Citrus fruits - Marketing

1975

EMPIRICAL CONTRIBUTIONS TO BASIS THEORY: THE CASE FOR CITRUS FUTURES

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Recent changes in both futures trading and regulatory activities attest to the interest and questions relating to the economic usefulness of futures markets. The economic usefulness of particular contracts and the conformity of futures markets to basic economic theories are major research issues in futures trading. These issues are especially important as the new Federal Commodities Trading Commission began evaluating the performance of each futures contract. The performance of the futures market, and hence its economic usefulness to an industry, depends on how well the market reacts to fundamentals within an industry. Much of the performance is measured through the basis and an economic evaluation of performance stems from the ability to empirically analyze the basis. If the basis cannot be explained, then there is reason to question both the market's performance and economic usefulness.

The literature on basis theory is reasonably well developed from a theoretical framework and somewhat less so empirically. In addition, many components to a basis model tend to be unique to the specific contract studied. This uniqueness becomes more evident as new contracts such as frozen orange concentrate (FCOJ) are added to the list of commodities and products traded.

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Florida Agricultural Experiment Station Journal Series Number .

Paper presented at AAEA annual meetings, Columbus, Aug. 10-13, 1975.

Frozen concentrated orange juice futures is a relatively new contract and represents an innovative concept to the processed food industry. Also, it is an interesting contract to study in that many of the unique aspects of a basis can be illustrated. From the industry standpoint, concerns as to how this market has performed have been raised [Dasse].

Given the above considerations, this paper will explore empirically those variables contributing to the basis in FCOJ. These efforts are intended to both illustrate basis theory as it applies to a given contract and to provide empirical reference for judging the economic performance of the orange concentrate contract. The basis model is developed in the first section followed then by an estimation of the model for FCOJ. Finally, the last section gives the empirical contributions to the FCOJ basis and their economic interpretation.

BASIS THEORY

Distant futures will exceed the spot price or nearby futures by the cost of storage and transformation assuming both prices are for similar qualities. However, if nearby prices reflect a shortage there is some convenience yield for having at least a minimal stock and this yield offsets at least part of the carrying cost [Kaldor, Working]. Weymar provides a detail study of the supply of storage for cocoa where the spread between the futures and cash price is related to inventory levels. Weymar's model includes both a risk premium and convenience yield which are related to inventory levels. Kofi addresses the theory of storage in his study of the efficiency of futures markets. Brennan provides empirical evidence to support much of the early theory of convenience yields with his studies of the supply of storage. He empirically shows that the spread between a futures and spot price can be explained in part by the net marginal outlay for storage and/or product transformation. The net marginal outlay is defined as the marginal outlay in physical storage plus a marginal risk-aversion factor minus the marginal convenience yield on stocks.

Each of these works add to the basis theory, yet they fail to incorporate the uniqueness inherent in each contract market. This omission can greatly distort the empirical results when a specific commodity market is being studied. The distortion in Brennan's model would be reflected in his derivation of the risk and convenience yield components of his model since they are derived as the residual once the marginal storage cost is subtracted from the basis. In fact, the residual includes both theoretical components as well as contributing factors unique to a particular market.

As indicated above, the FCOJ market is a good example for illustrating both the theory of storage and the uniqueness in a basis model. The FCOJ basis should reflect the net marginal outlay. Then following the methodology similar to Brennan's, the real marginal outlay for production and storage of FCOJ is defined where

$$(1) \quad MO_t = (e^{rt} - 1)(GP_t + TC_t) + C_t(t),$$

letting CP_t = weekly cash raw fruit price delivered-in to the processor at period t; TC_t = annual average variable cost per pounds solids of converting fruit into equivalent pounds solids of bulk concentrate; C_t = annual average cost of storing bulk concentrate per pounds solids per unit of time t; r = annual market interest rate; and t = time the inventories will be held or days to contract maturity. Further, define the basis model for

FCOJ as

$$(2)\quad B_t = FP_t - CP_t - TC_t,$$

given that FP_t = futures price in period t and B_t = basis in period t with both values measured in cents per pounds of solids of bulk concentrate. Subtracting the marginal outlay from the basis yields the residual (BR) to the basis model which must be explained by the convenience yield, risk premium, liquidity and those variables unique to the concentrate market.

$$(3)\quad BR_t = B_t - MO_t.$$

Given the values of BR over time, then both the performance and usefulness of the market to the citrus industry is predicated on explaining the basis residual.

THE FCOJ BASIS MODEL

Basis models cannot be developed without a clear understanding of the chronology of the industry studied. The chronology shown in figure 1 indicates when events occur in the life of a particular FCOJ contract. The season officially begins December 1, but the first crop estimate by the USDA is released in October. The industry is generally susceptible to a freeze from December to mid-February. Market adjustments in response to the events during the freeze period are evident during the months following February. Most of the crop is harvested by July and the cash fruit price is reported through July from which an equivalent bulk price is derived. There is no published bulk average price for the industry. Note that in equation (2) the price of bulk concentrate compared to the futures price is not used, rather the price is derived by adding the processing transformation cost (TC) to the price of the delivered-in fruit. During these latter months

