Expiration and Delivery on the World Sugar Futures Contract

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I. INTRODUCTION

In most countries sugar production is undertaken for domestic consumption. Of the roughly 100 million tons produced annually, less than 30 percent is internationally traded, and only 10–15 percent is traded on the world free market. The work sugar market is therefore a residual market and extreme price swings are not uncommon. Recent major price rises occurred in 1974 and 1981 (to over 40 cents/pound). Prices have fallen to as low as 2.5 cents/pound in June 1985 and have since hovered in the neighborhood of 10 cents.

The drafting of the New York No. 11 (World) sugar contract presented a problem of specification not commonly faced by futures markets. At present sugar produced in a foreign country can only be imported to the U.S. if covered by strict quota allocations. Prior to quotas, foreign sugar entered the U.S. under heavy import duties. Thus, the U.S. sugar market is and has been effectively divorced from the world market.

The World Sugar futures (WSF) contract differs from most other futures contracts in its specification of 28 ports of origin worldwide as delivery points. Furthermore, the traded commodity, raw cane sugar, is not deliverable at any United States port. The contract also differs from other contracts in the complete cessation of trading by the notice day (the first day of the delivery month). Large deliveries as a percentage of open interest are a common feature of trading in the contract. Despite these unusual characterstics, the WSF contract is actively traded (3 million contracts traded in 1985).

While there is a cash market for sugar, the prices quoted on this market are derived from sugar futures prices. Usually, prices are quoted as a basis over or under the WSF contract or compared to the white sugar futures contract traded in London. Moreover, spot quotes for sugar are usually for delivery two to three weeks in the future. There-

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fore, there is really no sugar cash market price behavior to analyze and compare to futures price behavior.

This study compares the price, open interest, and delivery data from the WSF market to similar data from the cocoa market to assess the effect of the delivery mechanism and trading period in the WSF contract on contract performance. Cocoa provides an apt comparison because it is also a food commodity produced overseas with a wide production base. Cocoa also has a reasonably active futures contract traded on the Coffee, Sugar, and Cocoa Exchange. The cocoa contract differs from the sugar contract in its specification of only three delivery points in the Unites States and in that trading in cocoa is allowed into the delivery month.

Delivery on Sugar and Cocoa Futures Markets

Delivery on futures markets is the mechanism whereby prices quoted on the futures market and the cash (physical) market are forced into alignment. Deliveries should, however, be infrequent or minimal (see Hieronymus (1977)). Excessive usage of the mechanism, or disadvantages incurred by either shorts or longs through delivery, can diminish the effectiveness of the delivery mechanism as well as the attractiveness of the contract to both speculators and hedgers. The disadvantaged parties may abandon the market entirely, or in less serious cases, the market may become extremely thin as expiration approaches.

In general, less than one percent of all futures contracts are delivered. However, on the WSF contract, 5–15% of the maximum open interest in any contract is commonly delivered. Deliveries on the cocoa contract are commonly 2–5% of the maximum open interest in any contract, higher than the average of all contracts, but considerably lower than deliveries on the sugar contract.

Deliveries on the cocoa contract may be made at one of three U.S. ports: New York, Delaware River, or Hampton Roads. The first notice day in cocoa futures occurs on the tenth full business day before the first business day of the delivery month. On this day open long traders may be issued delivery notices. The notice period (and all trading) ceases on the final notice day, ten full business days before the end of the delivery month. The delivery mechanism employed on the cocoa contract is similar to that used in most commodity futures contracts.

A port in the country of origin serves as specified delivery point in the WSF contract. As stated earlier, there are 28 specified delivery points worldwide, but none in the United States. No trading in the WSF contract occurs after the first notice day which is the first business day in the delivery month. After trading ceases and a settlement price is established, holders of open short contracts are required to declare to the Exchange the country of origin and port at which delivery will occur. The Exchange compiles all delivery information and issues a "Multiple Delivery Notice" to holders of outstanding long positions. These allocations made to longs are randomly assigned with respect to country of origin; but the Exchange makes an attempt to avoid the break up of deliveries into smaller portions than necessary. In other words, shorts with a large amount of sugar to deliver are matched with longs with large open positions, rather than with a number of longs of smaller positions. Longs may then exchange among themselves, with or without additional compensation. They have one day to do so after which they inform the Exchange of final commitments. Following this process, the receivers (longs) must provide ships which are loaded by deliverers at the deliverer's specified port of origin. Receivers then transport, at their own expense, the sugar to its eventual destination.

Since sugar may be delivered at any of 28 locations at par, shorts with the greatest incentive to deliver are those who would profit most by delivery, that is, those whose intended delivery location is of least commercial worth. Therefore, the price of the WSF contract should represent the commercial value of the least valuable delivery location.[1] The change in the WSF contract price over the life of the contract should reflect changes in this value with greater precision due to more complete information as expiration approaches. Even if there is no downward revision in the value of the expected delivery locations, longs are faced with an additional risk because the location of deliveries may be worth more or less to them as individuals than it is to the market in general. Thus, although longs may exchange delivery assignments among themselves, an important issue to longs besides the eventual market value of the expected deliveries is the exact location of those deliveries.

