Transactions of the Illinois Academy of Science
(1987), Volume 80, 1 and 2, pp. 1-13

REGIONAL CORN BASIS VARIATION IN ILLINOIS

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ABSTRACT

A preliminary analysis of regional corn basis variation in Illinois indicates that the variation in the local corn basis is accounted for by the variation in a few key market factors. These market factors, however, do not contribute to basis variation in a consistent manner among all regions. Tukey's honestly significant differences means test is used to reduce the number of possible candidates for interaction effects. A binary variable state-wide specification indicates that the contribution to seasonal basis variation of transportation rates and stocks relative to available storage capacity is region specific.

INTRODUCTION

All participants in the grain trade are affected by, and often dependent upon, their ability to interpret cash-futures price relationships. An understanding of this temporal price relationship, known as the basis, is required to enhance the profits from and minimize the marketing risks inherent in grain purchases and sales. Grain producers utilize basis knowledge when evaluating cash forward bids, participating in futures market contracts, and selecting delayed pricing contracts. Grain merchants analyze basis relationships at different locations and purchase or sell grain based upon suspected distortions in anticipated basis patterns. It is the predictability of the basis over the grain marketing year that makes the basis an invaluable marketing guide. In particular, basing trades upon an anticipated basis would likely lower the risk and increase the net income from grain trading to a greater degree than basing trades upon an anticipated cash price. In order to anticipate the basis, however, the factors that contribute to regional and temporal basis variation must be identified.

Seasonal variation in the marketing, carrying of inventories, and demand for corn is reflected in corn basis variation over the crop year. As a rule, the basis will strengthen as the crop year progresses beyond harvest.[1] However, the basis need not strengthen at a unform rate or in a particular crop year strengthen at the same rate for all market participants. Various factors, such as storage availability and utilization, warehousing costs, transportation equipment availability, weather and labor disputes can affect the nearby different than the future time period or have a differential impact among regions.

The objective of this study is to identify the factors which cause the local corn basis at Illinois elevators to vary during the crop year and to differ among regions. The factors which cause the level and seasonal strengthening of the basis to differ among Illinois crop reporting regions will be quantified through multiple regression techniques. This analysis will be region specific. In addition, a state-wide model incorporating the information gathered in the region specific analyses, and allowing for any significant interaction between independent variables and a particular region will be developed. Simply stated, the results from the state-wide model will suggest if a particular independent variable contributes differently to basis variation in one region than in another.

Empirical studies (Davis and Hill, 1974; Powers and Johnson, 1983; Martin, Groenewegen and Pidgeon, 1981; and Garcia and Good, 1983) have demonstrated that the linkage between basis variation and seasonality can be established by considering a few key market factors. Over a crop-year the interest costs of holding grain inventories, cash prices, grain stocks and transportation rates to primary grain markets will vary. Empirically supported hypotheses indicate that a positive change in any of these factors will cause the basis to weaken.[2] Over a period of years the inter-year variation in these factors along with variation in regional production levels and storage costs will impact the level of the basis. A weakening of the basis is expected if any of these factors increase over the previous year's level.

DATA REQUIREMENTS

The North, South Central, St. Louis and Wabash regions (see Figure 1) represent a cross-section of Illinois corn production and marketing patterns. The local basis for each region is calculated as the difference between Thursday's average cash price (#2 yellow corn) of reporting elevators and the closing Chicago Board of Trade July futures price on that date (ILL Grain and Livestock Market News). The Thursday's bases for a given month are then averaged to obtain a monthly series extending from

[1]The theory of carrying charges markets (Heironymus, and Working, 1976) offers an explanation for this pattern. This theory is based upon three assumptions: (1) storable commodities are produced at one time of year and used at a fairly even rate throughout the year necessitating the carrying of inventories, (2) there are costs in storing and maintaining the quality of commodities, and (3) there are virtually no costs in holding futures contracts. Therefore, cash prices will increase in relation to future prices as the storage season progresses.

[2]Garcia and Good, 1983, for example, demonstrate that a 10% increase in corn stocks relative to storage capacity, regional corn production relative to storage capacity, interest costs and cash price will cause a 1.5, 0.9, 0.3 and 1.9 cents per bushel of corn widening of the basis during the harvest season, respectively. It is also demonstrated that the impact of these factors will change depending upon the season. For example, the variation in transportation rates will have a significant impact upon basis variation in the post-harvest period, but not during the harvest periods.