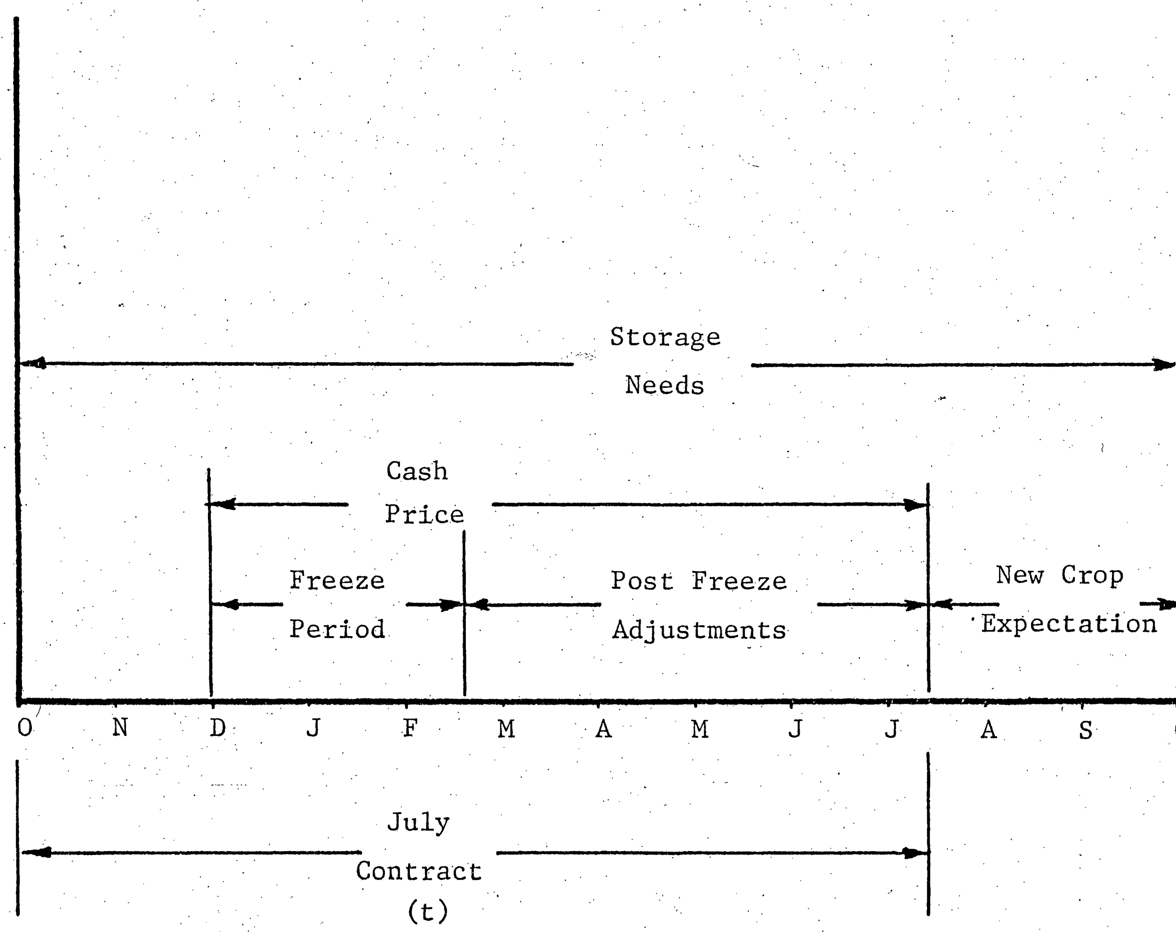

figure 1. Chronology of citrus harvesting and marketing.

of the season there is considerable reflection about next year's crop and this information may be reflected in the contracts extended over these months. Finally, over the time scale there is a continual need for storage since much of the fruit is processed into bulk concentrate and later converted to consumable packs [Ward and Dasse].

Recognizing these various events within the crop year, the July contract has been selected for studying the FCOJ basis model. July contracts extend over the complete harvesting period and should reflect a storage cost. Yet this contract is still far enough from the next season to not be greatly influenced by the new season's expected crop.

Six major variables have been hypothesized to contribute to the FCOJ basis residual derived in equation (3). A measure of risk premium, convenience yield and market liquidity are general variables expected to be in all basis models. Whereas a freeze bias, a crop forecast effect and the occurrence of a freeze may be unique to the FCOJ market [Dasse].

Risk Premium. Price risk is inherent in the carrying of FCOJ inventories and it is reasonable to expect that the basis should reflect a risk premium as a facilitator for carrying stocks [Brennan, p. 50]. Weymar explicitly notes that commodity holders can be induced to carry additional stocks only by the expectation of a return or risk premium for so doing. The degree of risk can be related to the price level for the actual stocks.[1] If prices are already low there is little risk of adverse price declines. While, as prices increase the potential for price declines may be greater. The market's reflection of a risk premium should be weighted by the remaining life (t) of the contract where the risk premium would be expected to decline as the contract approaches maturity. In addition, the risk level would be expected to be greater for the periods of higher interest rates. A risk premium variable (RP) can then be defined as

$$(4) \quad RP_t = (CP_t)(r)f(t),$$

assuming f(t) is some implicit time function.

A priori if the market just pays the interest opportunity cost, then the risk premium parameter should be near 1.0. A parameter above 1.0 would represent additional risk payment.