Rather than shoulder the price risk associated with the quantity and location of sugar deliveries, longs may liquidate their positions before expiration, regardless of whether they are considering standing for delivery or not. A sharp decline in open interest in the expiring contract is the likely result. Furthermore, open interest may overstate the amount of liquidity remaining in the contract if a large percentage of shorts are intending delivery.[2]

A substantial decline in open interest may result in both increased price volatility as the market becomes thinner and a change in the price of the expiring contract relative to later maturities. If the news is unfavorable to longs, the change would be a depreciation of the price of the expiring contract. Conversely, if the news is unfavorable to shorts, a relative increase in the price of the expiring contract would occur as shorts buy back open opsitions. It is more likely that the information would have a greater impact on longs than on shorts because shorts probably have greater information, albeit incomplete, regarding the value of impending deliveries.

This study seeks to provide possible answers to several related questions regarding the performance of the WSF contract. Does the uncertainty regarding delivery quantities and locations 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?

II. RELATED LITERATURE

Delivery Specifications and Market Performance

Gray (1965) analyzed the acceptability of the design of a futures contract to potential trading interests. Poor contract design may, for several reasons, lead to decreased open interest and possibly the demise of the contract. The ability by either shorts or longs to squeeze the opposite position may lead to a refusal by those disadvantaged to use the

[1]It is well-known that futures markets price the cheapest quality of a commodity deliverable on the contract. See Leuthold, Junkus, and Cordier, (1989) for further discussion of this issue.

[2]The expiration process is futher complicated by the occurrence of "against actual" (AA) transactions. An against actual transaction is one where two parties holding opposite open positions report an offsetting physical commodity transaction to the Exchange. The relevant futures positions are then matched by the Exchange and need not be liquidated on the trading floor. Open interest in the expiring contract may fall dramatically if large AA transactions occur close to delivery.

market.[3] A failure to attract speculators to the market may affect a hedger's costs through lack of liquidity. A lack of speculative interest is most likely to occur when either long or short hedgers dominate trading (Gray 1960). In a study of the Kansas City wheat contract, Working (1954) found that a small, relatively thin market may be viable if it provides traders a closer hedge than more liquid markets. Purcell and Hudson (1986) found that the certificate system of delivery in the live cattle futures market, designed to reduce the disadvantage of longs under the physical delivery system, did not enhance the attractiveness of the contract because it made delivery more difficult for shorts.

An in-depth discussion of price aberrations during the delivery month is provided by Paul (1976). He contends that large costs associated with delivery greatly increase the potential for futures prices to fluctuate independently of cash prices. Such a "long squeeze" may drive shorts to buy back open positions at higher prices than might otherwise prevail in the expiring contract. Alternatively, Paul suggests longs may be put at a severe disadvantage by the excercise of certain sellers' options. Under a "short squeeze," longs may be forced to accept and dispose of commodity lots with unwanted grades or in unfavorable locations, or sell back open positions at a lower price than anticipated. Paul proposes (and tests in Paul (1986)) that comparison of the prices of the maturing contract and later maturities will reveal manipulative behavior. Sudden changes in these price relationships near contract expiration might suggest the occurence of purposeful squeezes.

Price Bias in Futures Markets

The contention that futures prices do not reflect the market's expected price (bias) was first proposed by Keynes (1930) as normal backwardation. Debate has continued over many years as to the actual existence of a risk premium and is reviewed in detail by Kamara (1982). Several researchers (see Houthakker (1959) and Cootner (1960)) have found evidence supporting Keynes' contention. Using the CAPM framework, Carter, Rausser, and Schmitz (1983) and Breeden (1980) have also found evidence of significant risk premiums. They suggest that speculators would not include futures contracts in their portfolios if a significant return on capital were not available. But Dusak (1973) found with the CAPM framework that for routine long positions, systematic risk and average realized returns do not differ significantly from zero. The majority view is that there is no general risk premium in futures markets. (see Tesler (1958) Rockwell (1967) and Gray (1961)). Gray (1960) linked the existence of any price bias to the amount of trading in a particular contract. Liquid, active markets showed no significant risk premium while insufficiently traded "thin" markets may exhibit a structural "characteristic bias."

The term "liquidation bias" was coined by Paul (1986) to describe his finding of a small but statistically significant rise in the price of the expiring future relative to the price of the next maturity during the heavy liquidation period. Paul shows that 70 to 90 percent of maximum contract open interest remains at the start of the seventh week prior to expiration and examines the price spread between the expiring and the next maturing contract during this period. Using weekly average price spreads based on daily closing prices, he compares the average spread in the seventh week prior to expiration with that of the fifth week; the fifth with the third week; and the third with the first week. The change in percentage price spreads over these two week periods, when averaged over a period of years, is then tested for a statistically significant difference from zero.

[3]A price bias may, however, continue to exist in a contract if the potential cost to participants of being unhedged outweighs the expected price bias, or if obtaining information regarding the price bias is costly.