October, 1978 through July, 1983. As in previous work, the months of August and September are not included. The primary factor contributing to basis variation during these months is the expected size of the new crop. Since crop estimates during August and September are highly speculative, their impact upon the basis is exceedingly difficult to predict (Martin et. al., 1981). The July futures price is selected because the seasonal variation in the basis is portrayed in a continuous fashion reflective of a carrying charge market. In addition, the July contract incorporates factors that impact both the nearby and deferred markets within a given crop year, whereas a basis derived from nearby contract expiration months is primarily influenced by current market conditions.

For descriptive purposes, the model initially utilized in the four separate regional analyses to determine the factors contributing to basis variation may be represented as follows:

$$BASIS_{rt} = f\,(CASH_{rt}, INT_{rt}, PRODST_{rt}, STOCKST_{rt}, TRANS_{rt}, GULFBAS_{t}, DINDEX_{t}) \tag{1}$$

where

$BASIS_{rt}$ = local corn basis in center per bushel for region r, month t
$CASH_{rt}$ = local cash bid for corn at reporting elevators in region r, month t
INT_{rt} = local interest costs in cents per bushel in region r, month t
$PRODST_{rt}$ = ratio of corn production to permanent commercial storage capacity in region r, month t
$STOCKST_{rt}$ = ratio of corn stocks to permanent commercial storage capacity in region r, month t
$TRANS_{rt}$ = barge transportation cost to Gulf ports in cents per bushel for region r, month t
$GULFBAS_{t}$ = Gulf basis in cents per bushel in month t
$DINDEX_{t}$ = change in agricultural price index from previous year in month t.

The implied assumption behind the relationship between cash price (CASH)[3] and the basis is that producers base marketing decisions upon current price levels. Low prices will discourage the flow of corn to market and the basis will strengthen. Conversely high prices encourage heavy marketings and the basis will weaken. Variations in cash price will also impact the basis through the variation in the opportunity cost of holding inventories. Interest costs (INT), equivalent to the product of the interest rate times the cash price times the length of time in storage, serves as a proxy for this opportunity cost. Quarterly interest rates on non-real estate loans (USDA: Agr. Finance Stat.) is multiplied by cash price and the storage months remaining until contract expiration. For example, October is ten months, November is nine months, and so on. It is hypothesized that a cash price and/or interest rate increase will result in a greater risk to holders of grain inventories. The market place responds to greater risks by increasing handling margins and placing a greater risk premium on capital; both factors cause the basis to weaken.

Alternative measures of regional corn supply and usage are PRODST and STOCKST. PRODST measures the inter-year variation in regional corn production relative to off-farm commercial storage capacity (USDA: Grain and Feed Market

[3]The subscripts of equation 1 will be implied in all discussion and tables to follow.

News)[4]. STOCKST indirectly measures the monthly usage of corn over the crop year by estimating the current end of month stock situation relative to available storage capacity. Unfortunately, the data required to estimate end of month regional stocks; corn stocks in all positions and the estimated monthly percentage of farm sales of corn, are not reported at regional levels. Therefore, state wide corn stocks and market data on estimated farm sales were combined with regional off-farm commerical storage capacity to approximate regional corn usage. Computed in this manner the mean monthly regional stocks to storage ratios are 11.4, 3.4, 12.2, and 70.6 for the North, South Central, St. Louis, and Wabash regions, respectively. It is hypothesized that as the production to storage ratio increases, the basis will weaken. Similarly, as the quantity of available stocks relative to storage capacity increases, the basis will weaken.

Transportation costs to primary grain markets (TRANS) are an important contributing factor to temporal and spatial basis variation. Region specific barge rates (St. Louis Market Record, 1979-1983) in center per bushel are established for Seneca, IL (North region), Peoria, IL (South Central region), St. Louis, MO (St. Louis region) and Henderson, KY (Wabash region). Over the length of the time series, barge rates have been quite variable. This variability, however, has not been consistent across river segments. For example, barge rates for shipments originating at Peoria have ranged from 14 cents to 39 cents per bushel, whereas at Henderson, KY the range in rates is 11 to 41 cents. It is believed that region specific barge rates will allow for a more accurate depiction of the relationship between transport costs and regional basis variation.[5] It is hypothesized that as barge rates increase the basis will weaken.