Convenience Yield. Convenience yield is attributed to being able to take advantage of a rise in demand and price without resorting to a revision of production schedules [Brennan, p. 54]. When supplies are short, lack of adequate inventory will result in lost sales and operational inefficiencies. Thus for a firm to draw down inventories below adequate levels, the market must offer to pay for these costs. The market does this by bidding up prices in the near term in relation to distant prices. For FCOJ the yield would increase as inventories fall below the historical norm and should be zero when inventories are above the norm. Also, the yield should decline as the contract matures.

Define S_t as the ratio of inventories (I_t) to the norm ($\bar{I}_t$), then the convenience yield variable (CY_t) follows as[2]

$$(5) \quad CY_t = \begin{cases} \left(\frac{1}{S_t} - 1\right) f(t), & \text{if } 0 < S_t \leq 1 \\ 0, & \text{if } S_t > 1. \end{cases}$$

Market Liquidity. Market liquidity is reflected in both the volume of trading as well as the nature of the traders. Ward established that the presence of too few speculators in the FCOJ market can have a price distorting effect during the closing months of a contract. This effect could differ, however, as various periods within the contract life are analyzed. A somewhat less desirable alternative to the speculative index developed by Ward would be to use the ratio of trading volume to the changes in open interest for the contract within a given time period. This alternative is useful when data limitations necessary for calculating the speculative index are present.

The volume (V) of trading should exceed the changes in open interest ΔOI to at least a degree to prevent distortions from trader entry and exit. The liquidity index is then defined where

$$(6) \quad ML_t = \begin{cases} \dfrac{V_t}{|\Delta OI|}, & \text{if } |\Delta OI| \geq 1 \\ V_t, & \text{if } |\Delta OI| = 0. \end{cases}$$

This liquidity measure was used in the basis model because the trader types for the July contract could not be identified and no information on FCOJ traders was reported prior to 1971 [Ward, p. 151].

Freeze Bias. Florida orange industry is unique in that the production is concentrated geographically and can be severely influenced by a freeze. The freeze period extends over approximately 62 days from mid-December to late February as shown in figure 1. Futures markets reflect the expectation of possible events such as a freeze and this in turn can lead to a freeze bias in the basis model. A proxy variable for the freeze expectation (FB) is developed where the variable will be near 1.0 early in the freeze period and then decline as the freeze period is nearly over. Define

$$(7) \quad FB_t = \sqrt{1 - \frac{W_t}{62}},$$

where W = days into the freeze period from December 15 to February 15 with $0 \leq W \leq 62$.

Empirically the freeze bias should add a premium to the basis model. However, this premium may be weighted by the available inventories at the beginning of the freeze period. Large inventories should lessen the price response if a freeze occurred and this should be reflected in the freeze bias premium. Hence, the freeze bias should decline with greater inventories. An interaction (FBA) between availability and the freeze bias would account for this effect. A measure of availability (SA) is calculated by aggregating goods on hand as of December 1 of each season with the concentrate expected from the new crop and then is normalized by the mean value over the seasons studied. Define the normalized season's availability in December as

$$(8) \quad NSA_t = \frac{SA_t}{\overline{SA}_t},$$

then $(9) \quad FBA_t = (FB_t)(NSA_t)$.

Crop Expectation. Monthly crop forecasts can have a major influence on futures and cash price adjustments. However, when crop adjustments are publicized the futures market may react quicker thus leading to temporal basis changes. If a freeze occurs there may be immediate changes in the market even though the actual supply losses will not be reflected until later crop reports. Likewise, crop reports can change as a result of physiological aspects of citrus production. This may represent an element of surprise to the trader and futures prices will show an immediate response.

The basis residual model must reflect these temporal adjustments if the model is to be correctly specified. A crop adjustment variable (CA) for period t is derived letting [3]

(10) $CA_t = CF_t - CF_t'(1 + \gamma(DT))$

where CF_t = crop forecast (in gallons) in period t and normalized by the December availability (SA); CF_t' = crop forecast (in gallons) in the previous month or period t' normalized by SA; $\gamma(DT)$ = freeze adjustment function where DT is the degrees below the 28° damaging freeze level. The function $\gamma(DT)$ would yield an immediate futures response while if $CF_{t'}$ differed from CF_t an additional element of surprise may occur. These considerations lead to two variables entering the basis model. A crop forecast change (CXX_t) and a freeze effect (CXF_t) are defined as

(11) $CXX_t = (CF_t - CF_{t'})$,

(12) $CXF_t = \gamma(DT)(CF_{t'})$.

Note that γ can be identified once the crop expectation parameter in the basis residual model is estimated. Also, the variable $CF_{t'}$ will not change over the four weeks between each month's new crop estimate.

EMPIRICAL BASIS MODEL

Incorporating the variables defined above in the basis residual gives the explicit model where

(13) $$BR_t = \lambda_0 + \lambda_1 RP_t + \lambda_2 CY_t + \lambda_3 ML_t + \beta_1 FB_t + \beta_2 FBA_t + \beta_3 CXX_t + \beta_4 CXF_t + \varepsilon_t.$$

The λ_j coefficients represent those theoretical variables common to all basis while the β_j's are unique to the FCOJ model. A priori, $\lambda_1 > 0$;

$\lambda_2 < 0$; $\lambda_3 \gtrless 0$; $\beta_1 > 0$; $\beta_2 < 0$; $\beta_3 < 0$; and $\beta_4 > 0$. Estimation of equation (13) is reported in table 1. Note that the first equation (13a) shows a high degree of serial correlation thus invalidating the standard errors. An analysis of the residuals from (13a) suggests a second order autoregressive scheme as a correction factor. Equation (13b) gives the parameter estimates after correcting for serial correlation.