Paul finds a significant liquidation bias in the final two weeks of trading for fifteen of twenty-two agricultural and metal contracts examined. In none of the contracts he examines does price fall a statistically significant amount relative to the next near contract. The attractiveness of the large profits detected by Paul (113% on an annualized basis) is diminished somewhat by the infrequency of trading opportunities, the high variability of returns, and the risk of taking delivery of the commodity if shorts do not liquidate their positions. Paul's analysis also does not include coffee, sugar or cocoa.

In searching for causes of this liquidation bias, Paul discusses the possiblity of a squeeze by longs who also control most physical supplies, or by long commodity firms who are better equipped to accept delivery than shorts are to deliver. Paul discounts both possiblities because they do not reflect market conditions. Instead, he favors explanations based on the Keynes' risk premium and the day-to-day cost of carry during the delivery month. In his view, cash settlement (rather than physical delivery) would eliminate such bias, but given the stringent requirements for adopting cash settlement, he concludes the observed liquidation bias is likely to continue.

Volatility in Futures Prices

The issue of volatility in futures prices also has been widely debated in the literature. Gray (1961) contends that not only is it possible for structurally lopsided markets to display a price bias, but that lack of speculative interest and "proper" scalping will result in a wider price dispersion than would occur in a balanced market. Lack of speculation and scalping activities are likely to be found in thin markets.

Samuelson (1965) provided a model of what has become known as the maturity effect which postulates that futures price volatility increases as maturity approaches because futures contracts close to expiration react more strongly to new information than do more distant contracts. Evidence regarding this theorized effect is, however, mixed (see Rutledge (1976) and Grauer (1977)).

An alternative to the Samuelson hypothesis is proposed by Stein (1979) and by Anderson and Danthine (1980). Their state variable hypothesis maintains that the volatility of futures prices will be high (low) when the uncertainty regarding future supply and demand is high (low). The Samuelson maturity effect is a special case of the more general Anderson-Danthine version of the state variable hypothesis. Kenyon, Kling, Jordon, Seale, and McCabe (1987) found support for the state variable hypothesis by showing that the loan rate, which provides a floor price for many grains, has a significant effect on volatility in grain futures. Anderson found that the variance of futures price changes is not constant and that variance changes follow a seasonal pattern, with maturity being a secondary factor affecting volatility.

III. EMPIRICAL ANALYSIS

Paul-Type Tests for Liquidation Bias and Changes in Volatility

Methodology. The methodology used for this analysis differs from that used by Paul in two ways. First, where Paul examined only the spread between the expiring and next maturity, the spread between the second and third maturities is also examined in this study. Because the spread is a ratio, it is possible, (though Paul comments, unlikely), that the cause of a price bias could be the behavior of the second maturity rather than the behavior of the expiring contract. For a relative price increase (decrease) on expiration, this alternative would imply a price fall (rise) by the second maturity. Examination of two price spreads in this study should shed light on this issue.

The second difference between Paul's methodology and that used here is in the data utilized for analysis. Paul calculates weekly average price spreads based on daily closing prices (mostly settlement prices). The data used in this study are settlement price data from expiration day, and comparable data from each Thursday up to seven weeks prior to expiration. This procedure is justifiable if the representative day chosen exhibits no idiosyncratic market behavior. Since Fridays and Mondays have sometimes been associated with a "weekend effect," Thursdays were chosen and used uniformly throughout this study.

Following Paul, to test liquidation bias, two ratios were formed from the raw data as follows:

$$\text{SPR1} = \text{SP1}/\text{SP2} \times 100$$

$$\text{SPR2} = \text{SP2}/\text{SP3} \times 100$$

The first settlement price ratio (SPR1) is the settlement price of the expiring contract (SP1) expressed as a percentage of the next expiring contract (SP2). SPR2 similarly expresses the settlement price of the second maturity (SP2) as a percentage of the third maturity (SP3). The change in these percentage price ratios (denoted dSPR1 and dSPR2) are calculated from week 7 to week 5; week 5 to week 3; and week 3 to week 1, with 'n' representing the weeks to maturity:[4]

$$\text{dSPR1}_2 = \text{SPR1}_{n-2} - \text{SPR1}_n$$

$$\text{dSPR2}_2 = \text{SPR2}_{n-2} - \text{SPR2}_n.$$

Statistical significance is determined by means of a simple t-test that indicates whether any average price rise or fall over the two week periods for the contracts analyzed is statistically different from zero. This procedure allows comparability with Paul's results.

The volatility of a futures contract during any particular day may be measured by the high and low prices of its trading range relative to the daily average price level. Because the daily trading range provides a daily measure of volatility, this measure of volatility is preferred over related measures such as the standard deviation of price changes. In stable market conditions, prices generally trade in a narrow range. Price volatility for each price observation taken is measured here as follows:

$$\text{VOL1} = \frac{\text{High} - \text{Low}}{\text{Settlement Price}} \times 100$$

Volatility is calculated for the same daily price observations as are used in generating SPR1 and SPR2. The volatilities of the expiring (denoted here VOL1) and the next two maturities (VOL2 and VOL3) are examined to allow a comparison across contracts. Differences in volatility measures are analyzed because they abstract from the problem of the starting level of volatility. The change in percent volatility is calculated as follows:

$$\text{dVOL1}_2 = \text{VOL1}_{n-2} - \text{VOL1}_n$$

where dVOL1 is the percentage change in volatility in the expiring contract across the same three two-week periods used in the dSPR calculations. The statistical significance of such changes in volatility over time can be tested with a simple t-test.

