium $Cy_t = 0$. Using Granger's representation theorem, an error-correction model (ECM) can be specified. By the recent asymptotic results in cointegration theory (Johansen (1988), and Phillips), the vector autoregressive model with Gaussian errors is given by

$$y_t = \mu + \Gamma_1 y_{t-1} + \ldots + \Gamma_{p-1} y_{t-p+1} - \Pi_p y_{t-p} + e_t, \qquad (1)$$

where t=1,2, ...,T, and $e_1,\ldots,e_T$ are independent Gaussian variables in k dimensions with mean zero and variance Σ. This model can be reparameterized in ECM as

$$\Delta y_t = \mu + \Gamma_1 \Delta y_{t-1} + \ldots + \Gamma_{p-1} \Delta y_{t-p+1} - \Pi y_{t-p} + e_t, \qquad (2)$$

or

$$\Delta y_t = \Gamma_1 \Delta y_{t-1} + \ldots + \Gamma_{p-1} \Delta y_{t-p+1} - B[C, \tilde{\ }][y'_{t-p}\ 1]' + e_t, \qquad (3)$$

where

$$\Gamma_i = -(I_K - \Pi_1 - \ldots - \Pi_p), \quad i=1,2, \ldots, p-1, \qquad (4)$$

and

$$\Pi = -I + \Pi_1 + \ldots + \Pi_p. \qquad (5)$$

Equation (3) is used if μ can be absorbed into the cointegration relation and equation (2) otherwise (Johansen 1991).

These specifications are convenient since the hypothesis of cointegration implies restrictions on the Π matrix leaving the other parameters free. The hypothesis of at most r cointegrating relations is formulated as the restriction

$$H_r = \Pi = BC \tag{6}$$

or

$$H_r{}^* = \Pi = BC \text{ and } \mu = BC_0 \tag{7}$$

where B and C' are kxr matrices and C_0 is an rx1 vector. Hypotheses (6) and (7) correspond to models (3) and (4), respectively. The integer value of r depends on the number of variables in the system, and therefore lies between zero and k. When the rank of Π is zero, the EC term disappears and the classical VAR in differences is the appropriate structure. If the rank of Π equals the number of variables in the system (k) then a VAR in levels should be estimated.

The procedure for testing cointegration can be outlined as follows:

1. Specify a VAR representation as in equation (1).
2. Define $\Delta Y = [\Delta y_1, \Delta y_2, \ldots, \Delta y_T]$ as a KxT matrix of first differences with variables on the rows and observations on the columns, $X_t = [\Delta y'_{t-1}, \Delta y'_{t-2}, \ldots, \Delta y'_{t-p+1}]'$ a K(p-1)x1 matrix of lagged differences for one observation, $X = [X_1, \ldots, X_T]$ a K(p-1)xT matrix of lagged differences for all observations, $Y_{-p} = [y_{1-p}, \ldots, y_{T-p}]$ a KxT matrix of data on lagged levels, $\Gamma = [\Gamma_1, \ldots, \Gamma_{p-1}]$ a Kx(K(p-1)) a matrix of coefficients on lagged changes, and $E = [e_1, \ldots, e_T]$ a KxT matrix of residuals. Obtain the residuals, $R_0 = \Delta YM$ and $R_1 = Y_{-p}M$, that is by regressing ΔY on X and Y_{-p} on X, respectively.
3. Compute the second-moment matrices $C_{ij} = T^{-1}R_iR'_j$ with i,j=0,1 and find the eigenvalues, $\lambda_1 \geq \lambda_2 \geq \ldots \geq \lambda_K$, between R_0 and R_1 by solving the determinantal equation

$$|8S_{kk} - S_{k0}S_{00}^{-1}S_{0k}|=0.$$

4. Compute the Trace test by

$$\text{Trace Test} = -T\ '\ _i \ln(1 - 8_i),\ \ i=r+1,..., K$$

This is used for testing the null hypothesis of K or less cointegrating vectors.

Johansen and Juselius also suggest using a maximal eigenvalue test which uses the $(r+1)^{th}$ largest eigenvalue, and therefore called the Maximal Eigenvalue Test (or 8max Test) given by

$$8\text{max Test} = -T\ln(1 - 8_{r+1}),$$

Critical values for testing the number of cointegrating relations are tabulated in Johansen and Juselius Tables A2and A3.