λ_j Parameters. The FCOJ futures basis does reflect the basic fundamentals as hypothesized by the theory of storage. The futures-cash spread covers the storage cost as initially derived in (1) once the effects of other economic factors are measured.

A positive *risk premium* is evident from the risk parameter in equation (13b), table 1. The value of λ_1 indicates that the futures market is paying interest opportunity cost and 10 percent more as a risk premium. For example, assuming that the interest rate is 7 percent, the spot price is 50 cents and the contract is 100 days from maturity; then the July basis model would pay a risk premium of approximately one cent per pounds solids. As evident from the derivation of RP, this premium would increase with greater prices and/or longer periods from maturity since both of these variables increase the risk level.

The basis residual model also reflects a *convenience yield* although its significance level is less than for the risk premium as reported in table 1. The yield changes with both the stock level and the amount of trading time remaining in the contract. If stocks were 75 percent of the norm (i.e., $S_t = .75$) and there were 150 days remaining in the contract life, then the contract reflects a yield of approximately .75 cents per pounds solids. This and other examples are illustrated in figure 2.

Table 1. Empirical estimates of the FCOJ basis residual model based on the July contract.

Model	Constant	Risk[a] Premium RP	Conven-ience Yield[a] CY	Market Liquidity ML	Freeze Bias FB	Freeze Bias Adjustment FBA	Crop Adjust-ment CXX	Freeze Adjust-ment CXF	Statistics	
(13a)	-1.916	1.336	-.501	-.032	18.096	-11.862	-69.126	1.808	R^2 = .672	F = 65.552
	(.461)[b]	(.517)	(.278)	(.056)	(2.800)	(2.621)	(11.100)	(.231)	DW = .62	df = 224
(13b)	-1.556[c]	1.103	-.455	-.027	17.861	-10.835	-63.963	1.699	R^2 = .657	F = 61.227
	(.401)	(.553)	(.299)	(.047)	(2.722)	(2.556)	(11.440)	(.233)		df = 222
										n = 230

[a]This variable was weighted by some function f(t) where f(t) = t for the risk premium and f(t) = $\log_e$ t for the convenience yield. The analysis is based on weekly increments from the first week in December through mid-July for the 1967-68 through the 1973-74 seasons.

[b]Standard errors are reported in the parentheses.

[c]Equation (13b) was estimated assuming a second order autoregressive process where

$$\varepsilon_t = .098\ \varepsilon_{t-1} + .065\ \varepsilon_{t-2} + \nu_t.$$

All variables were transformed using this process. Spectral analysis of the residuals was used to establish this residual correlation scheme.