The Gulf basis (GULFBAS) is calculated as a monthly average of the Thursday differences between the FOB New Orleans corn export price and the closing Chicago Board of Trade futures quote. The intent of including the Gulf basis was to estimate the response in the local basis to export demand. Although both the Gulf price and the local cash price are differenced from the July futures price, the market conditions suggested by the individual bases are distinct. The magnitude of the Gulf basis reflects export demand in relation to corn availability at Gulf ports. The magnitude of local basis reflects local market conditions. A shortage of corn at Gulf ports would cause the Gulf price to gain in relation to the futures. The Gulf basis would strengthen. Given that corn exports command a healthy share of total Illinois corn usage, the strengthening of the Gulf basis would increase demand for export corn in local markets. The local basis, therefore, will also strengthen.

Since a reliable time-series of storage cost data is difficult to obtain, the variation in storage costs is approximated by the change in the agricultural production prices-paid index (DINDEX). This index is an index of prices paid by farmers for inputs (USDA: Agr. Stat) and includes a wide range of production expenses. In contrast to a linear trend, as used in previous studies, DINDEX should better approximate the variability in costs over the series. For example, between 1978 and 1979 the price index increased by 17%; however, the increase between 1981 and 1982 is only 1%.

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[4]Given that regional production levels and storage capacity will vary over a period of years, previous researchers have standardized the supply relationship as a ratio of production levels to storage capacity. This practice, which allows for inter-year adjustments in both quantities is followed in this analysis..

[5]Given that the barge trading session has been in operation since August 1, 1978, previous studies have not had access to river specific rates. Garcia and Good, for example, utilized an average monthly rate computed for Peoria, IL and accounted for regional variation in transport rates by a regional dummy variable configuration.

A linear trend would have assigned an equal weighting to each of these between year changes. The hypothesized relationship between the basis and DINDEX is positive; that is, a larger change in the price index would result in a relatively larger weakening of the basis over the previous year than if DINDEX was small.

REGIONAL MODEL SPECIFICATION

Table 1 presents the estimated relationship between the variability in the local basis and the market factors discussed in the previous section. Multiple regression parameter estimates and accuracy measures are presented for the best-fit models as determined by preliminary analysis. Ordinary least squares (OLS) regression is utilized in the North region, while corrections for autoregressive behavior of the residuals (ALS) have been included in the South Central, Wabash, and St. Louis specifications.[6]

The parameter estimates for GULFBAS, TRANS and STOCKST are significant and of the hypothesized sign in all four regions. The Gulf basis has the most consistent estimate across the four regions. A one cent increase (strengthening) of the Gulf basis implies an approximate 0.5 cent strengthening of the local basis. Both the parameter estimates and t-values for the independent variable TRANS imply that the impact upon the local basis of a change in transportation costs declines as the distance to Gulf ports decreases. In the North region a one cent per bushel increase in barge rates implies a 0.92 cent weakening in the local basis. The local basis in the Wabash region, however, would weaken by 0.43 cents. While the impact of an increase in the stocks to storage ratio (STOCKST) is of the hypothesized sign in all regions, that is, as stocks to available storage increases the basis weakens, the pattern of coefficients suggests an inverse relationship to the estimated stocks to storage capacity ratio. The largest coefficient is reported for the South Central region and the smallest for the Wabash region. The South Central region contains the relatively largest storage capacity, and therefore the smallest stocks to storage ratio. The opposite hold true for the Wabash region.

The remaining independent variables (DINDEX, INT, and PRODST) did not consistently impact basis variation in all four regions. DINDEX is a significant factor in explaining basis variation in the St. Louis and Wabash regions. A one unit (one percentage point) increase in DINDEX will cause a 0.47 cent and 0.65 cent weakening of the local basis for the St. Louis and Wabash regions, respectively. INT is significant in the North and Wabash regions. A one cent increase in interest costs causes 0.32 and 0.24 cent weakening of the local basis in the North and Wabash regions, respectively. PRODST is significant in the North Region.