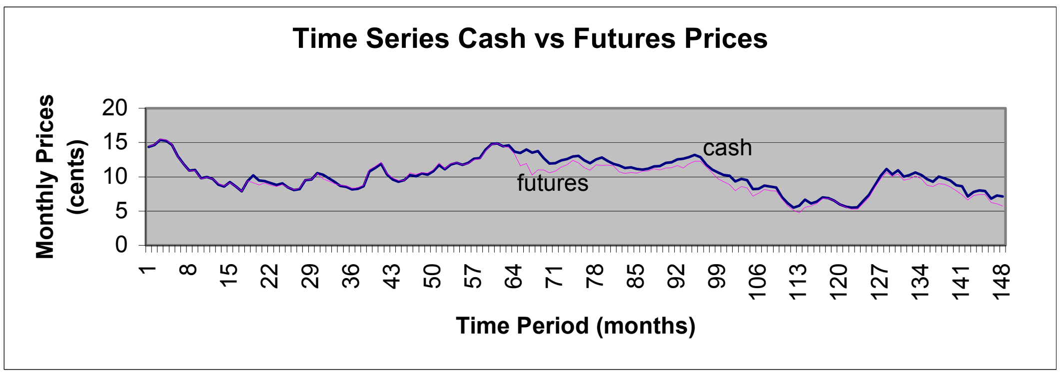
Data and Method

The data used in this analysis consists of the average monthly New York closing futures prices for world #11 sugar deliverable on the contract from 01/90 - 04/02, and monthly world #11 sugar cash prices for Dominican Republic for the same period. This gives a total of 148 data points for both series. Futures contracts on sugar #11 (world) are specified in trading unit of 112,000 lbs. (50 long tons) with prices which has no daily limits quoted in cents per pound. Grade is regarded as raw centrifugal cane sugar based on 96^0 average polarization. These contracts are traded for delivery in the months of March, May, July, and October commencing with January of every year. In order to derive the value of a futures contract at a point in time, this value has to taken as the current price of futures contract closest to the delivery month in relation to the time in question.

For example, if in the month of January, an investor purchases or sells a futures contract, the price of this contract will be the prices for March's contract since this is the closest delivery month following the transaction period. Therefore, on first notice day (i.e., the first day on which physical delivery can be made against a given futures contract), the expiring contract is dropped and the next contract closest to maturity is observed.

Figure1 represents the plots of the raw cash and futures prices over time. Observation of this graph shows a high degree linear correlation between cash price for the Dominican Republic and futures prices.

Fig.1



Pearsons' correlation analysis reveals a very high correlation coefficient of 0.96 between the variables cash and futures prices, this is a desirable feature for the task at hand. This tells us that there is a strong relationship between the price series thus, information from one may feed into the other, if this is so, then forecasting accuracy maybe enhanced.

The data reveal mean prices of 9.83 and 10.29 cents/lb. for futures and cash respectively, with associated standard deviations of 4.77 and 2.35. The presence of unit-roots is tested using the augmented Dickey-Fuller statistic. The Garbade and Silber (1982) simultaneous price dynamics model is used as the basic model as mentioned earlier for testing cointegration

(Johansen's method). The lag-length in the dynamic model is chosen using a likelihood ratio test (Lutkepohl). Granger-causality tests are used to examine the causal relationship between futures and cash prices.[2]

Model Selection

The testing procedure used to identify the lag-length of the ECM is the Likelihood Ratio since this includes multiple equations. The test statistic recommended is: $(T-c)(\log|'_r|-\log|'_u|)$

where $'_r$ and $'_u$ are the restricted and unrestricted covariance matrices and T is the number of observations. This is asymptotically distributed as P^2 with degrees of freedom equal to the number of restrictions, c is a correction to improve small sample properties which is equal to the number of variables in the unrestricted equation is the system (RATS 2000, P.287).

The result suggests VAR 2 for the likelihood-ratio statistic with a maximum of 12 lag-length considered in sequential testing using residuals from data set for both time series.