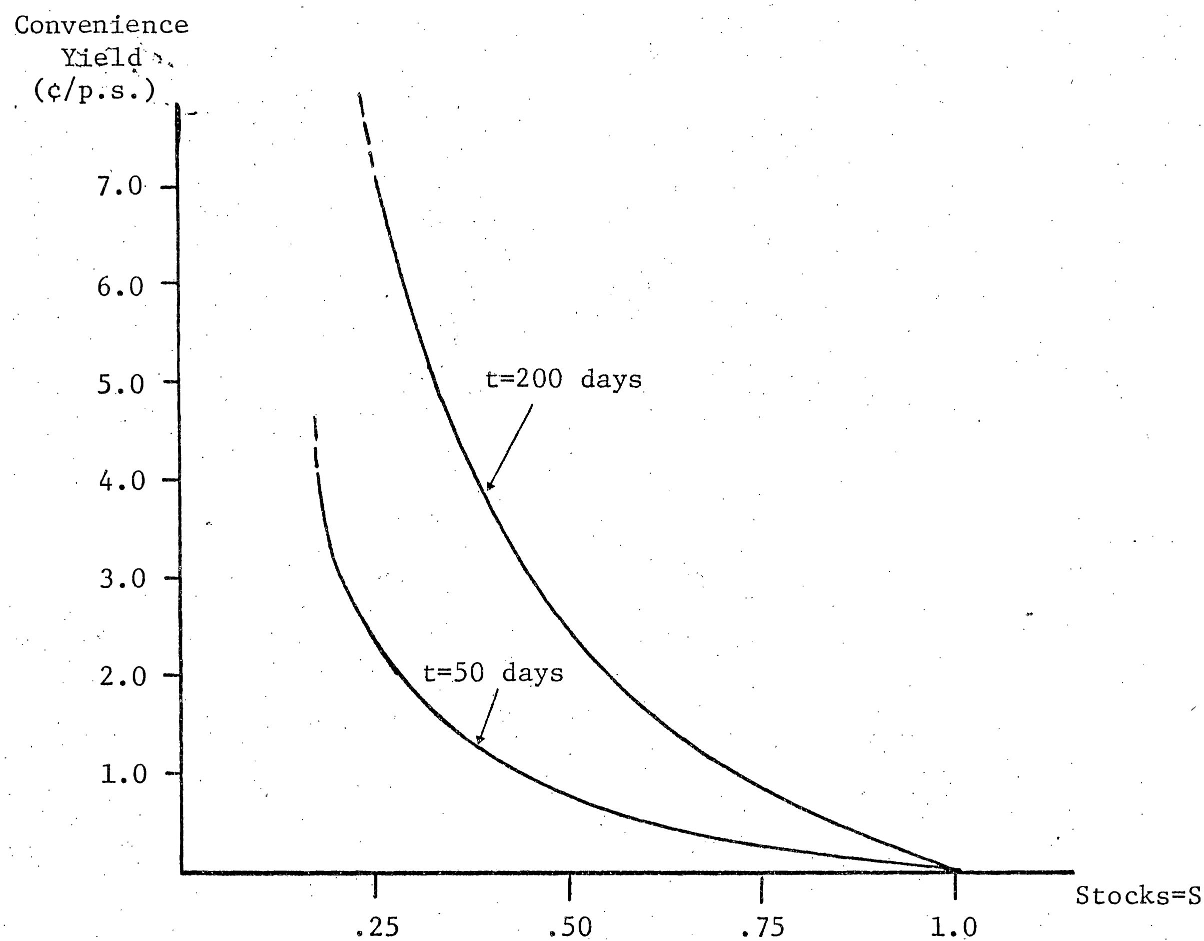

figure 2. Convenience yield in the FCOJ basis model.

Although the convenience yield is present, it remains relatively small as long as $S_t > .50$. When $S_t < .50$ the yield increases substantially and could lead to an inverted market since

$$(14)\quad \frac{\partial BR_t}{\partial S_t} = \begin{cases} \dfrac{.455 \log t}{S_t^2} > 0\,, & 0 < S < 1 \\ 0\,, & S \geq 1.0. \end{cases}$$

As S_t declines, the basis residual declines and could ultimately result in an inverted price spread where $BR < 0$. Also, the presence of $\log_e t$ in equation (14) further illustrates that the yield cannot lead to market inversions as the contract approaches maturity since $\lim_{t\to 1.0} \partial BR_t/\partial S_t = 0$ and $\lim_{t\to 1.0} \lambda_2 CY_t = 0$.

The July basis shows little response to the *market liquidity* variable as derived in equation (6). The measure of liquidity as suggested earlier is less than desirable and that may have contributed to the lack of a significant effect from this variable. Hence, results relating to the level of trading influence on the market are not conclusive at this stage in the research. Recall again that Ward's study was a measure of the distortion over all contracts during the closing period of each contract, while this analysis measures the basis over the life of one contract.

β_j Parameters. Those variables unique to the FCOJ basis model exhibit a pronounced effect on the basis residual and as evident from table 1 they cannot be ignored.

A significant *freeze potential bias* is evident in table 1. The total bias includes both the days into the freeze period and an accounting for the total availability where

$$(15)\quad \text{Freeze Bias} = (17.861 - 10.835\ \text{NSA})\sqrt{1 - \frac{W}{62}}\,.$$

Equation (15) is illustrated in figure 3 where the darker curve represents the bias for a normal season (i.e., NSA = 1). Under these circumstances, the market will generally reflect a freeze bias in the vicinity of seven cents and then decline as the freeze period ends. In contrast, when the supplies are relatively small (i.e., NSA $<$ 1.0) a freeze would have a greater effect on the price. The market clearly reflects this potential in that the bias is above that shown for normal supply levels in figure 3. Similarly, if NSA $>$ 1.0 there are more than normal inventories and a freeze potential would not have as great of an effect on prices. This is shown by the bias curve lying below the normal curve. For each level of NSA the bias remains relatively high through most of the freeze period and then declines rapidly as the period nears the end. This response is consistent with the situation where freezes are likely to occur any time within the freeze period.

The freeze bias can be expected to consistently occur even with extremely large crops. Note that from equation (15), NSA $>$ 1.65 before the freeze bias reduces to zero. However, the probability of crops yielding this large of a normalized seasons availability is extremely low.

The freeze bias in figure 3 provides a potential windfall to short hedgers. The basis widens at nearly the same time that many short hedged positions should be placed. The narrowing basis as the freeze period ends benefits the short hedger if the hedges are placed at the right time. Hence, correctly timing citrus hedging by both growers and processors to capitalize