For the t-tests for liquidation bias and changes in price volatility, prices from three heavily traded sugar contracts (October, March, and July) and two low volume contracts

[4]Expressing the changes as percentage changes rather than as the arithmetic differences between prices avoids the problem of price level distortion.

(September and January) are analyzed for a wide comparison of contract differences. For cocoa, two heavily traded (March, July) and one lower volume contract (September) form the data set. A total of 46 sugar contracts (five contracts per year between 1978 and 1986 plus January 1987) and 27 cocoa contracts (three contracts per year between 1978 and 1986) are analyzed.

Data were taken chiefly from the *Coffee Sugar and Cocoa Exchange Statistical Annual* (1980–1986). Statistical annuals were not published prior to the amalgamation and formation of the Coffee, Sugar, and Cocoa Exchange in 1979. Data for 1978 and 1979 were taken from the *Wall Street Journal*.

Results-Paul Test for Liquidation Bias. Average changes in price spreads and their standard deviations for sugar and cocoa contracts grouped by contract month are presented in Table I. Although all sugar contracts show the hypothesized sign (negative) for dSPR1 in the final two weeks, none are significantly different from zero. Futhermore, none of the average price changes from the other two week intervals for both dSPR1 and dSPR2 is significantly different from zero, and a few are positive. The cocoa contracts examined also fail to show any significant liquidation bias. The standard deviations for dSPR appear to be larger for sugar than for cocoa. The volatility of the sugar market, and the variation in the expiration behavior from year to year, may account for such large standard deviations.

The order of magnitude of dSPR1 is generally much larger than that for dSPR2. While this does not disprove the possibility that any liquidation bias may be due to the

TABLE I
AVERAGE CHANGES OF THE PRICE OF THE EXPIRING AND NEXT NEAR FUTURES CONTRACT AS A PERCENTAGE OF THE PRICE OF THE NEXT MATURITY DURING THE LAST SEVEN WEEKS OF TRADING OF THE EXPIRING CONTRACT

		dSPR1 (%) (Interval in Weeks)			dSPR2 (%) (Interval in Weeks)		
		7th-5th	5th-3rd	3rd-1st	7th-5th	5th-3rd	3rd-1st
SUGAR	January	−.53	−1.42	−2.44	.36	−.61	.09
		(1.01)	(2.86)	(3.99)	(1.16)	(1.44)	(.66)
	March	.28	−.48	−.56	.07	−.13	−.48
		(1.20)	(1.40)	(4.68)	(.92)	(1.09)	(1.69)
	July	−1.19	.81	−3.55	−.07	−.22	−.17
		(3.63)	(1.81)	(5.61)	(.53)	(1.33)	(.71)
	September	.81	−.97	−1.72	−.25	−.49	−.88
		(1.23)	(1.13)	(3.58)	(1.84)	(1.08)	(1.87)
	October	−1.43	−.25	−.002	.20	−.80	.39
		(1.51)	(1.79)	(6.26)	(2.17)	(1.62)	(1.44)
COCOA	March	−.79	.88	−.36	−.52	.22	.67
		(1.13)	(1.12)	(1.52)	(.67)	(.40)	(1.36)
	July	−.52	.03	.78	−.17	−.40	−.02
		(1.42)	(1.39)	(1.92)	(.81)	(.65)	(1.28)
	September	.42	.44	1.19	−.21	.25	.17
		(2.29)	(1.69)	(1.39)	(.77)	(.96)	(.71)

Note: Standard deviations are in parentheses.

behavior of the second maturity (rather than the expiring contract), it does not lend support to this possibility.

The conclusion drawn from the test of liquidation bias using Paul's (1986) methodology is that no statistically significant liquidation bias exists in either the sugar or cocoa markets.

Results-Paul Test for Changes in Price Volatility on Contract Expiration. Measures of price volatility on contract expiration using methodology similar to that for liquidation bias are shown for sugar and cocoa contracts in Table II. The volatility of the expiring contract and the next two maturities is measured separately.

Volatility appears to have consistently increased in the final two weeks of trading in the expiring sugar contracts as measured by the positive sign on volatility changes, but not by a statistically significant amount. Volatility appears to decrease, although not significantly, in cocoa contracts upon expiration. The magnitude of the volatility changes in the expiring contract appears larger for sugar in the final two weeks of trading than in the previous periods. No pattern emerges with respect to volatility for sugar or cocoa in the second or third maturing futures during these periods. As with the tests for liquidation bias, tests for volatility changes in the sugar and cocoa markets are uninformative due to the extremely large standard deviations in price volatility.

REGRESSION ANALYSIS

The Effect of Deliveries on Price Spreads

To test whether the amount of deliveries on the WSF contract affects the behavior of the price spread near expiration, three measures of changes in the price of the expiring contract in the expiration period relative to the next maturity are regressed against the number of contracts delivered. The three measures are: (1) the first differences of price spreads from week 7 to week 1 (expiration), cumulatively summed to produce the variable NETSPR; (2) $dSPR1_2$ across the last two weeks of trading ($SPR1_3 - SPR1_1$); and (3) $dSPR1_1$ across the last week of trading ($SPR1_2 - SPR1_1$). These three measures are considered because it was unclear what time horizon was relevant for expiration effects. Delivery information was made available by the Exchange.