Noticeably absent from any of the four regional specifications is the significant influence of cash price on basis variation. In fact, preliminary analysis indicated a

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[6]As a general rule, serial correlation among the residuals will not affect the unbiasedness or consistency of the OLS parameter estimates; it does, however, affect their efficiency. This will lead to the conclusion that parameter estimates are more precise than they actually are. The t-statistics and R^2 will be overstated. The calculated Durbin-Watson statistic (DW) for the OLS estimates indicated definite positive autocorrelation for the South Central region (DW = 1.25). The test was inconclusive for the St. Louis (DW = 1.59) and Wabash (DW — 1.46) regions. In addition, upon correction for serial correlation the parameter estimate for DINDEX was no longer significant in the South Central region: this variable was dropped from the model specification. There were no changes in the specifications of the St. Louis and Wabash models.

non-significant and negative relationship between cash price and basis variation, that is, as cash price increases, the basis strengthens. Previous stated hypotheses, supported by empirical studies (Garcia and Good, 1983) suggest, however, that cash price and the basis should be positively related. Two comments are required. First, the previous study considered local basis patterns under the nearby contract expiration month. A comparison of between year basis levels, therefore, would emphasize trend over seasonality. In this study, a greater emphasis is placed upon seasonal basis variation. During the five year time span, the general trend was for the cash price to increase and the basis to strengthen from harvest levels. Secondly, over the time period studied, there has been a dramatic decline in barge rates. For example, for Gulf shipments originating in Peoria, the mean barge rate from October to July for the 1980/81 crop year was 29.2 cents per bushel. For the crop year beginning October, 1983 the mean barge rate had declined to 17.9 cents. Accompanying this decline in barge rates has been a similar decline in the local basis. The mean basis during the 1980 crop year was 45.6 cents per bushel. For the crop year beginning October, 1983 the mean basis had declined to 20.3 cents. Cash prices, however, did not decline in a similar fashion. Indeed, over the five year period, mean cash prices increased from $2.23 per bushel to $2.70. Therefore, it seems likely that the weakening of the basis expected to result from increasing cash prices was offset by the decline in barge rates.

STATE-WIDE MODEL SPECIFICATION

In the previous section, the independent variables TRANS, INT, STOCKST, GULFBAS, DINDEX, and PRODST were determined to have a significant impact upon regional basis variation. The changes in these explanatory variables did not, however, contribute to basis variation in a consistent manner in all regions. In this section, a state-wide specification, incorporating the data from all four regions, is developed to examine the primary contributing factors to seasonal variation in the corn basis. A model of this type must allow for interaction between independent variables and particular regions. The multiple regression framework may be extended to include all possible interactions as follows:

$$BASIS_{rt} = Bo + B_i X_{rt} + \delta_r X_{rt} Z_r + e_t$$

where

X_{rt} = independent variables, as defined in equation 1, for region r, month t

$\delta_r X_{rt} Z_r$ = interaction term, where δ = regression parameter specific to region r, and Z_r = binary (dummy) variable equal to 1 for region r, zero otherwise

Given four regions and six independent variables, the possible candidates for interaction effects is quite large. Specifically, there are 84 such combinations of a binary variable and the six independent variables considered.[7] Therefore, some judgement must be made concerning the possible candidates. On apriori grounds the variables DINDEX and GULFBAS can be dropped from consideration. The data for each of these variables if replicated in each region's observations. A preliminary

[7]For each independent variable the number of candidates are the sum of ${}_4C_1$ + ${}_4C_2$ + ${}_4C_3$ where C means the combination operator. The remaining combination, ${}_4C_4$, is equivalent to an insignificant interaction effect.

indication of interaction between the remaining variables and region may be ascertained by testing for significant differences between the regional means of individual variables. Tukey's honestly significant difference (HSD) allows for a multiple comparison between regions of the mean values for a particular variable. Of the various methods available for this purpose, Tukey's HSD is suitable when samples are of equal size (Roscoe, 1975) as is the case in this analysis (50 observations per variable in each region.)[8]