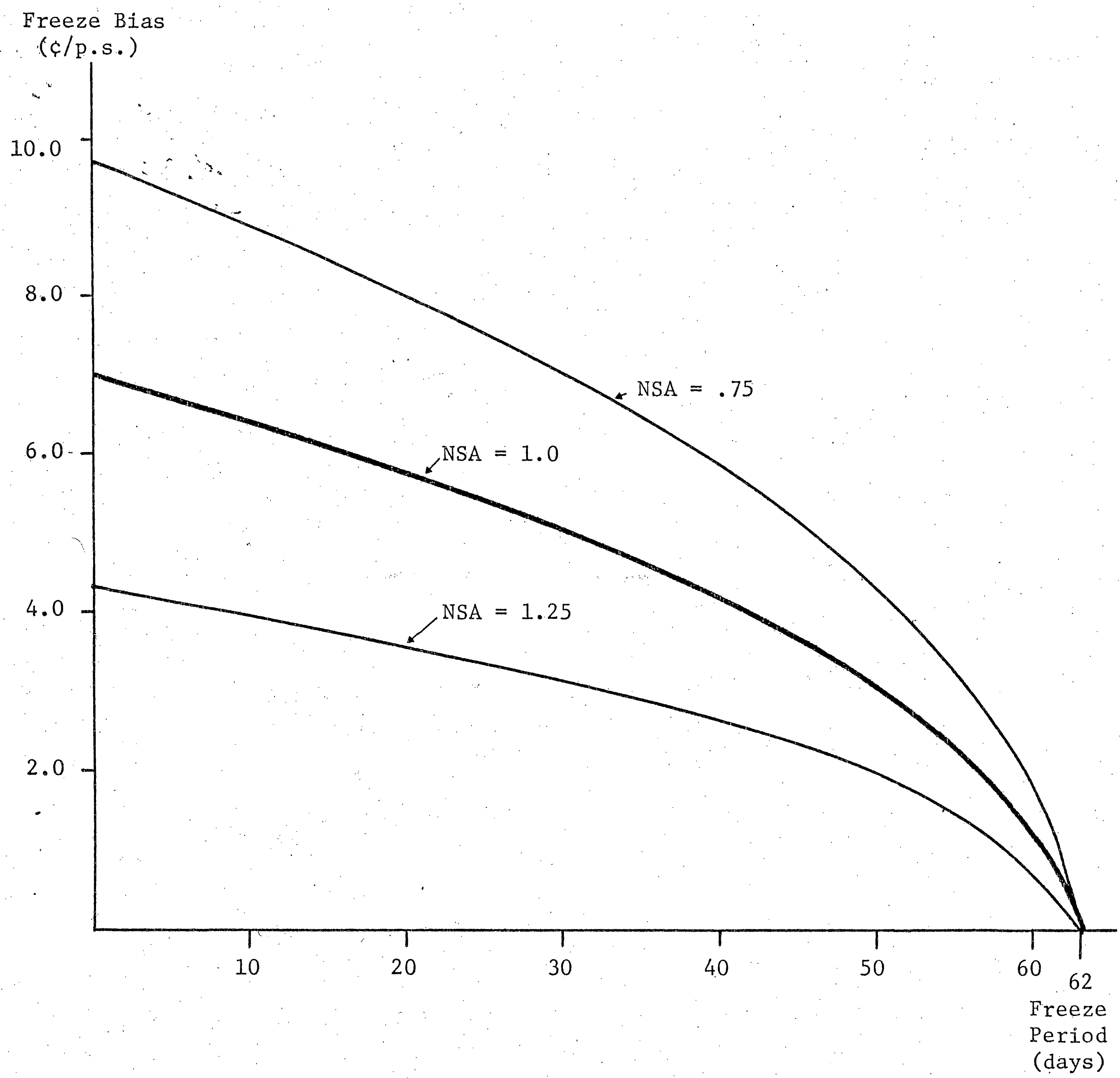

figure 3. Freeze bias in the FCOJ basis model.

on the basis bias can lead to additional hedging gains [Niles and Ward]. Also, an understanding of the crop size would give a trader some clue as to the potential basis gains that could be realized from short hedges.

While the freeze bias represents an anticipatory effect on the basis model, the *actual crop adjustments* lead to price response to factual information. Crop adjustment variables were developed in equations (11) and (12) and their empirical effect on the basis residual is given in the last two variable columns in table 1. The freeze adjustment parameter β_4 is a reduced form where $\beta_4 = \beta_3 \gamma$ as in equation (10). Recall that γ is the adjustment applied to the previous crop forecast as temperatures drop below 28° (i.e., $\gamma = +.02$). Using the reduced form parameters, the crop adjustment effect on the basis residual is calculated giving

$$(16) \quad \text{Crop Adjustment Bias} = -63.963(CF_t - CF_{t'}) + 1.699\ (DT)(CF_{t'}).$$

Equation (16) provides a model for measuring the market response to freeze information and other crop-adjusting effects. Suppose that initially no major weather or other contributing factors have occurred during the time interval $t - t'$. Then $DT = 0$ and $CF_t = CF_{t'}$ and there would be no crop adjustment bias. Intuitively, this model simply implies that the previous forecast is an estimate of the next month's forecast and there is no price adjustment if this estimation is realized.

In contrast, if temperatures dropped to 24° for example, then $DT = 4$ and the crop report is adjusted by the factor γ as in equation (10). From equation (16) an immediate freeze effect would cause the basis to temporarily increase. If $CF_{t'} = .80$ the basis would adjust by approximately five cents. At this point $CF_t = CF_{t'}$ and no added response is expected if the report CF_t

has not had time to reflect a freeze damage. In succeeding weeks the basis should adjust back to the norm since both cash and futures markets will then have time to assimilate the factual freeze information.

The market can also adjust to surprises when there is an unexpected change in the month's crop estimate. If the crop forecast increased by 10 percent, then the basis residual suggests a temporal adjustment of -6.4 cents. Much of this adjustment arises from the situation where futures prices as reported tend to react immediately to the new information while the cash price statistics reported do not record the immediate response.