Results of the regressions relating NETSPR, dSPR1 across the last two weeks of trading, and dSPR1 across the last week of trading to number of contracts delivered (DELS) are as follows:

$$\text{NETSPR} = \underset{(-3.33)^*}{-3.67} + \underset{(1.69)}{.00112}\ \text{DELS}$$

$$\text{Adjusted } R^2 = .04 \qquad F = 2.85\ (1{,}44) \qquad D - W = 1.87$$

$$\text{dSPR1}_2 = \underset{(-3.45)}{-3.18} + \underset{(2.41)}{.00134}\ \text{DELS}$$

$$\text{Adjusted } R^2 = .10 \qquad F = 5.81\ (1{,}44) \qquad D - W = 2.08$$

$$\text{dSPR1}_1 = \underset{(-3.06)}{-2.47} + \underset{(2.32)}{.00114}\ \text{DELS}$$

$$\text{Adjusted } R^2 = .09 \qquad F = 5.40\ (1{,}44) \qquad D - W = 2.06$$

*t-ratios are in parentheses

TABLE II

AVERAGE PERCENT CHANGES IN VOLATILITY OF THE EXPIRING AND NEXT TWO MATURING FUTURES CONTRACTS DURING THE LAST SEVEN WEEKS OF TRADING OF THE EXPIRING FUTURE

		Expiring Contract Interval in Weeks			Second Maturing Contract Interval in Weeks			Third Maturing Contract Interval in Weeks		
		7th-5th	5th-3rd	3rd-1st	7th-5th	5th-3rd	3rd-1st	7th-5th	5th-3rd	3rd-1st
SUGAR	January	.04	−.22	1.44	−.21	−.28	−.07	−.47	−.21	−.51
		(2.52)	(1.65)	(1.77)	(2.53)	(1.31)	(.88)	(2.70)	(1.61)	(1.04)
	March	−.41	−.34	3.07	−.27	−.89	.25	−.50	−.75	−.58
		(1.48)	(1.35)	(3.96)	(1.31)	(1.40)	(.95)	(1.02)	(1.62)	(.93)
	July	.44	.40	3.94	.91	.82	−.34	.92	.74	−.24
		(2.10)	(2.77)	(5.15)	(2.51)	(2.92)	(3.01)	(1.92)	(2.02)	(2.59)
	September	−.40	−.39	1.98	.52	.43	−.80	.33	.14	−1.42
		(2.55)	(2.19)	(2.84)	(1.71)	(2.08)	(2.00)	(1.65)	(1.22)	(2.18)
	October	−.21	−.32	4.73	−1.07	1.08	.06	−.34	−.24	.70
		(2.65)	(1.56)	(2.88)	(2.22)	(1.66)	(1.98)	(1.90)	(1.47)	(2.24)
COCOA	March	.13	−1.10	−.66	−.21	−.23	.18	−.34	−.08	.31
		(2.38)	(1.84)	(1.03)	(1.32)	(1.48)	(1.10)	(1.13)	(1.34)	(1.37)
	July	−.03	−.67	−.76	−.09	.28	−.70	−.22	.36	−.77
		(1.97)	(3.39)	(2.77)	(2.03)	(1.62)	(1.31)	(1.64)	(1.40)	(1.16)
	September	.24	−.84	−.53	.27	.44	.004	.22	−.24	.05
		(2.29)	(2.13)	(1.11)	(2.08)	(1.69)	(.78)	(1.52)	(1.30)	(.57)

Note: Standard deviations in parentheses.

These regressions suggest that there is positive relationship between the change in sugar price ratios and the number of contracts delivered. Although this result is somewhat unexpected, it may indicate that longs are more willing to stand for delivery and thus do not offset their positions, when the quantity and location of likely deliveries are of greater value than expected. The regression intercept also indicates that if no contracts are delivered, all three measures of the change in the expiring contract relative to the next maturity are likely to be negative suggesting a decrease in the expiring contract relative to the next maturity. For the NETSPR regression to imply a positive value for NETSPR, the number of contracts delivered must exceed 3277. The number of contracts that must be delivered for the dSPR1 regressions to imply a positive value for dSPR1 are 2373 (last two weeks of trading regression) and 2167 (last week of trading regression). The average number of contracts delivered in the study period was 1122, with a minimum of zero and a maximum of 4217.