Results

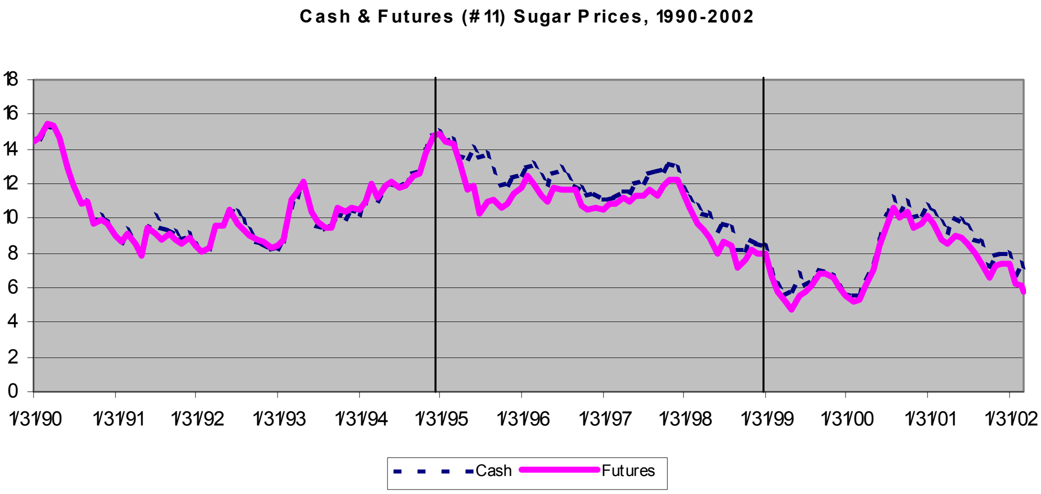
The relationship between nearby sugar futures (#11) prices and Dominican Republic #11 cash prices follow each other closely. During January 1990-January 1995 (figure 2) the co-movement was extremely close but deteriorated somewhat in the mid-1990s (up to about January 1999), and again in 2001-02. From figure 2 it is easy to observe that not only have mean prices changed, but there is also considerable volatility in the market.

Prior to conducting cointegration tests, one must confirm that the individual cash price series are nonstationary. Futures and cash prices were tested for unit-roots using augmented Dickey-

[2] Granger-causality tests will be reported in later updated version

Fuller(ADF) tests. The ADF value was -1.83 for futures and -2.34 for cash, which for a 10% level critical value (-2.57) would suggest one unit-root in both series. This result is consistent with the price pattern observed in figure 2.

Figure 2



Cointegration tests were conducted using Johansen's maximum likelihood procedure to test the relationship between cash and futures prices using an error-correction model (ECM). The lag length of the ECM was set at 2 based on the Lagrange multiplier test. The Lambda-max statistic of 11.26 is significant at the 10% level (10.29) for no cointegration, but not significant for one cointegrating relation. This suggests cointegration between New York nearby futures and the Dominican Republic cash prices for sugar. [3]

Summary and Conclusion

This study of price discovery in the futures and cash markets for world #11 sugar was developed based on the theory of market efficiency which if a function of how fast and how much information is reflected in prices. The model used for this investigation, was developed by

[3] An updated version of this paper will be provide at the SAES meetings

Garbade and Silber. The results of this paper lend support to the important price discovery role of the WSF market for a small sugar producing country such as the Dominican Republic. This finding would imply that the Dominican Republic could effectively use futures prices to place a hedge on traded sugar as a means to manage price risk in this market and as a way to stabilize foreign exchange earnings from sugar trade. Future work should investigate the issue of an optimum hedge ratio.

Bibliography

1)Bessler, D.A., Covey, T.,*Cointegration: Some Results on U.S. Cattle Prices*, The Journal of Futures Markets, Vol 11, No. 4, 461-474 (1991).

2) Catlett, L.B., Libbin, J.D., *Investing in Futures & Options Markets*, 1997,by Delmar Publishers.

3) Dhrymes, J.P., *Introductory Econometrics*, 1978, by Springer-Verlag New York Inc.

4) Fortenbery, R.T., Zapata, H.O., *Stochastic Interest Rate and Price Discovery in Selected Markets*, Review of Agricultural Economics 18(1996): 643-654

5) Garbade, K., Silber, W.L., *Price Movement and Price Discovery in Futures and Cash Markets,* The Review of Economics and Statistics, 1982 p 289-297.

6) Harvey, A.C., *The Econometric Analysis of time Series*, A Halsted Press Book, 1981.

7) Schroeder, T.C., Goodwin B.K., *Price Discovery and Cointegration in live hog Markets*, Department of Agricultural Economics Kansas State University 1991, No 91-14.

8) User's Guide, RATS, Estima, 1800 Sherman Ave., Suite 301, Evanston, IL 60301, 2000 p.287.

9) Thompson, S., McNeill, T.J. and Eales, J., *Expiration and Delivery on the World Sugar Futures Contract,* The Journal of Futures Markets, Vol.10, No. 2, 153-168 (1990).