The two crop adjustment effects are illustrated in figures 4 and 5. Figure 4 gives the positive bias from a freeze while figure 5 shows an adjustment to changing crop estimates. The aggregate bias from a crop adjustment will always be some combination of these two effects and it is possible for $CF_t \gtreqless CF_{t'}$ and $DT \geq 0$.

Closing Basis. The closing periods of the model are consistent with basis theory in that

$$\lim_{t \to 0} MO_t = 0, \quad \lim_{t \to 1} BR_t = \lambda_0 + \lambda_3 ML_t \text{ and}$$

$C_t(t)$, RP, CY, FB, FBA, CXX and CXF are zero. When the July contract ends most of the crop is harvested implying $CF_t = CF_{t'}$ and $DT = 0$ since the freeze period is over. Hence the closing spread shown in equation (2) approaches $\lambda_0 + \lambda_3 ML_t$. Since the liquidity parameter in the empirical model was insignificant, the closing basis approximates λ_0. In the perfect market the closing differential (λ_0) should represent the cost of delivery. In the FCOJ market this cost is calculated to be $75 per contract or 0.5 cents per pound solids. The extra 1.0 cent per pound solid in λ_0 may represent the quality differential between deliverable concentrate and concentrate normally used in the cash markets, or possible imperfections in the measurement of CP and TC.

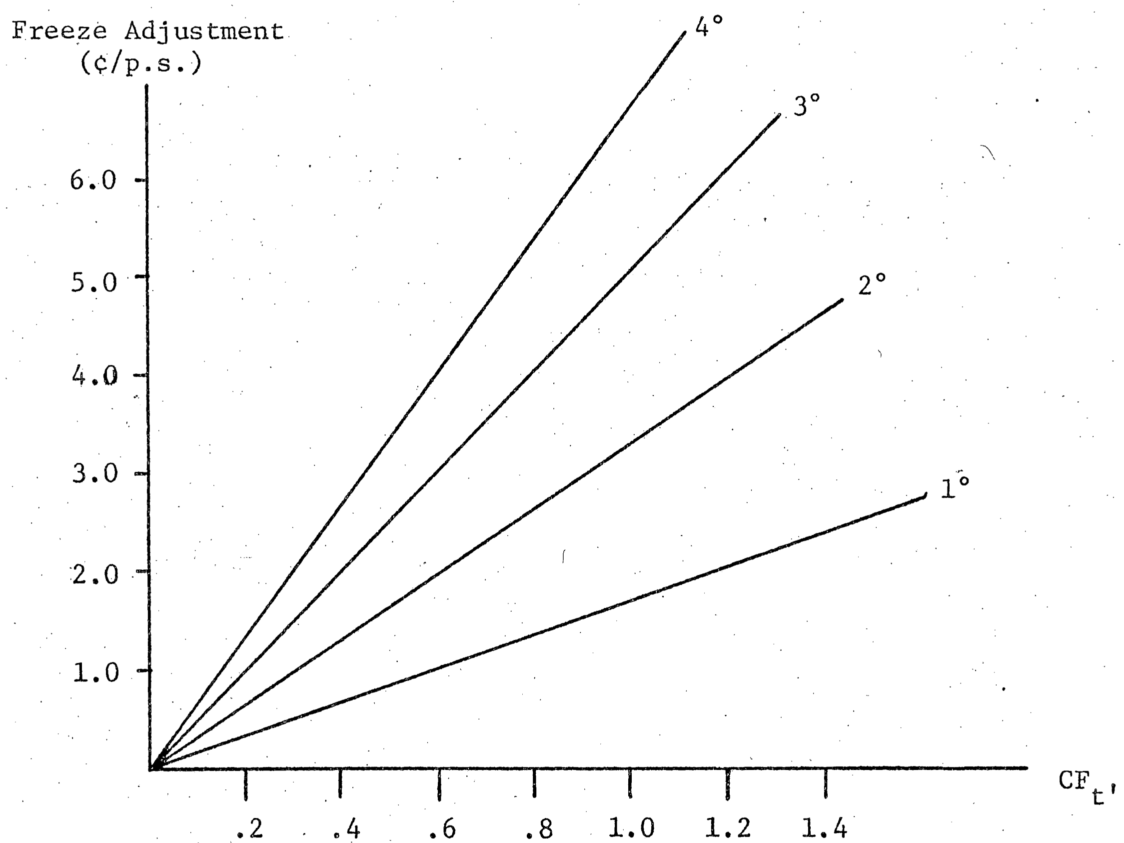

figure 4. Basis adjustment to a freeze of 1°, 2°, 3° or 4°.