The complexity of the factors interacting in the market as expiration approaches are not captured by the quantity of deliveries alone. No satisfactory data exist to model the port of origin and final destination considerations. Other factors such as "against actuals" transactions close to expiration (which may relieve the market of potential deliveries) also may have some bearing upon the expectations held by traders regarding quantities and origins of possible deliveries.[5]

The Effect of Time to Maturity and Changes in Open Interest on Price Behavior

Besides time to maturity, changes in contract open interest may reflect the interactions occurring during the period approaching expiration. In particular, the change in open interest as expiration approaches may reflect the reactions of market participants to information regarding likely delivery quantities and locations. To test whether changes in the price spread between the expiring and next maturity and changes in price volatility are influenced by changes in open interest in addition to, or rather than, time to maturity, the following relationships will be tested for both sugar and cocoa contracts:

$$\text{dSPR} = f(\text{ dOI, TIME })$$

$$\text{dVOL} = f(\text{ dOI, TIME }),$$

where dOI is the percentage change in open interest in the seven weeks before expiration:

$$\text{dOI} = \frac{\text{OI}_n}{(\text{OI}_{n-1} - \text{OI}_n)} \times 100.$$

TIME is measured as a linearly increasing variable taking the value 1 for the first difference in spreads between weeks 7 and 6 and taking the value 6 for the first difference in spreads between weeks 2 and 1 (expiration). The variables dSPR and dVOl are as defined earlier except that changes over each of the seven weeks before expiration are considered rather than changes over two week periods as in the Paul-type tests. It is hypothesized that, because declines in open interest mostly reflect longs liquidating to prevent taking delivery, the price of the expiring contract will fall relative to other maturities as open interest declines. Therefore, the coefficient on the open interest variable in the dSPR regression is expected to be positive since the specified price ratio falls with open interest. Volatility is expected to rise as open interest falls, resulting in a negative coefficient for open interest in the dVOL regression. A positive (negative) coefficient on

[5]For a description of "against actuals" transactions, see footnote 2.

the time trend variable in the dSPR regression indicates that the price of the expiring contract rises (falls) relative to the next maturity. A negative (positive) coefficient on the time trend variable in the dVOL regression indicates that price volatility increases (decreases) as open interest decreases (increases).

All regressions are estimated with a procedure suggested by Kmenta (1986) for pooled cross-section time series data that accommodates heteroskedasticity and autocorrelation of error terms. This method is appropriate to the data set because the data set [for sugar] is comprised of 41 time series representing the expiration behavior of five contracts over eight years plus one contract in the ninth year. There is no reason to believe a *a priori* that the variances are the same for every contract and in every year in the data set.

The same data are used for the regression analysis of liquidation bias and changes in price volatility in sugar and cocoa contracts as in the Paul-type tests except that the data set used for the regression analysis ends in January of 1986 for sugar and in September of 1985 for cocoa due to the unavailability of open interest data beyond these dates.

Regression Results-Liquidation Bias[6]

Results of the regressions of dSPR1 and dSPR2 for sugar contracts on dOI and TIME using the estimation method for pooled cross-section time series yields the following:

$$\underset{}{\text{dSPR1}} = \underset{(.78)}{.194} + \underset{(1.82)}{.0205\ \text{dOI}} - \underset{(-.56)}{.0401\ \text{TIME}}$$

Buse $R^2 = .05$ $\quad F = 6.10\ (2{,}243)$ $\quad D - W = 2.11$

$$\text{dSPR2} = \underset{(.76)}{.0867} + \underset{(1.11)}{.00676\ \text{dOI}} - \underset{(-.57)}{.0219\ \text{TIME}}$$

Buse $R^2 = .03$ $\quad F = 4.02\ (2{,}243)$ $\quad D - W = 1.82$ $\quad \text{rho} = -.361$

Comparable results for cocoa contracts are the following:

$$\text{dSPR1} = \underset{(.16)}{.060} + \underset{(.74)}{.00538\ \text{dOI}} + \underset{(.17)}{.0128\ \text{TIME}}$$

Buse $R^2 = .02$ $\quad F = 1.59\ (2{,}141)$ $\quad D - W = 1.91$

$$\text{dSPR2} = \underset{(-1.56)}{-.373} - \underset{(-.37)}{.00172\ \text{dOI}} + \underset{(1.76)}{.0859\ \text{TIME}}$$

Buse $R^2 = .06$ $\quad F = 4.80\ (2{,}141)$ $\quad D - W = 2.01$

The statistics in brackets below coefficients are t-ratios. Both sugar regressions are significant at the .05 level, while only the dSPR2 regression for cocoa is significant. A correction for autocorrelation assuming a constant value for rho across all cross-sections is made in the dSPR2 regression for sugar since the restriction that rho equals zero was rejected using the likelihood ratio test.

Both sugar regressions indicate a positive relationship between dSPR and changes in open interest and a negative relationship between dSPR and proximity to maturity. Thus both the expiring contract and the next near contract decline in price relative to the next

[6]All sugar and cocoa regressions involving dSPR and dVOL are based on a data set that ends January of 1986 and January of 1985. Regressions of these variables on a time trend alone using data through January of 1987 for sugar were very similar to those using data through January of 1986, except that TIME enters more significantly in the regressions based on the longer data set.

maturity as open interest declines and as expiration approaches. These results, therefore, do not support the hypothesis that a relative price decline in the expiring contract is caused by a rise in the price of the next maturity. However, the magnitude of the effects of changes in open interest and proximity to maturity are much greater in the dSPR1 regression, suggesting that a greater relative decline occurs in the expiring contract than in the next near contract as open interest declines and expiration approaches.