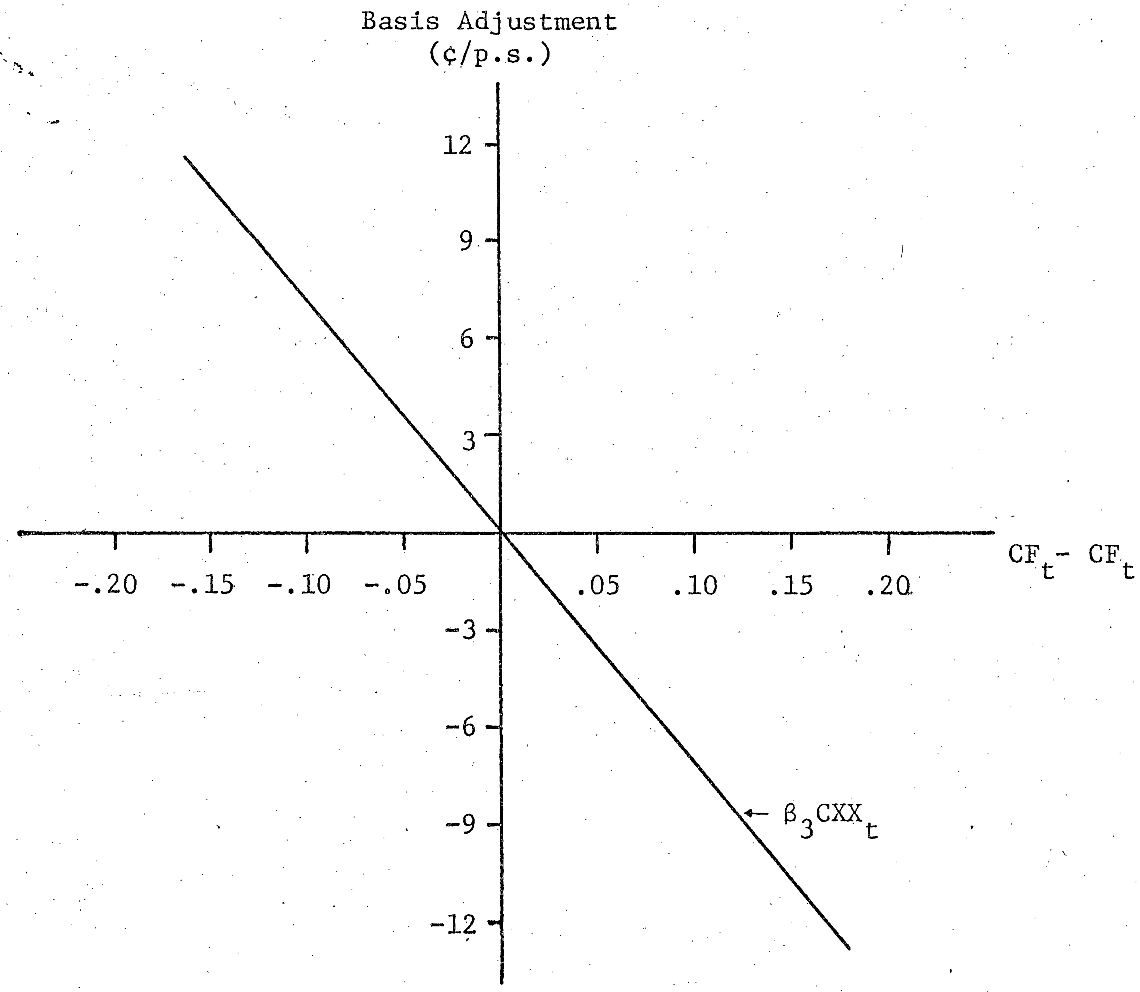

figure 5. Basis bias in response to a crop adjustment report.

CONCLUSIONS

The basis model developed clearly supports both the theory of storage and establishes the necessity for measuring market bias. The results establishes the credibility of the orange contract as a hedging tool and further illustrates certain basis patterns which can be used by the industry. Much of the basis theory cannot be clearly related to the practicing hedger nor is it necessary. Yet it is essential that those traders using the market can have confidence in its economic performance. Although the basis model does reflect the theory of storage, the actual basis residual model may differ substantially from the supply of storage models developed by Brennan and Weymar. Market bias can clearly cause deviations from the storage curve. This bias must be recognized as to its cause and remedied if needed. For the citrus contract, however, the freeze bias is a normal part of the anticipatory activity of the market and does not necessitate corrective action.

From a practical hedging standpoint the model provides useful guidelines for developing trading plans. In particular, the market does cover the cost of storage and exceeds this cost substantially during those periods where a positive market bias is evident. The model also suggests that traders must be prepared for basis shocks, especially during a freeze scare. The basis can widen and this temporarily reduces basis gains from short hedging. Although the analysis began with the first of each new crop season, a review of futures prices one or two months prior to this date suggests that the short hedger does have some flexibility in timing his positions and still capitalize on the freeze bias.

From a governmental perspective the empirical basis model supports the continuation of this contract if the market's performance is to be judged by conformity with theory. Likewise, the results have at least indirect implications for evaluating market manipulation on a large scale. Manipulative practices should visibly alter the basis performance relative to the basis theory and those unique factors measured in the basis residual model.

FOOTNOTES

[1]Brennan suggests that risk is related to the stocks that must be stored. Generally, stocks in inventory will increase as prices increase, thus relating risk to prices is consistent with Brennan's risk model using stocks.

[2]Inventories are usually expressed in weeks of supplies where I_t is calculated by dividing the goods on hand at period t by the total movements of the previous season. Expressing inventories in weeks facilitates comparing seasons even though total supplies change. The normal inventory is the average over the seasons for period t.

[3]Some confusion between month i and period t can occur. As shown in figure 1 these time scales cover the same periods but have a different reference point.

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