No significant relative price change occurs in expiring cocoa contracts as a function of changes in open interest or proximity to maturity. However, there does appear to be a significant relationship between dSPR2 for cocoa contracts and TIME which may suggest that the price of the next near contract increases relative to the subsequent maturity as the nearby cocoa contract expires. This may be occasioned by buying interest in the next near cocoa contract as long as hedgers roll over hedges out of the nearby contract into the next near.

The coefficient on TIME is not significant in either of the dSPR regressions for sugar. Therefore, a restricted form of the sugar regressions relating to dSPR to dOI was tested with the likelihood ratio test. This test indicated no reason to reject the following restricted models:

$$\underset{}{\text{dSPR1}} = \underset{(.73)}{.108} + \underset{(2.80)}{.0240}\ \text{dOI}$$

$$\text{Buse } R^2 = .05 \qquad F = 12.01(1{,}244) \qquad D - W = 2.10$$

$$\text{dSPR2} = \underset{(.58)}{.0371} + \underset{(2.35)}{.00917}\ \text{dOI}$$

$$\text{Buse } R^2 = .03 \qquad F = 8.40(1{,}244) \qquad D - W = 1.81 \qquad \text{rho} = -.358$$

The restriction that rho equals zero was again rejected in the dSPR2 regression. The dSPR1 regression suggests that a 50 percent fall in open interest in the expiring contract will be accompanied by a 1.09 fall in the predicted percentage price ratio of the expiring contract to the next maturity. The dSPR2 regression suggests that a 50 percent fall in open interest in the expiring contract will be accompanied by a .42 percent decline in the percentage price ratio of the next near contract relative to the subsequent maturity. Therefore, because of the positive relationship between declines in open interest and declines in the price of the expiring contract, open interest declines near expiration appear to be largely occasioned by longs liquidating. The incentive for longs to liquidate is generally greater than for shorts to cover and causes greater selling pressure than buying pressure near expiration in the WSF contract.

Regression Results-Changes in Price Volatility

The relationship between the change in price volatility, changes in open interest, and time to maturity (ie., a Samuelson effect) was investigated using again the estimation method for pooled cross-section time series for sugar and cocoa contracts. The results of regressions of dVOL1 and dVOL2 on dOI and TIME for sugar contracts are as follows:

$$\text{dVOL1} = \underset{(-1.78)}{-.417} - \underset{(-2.95)}{.0371}\ \text{dOI} + \underset{(.57)}{.0445}\ \text{TIME}$$

$$\text{Buse } R^2 = .13 \qquad F = 18.6\ (2{,}243) \qquad D - W = 2.12 \qquad \text{rho} = -.61$$

$$\text{dVOL2} = \underset{(.47)}{.0732} - \underset{(-2.31)}{.0194}\ \text{dOI} - \underset{(-1.62)}{.0858}\ \text{TIME}$$

Buse $R^2 = .04$ $F = 5.35\ (2,243)$ $D - W = 1.98$ rho $= -.51$

Comparable regressions for cocoa contracts are as follows:

$$\text{dVOL1} = \underset{(-1.86)}{-.896} - \underset{(-2.06)}{.0202}\ \text{dOI} + \underset{(1.11)}{.106}\ \text{TIME}$$

Buse $R^2 = .07$ $F = 5.07(2,141)$ $D - W = 2.20$ rho $= -.507$

$$\text{dVOL2} = \underset{(-.70)}{-.298} - \underset{(-.97)}{.00829}\ \text{dOI} + \underset{(.61)}{0.514}\ \text{TIME}$$

Buse $R^2 = .01$ $F = 1.02\ (2,141)$ $D - W = 2.05$ rho $= -.465$

Except for the regression of the change in volatility in the next near cocoa contract (dVOL2), all regressions are significant at the .05 level. Since the restriction that rho equals zero was rejected at the .05 level in each regression, an estimate of rho was obtained assuming that rho is the same across the cross-sections in each regression.

All regressions indicate an inverse relationship between dVOL and changes in open interest. The sign on TIME is not consistent across regressions, nor is it significant. Thus, increases in price volatility are associated with decreases in open interest in the expiring contract. Based on the magnitude of the coefficients on dOI, price volatility in the expiring sugar future contract appear to be the most sensitive to changes in open interest.

Because TIME is not significant in any of the dVOL regressions above, restricted forms of the relationship were estimated to further isolate the impact of changes in open interest on changes in volatility. The restricted models relating dVOL to dOI for sugar are as follows:

$$\text{dVOL1} = \underset{(-2.22)}{-.312} - \underset{(-4.91)}{.0412}\ \text{dOI}$$

Buse $R^2 = .13$ $F = 37.64\ (1,244)$ $D - W = 2.15$ rho $= -.613$

$$\text{dVOL2} = \underset{(-1.27)}{-.121} - \underset{(-2.04)}{.0114}\ \text{dOI}$$

Buse $R^2 = .03$ $F = 6.25\ (1,244)$ $D - W = 1.99$ rho $= -.509$

The restricted model relating dVOL1 to dOI for cocoa is as follows:

$$\text{dVOL1} = \underset{(-3.44)}{-.378} - \underset{(-2.29)}{.0114}\ \text{dOI}$$

Buse $R^2 = .05$ $F = 7.83\ (1,142)$ $D - W = 2.18$ rho $= -.516$

The dVOL1 sugar regression indicates that if open interest falls 50 percent from one week to the next, volatility as a percent of contract value in the expiring contract will increase by 1.75 percentage points. Similar declines in dOI will increase volatility by .45 percentage points in the next sugar maturity, and by .19 percentage points in the expiring cocoa contract. Volatility increases are small with declines in open interest, especially in cocoa, because the regression intercepts, representing the change in volatility with no change in open interest, are all negative.

Since volatility is calculated as the representative daily high minus low divided by settlement price, a trading range of .30 cents in sugar and a settlement price of 10 cents yields a volatility of 3 percent. A decline in open interest of 50 percent in the expiring contract will, in this example, raise volatility in the expiring sugar contract to 4.75 percent, or to a trading range of .48 cents (assuming a constant settlement price). Therefore, in a week where the open interest in the expiring contract is declining, the daily trading range (volatility) can be expected to be larger than in a week where open interest in the expiring contract is relatively stable.

The regression analysis has revealed that a relative decline in the price of the expiring contract and increasing volatility as expiration approaches therefore does not occur simply because the contract is expiring. The driving force behind price behavior in the expiring WSF contract appears rather to be changes in the open interest in the expiring contract that, given the relationship between changes in open interest and dSPR1, are generally occasioned by longs liquidating.

IV. SUMMARY AND CONCLUSIONS

This study examined the price implications of the delivery specifications of the WSF contract by comparing price behavior in the WSF contract to price behavior in the cocoa contract during the seven weeks before contract expiration. No significant change in the price behavior of the expiring sugar or cocoa contracts was detected using the Paul-type t-tests. However, regression analysis revealed that the volatility of sugar prices and price spreads near contract expiration are significantly related to changes in open interest that are largely occasioned by longs liquidating; and that, for the data examined, the open interest effect outweighs the time to maturity effect. In light of the generally large deliveries as a percentage of contract open interest, these results suggests that the WSF delivery mechanism favors shorts at the expense of longs and that longs tend to avoid taking delivery. However, given that the WSF contract is actively traded, longs are either not heavily disadvantaged by the contract's delivery specifications, or the advantages of being able to hedge in the market outweigh the potential disadvantages.

No evidence was found of a decline in the price of the expiring cocoa contract relative to the price of the next cocoa maturity. A significant relationship was found between changes in volatility of the expiring cocoa futures contract and changes in open interest suggesting that open interest declines are associated with increases in price volatility. However, it is only with open interest declines greater than 33% that the change in price volatility is positive. Furthermore, it is not surprising that large changes in open interest would result in, or be associated with, increases in price volatility in *any* contract. What is noteworthy with respect to the sugar contract is that a much smaller decline in open interest results in positive changes in price volatility in sugar than in cocoa contracts, and that the magnitude of the response is larger in sugar than in cocoa. The finding that the price behavior characteristic of sugar contracts during the expiration period was not found in a contract that is similar except for differences in contract specifications regarding delivery and expiration strongly suggests that these specifications are responsible for the unusual price behavior of the sugar contract during the expiration period.

A positive relationship was found between the quantity of sugar delivered and the price behavior of the expiring contracts. This finding may reflect a willingness of longs to stand for delivery, and thus not offset their positions, when the quantity and location of likely deliveries are of greater value than expected. However, the quantity of deliveries only partially captures the deliveries information required to specify fully the relationship between likely deliveries and the price of the WSF contract. Data relating to origin and final destination of delivered sugar, regional supply, and demand relationships, and possibly data relating to "against actuals" transactions close to expiration would be necessary to specify this regression equation fully. Further insight might be gained also if more data were available that identifies the composition of open interest in expiring sugar contracts. Exchange records could shed light on the major players involved in the delivery process and might reveal whether (and which) short hedgers or speculators induce squeezes and unusual price behavior upon contract expiration.

The Coffee, Sugar, and Cocoa Exchange may want to reconsider WSF contract specifications regarding expiration and delivery. It would be politically difficult to remove any ports of origin from the delivery list. One source of risk for longs may, however, be moderated if trading were extended beyond the notice day. This commonly-used contract specification would provide information on delivery quantities and locations before contract expiration. Longs would be able to liquidate undesired positions with lower transactions costs than would be incurred outside the futures market. This process would not, however, eliminate delivery uncertainty prior to contract expiration. The net return from liquidating after the first notice day should reflect the difference between the market's earlier expectation of delivery quantity and origins and what eventuated in the delivery period. The effect of trading after the first notice day on price volatility and the price of the expiring contract would depend on whether the pressure on longs to liquidate as expiration approaches is reduced.

The Exchange may wish also to study the possiblities of cash settlement or optional cash settlement for the WSF contract. A cash index would need to be constructed that reflects the "world" cash price of raw sugar. However, an index of traded prices may be difficult to calculate at a single point in time. Moreover, as mentioned in the introduction, since most spot quotes are derived from futures prices, it is doubtful whether a workable cash index could be constructed.

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