Table 2 presents the regional means, relevant test statistics, and the significantly different grouping of means as determined by the Tukey HSD comparison. As indicated, there are no significant regional differences in the mean values of the variable INT. The only variation in INT is the regional cash prices. The variation in cash prices is, therefore, not significant enough to cause INT to differ between regions. The mean values for the variable TRANS are classified into two distinct groupings. It is interesting to note that the groupings are upon a river segment basis. The North, and South Central regions are served by the Illinois River. The St. Louis and Wabash regions are served by the Lower Mississippi and Ohio Rivers, respectively. Both STOCKST and PRODST are classified on the basis of mean values into three distinct groupings. Establishing that the regional means of PRODST, STOCKST, and TRANS are significantly different is at best a preliminary result. The significance of the suggested interactions need to be tested within the framework of equation 2. However, note that because of apriori reasoning and the results of Tukey's HSD comparisons test, the 84 candidates for interactive effects have been reduced to eight. Furthermore, given that the utilization of binary variables requires a control, that is, a noninteractive term, the significance of only 5 interactive terms will need to be tested. Table 3 presents the regression parameter estimates and accuracy measures for the state-wide model specification. As in the regional analyses, only the best-fit model is presented. The Durbin-Watson statistic suggested the presence of serial correlation among the errors of the ordinary least squares (OLS) estimates, therefore, the parameters corrected for this behavior (ALS) are also included. The independent variables STW and STCS are defined as a binary variable times STOCKST for the Wabash and South Central regions, respectively. TILL is a binary variable and TRANS combination for Illinois River shipments (i.e., North and South Central regions).

The primary factors contributing to seasonal basis variation in Illinois are TRANS, INT, STOCKST, GULFBAS, and DINDEX. The coefficient for GULFBAS (0.52) is very similar to the coefficients estimated in regional models. The variables DINDEX and INT, although they did not significantly contribute to basis variation in all the regional analyses, do enter the state-wide model in a significant fashion. A one percentage point increase in DINDEX will cause an estimated 0.32 cent weakening of the basis. A one cent increase in INT will cause an estimated 0.21 cent weakening of the basis. Both effects are somewhat diminished from the regional specification. The impact upon basis variation of a change in TRANS or STOCKST depends upon region. This difference can be illustrated by considering the regression coefficients

[8]It is also true that regional differences between available means can be determined using Analysis of Variance (ANOVA) procedures with region as the classification variable. ANOVA, however, only suggests that the difference is significance, not which particular region, or regions, are the cause of this difference. Results from the ANOVA procedure indicated significant differences at the 99% confidence level for all variables but INT. For INT, the null hypothesis of no significant differences could not be rejected at the 95% confidence level.

(slopes) for each of the four regions. Simplifying to only these two effects, the contribution of TRANS and STOCKST to basis variation is the following:

North region:	(1.59 + 0.00) STOCKST	+ (0.62 + 0.16) TRANS
South-Central region:	(1.59 + 2.60) STOCKST	+ (0.62 + 0.16) TRANS
St. Louis region:	(1.59 + 0.00) STOCKST	+ (0.62 + 0.00) TRANS
Wabash region:	(1.59 − 1.40) STOCKST	+ (0.62 + 0.00) TRANS

An interesting perspective on how the interaction of TRANS with region and STOCKST with region impact the level and strengthening of the corn basis may be gained with reference to Figure 2. The estimated October and July bases, controlling for the variation in all independent variables but TRANS and STOCKST[9], are determined by allowing TRANS and STOCKST to assume mean values by the regional classifications of Table 2 for these months. All mean values are then substituted into the ALS mdoel of Table 3. The slope of the line segment connecting the October and July bases represents the average monthly strengthening of the basis resulting from the differential regional impacts of TRANS and STOCKST. Note that the basis in the North and South Central regions (served by the Illinois river) are consistently wider. In addition, note that the rate at which the basis strengthens differs among the regions. The basis strengthens the least in the Wabash regio (about 1.8 cents per month). The largest rate of basis narrowing — 2.7 cents per month — occurs in the North region. This differential rate of basis narrowing over the crop year results in a range of basis levels that is considerably smaller in July than in October.

SUMMARY

A variety of market factors impact the level and the rate at which the basis strengthens over the crop year among Illinois crop reporting regions. The variation in these factors, however, does not contribute to basis variation in a consistent manner among all regions. This is demonstrated, first, by the fact that a consistent set of independent variables and regression parameter estimates could not be developed in separate regional analyses, and secondly, by the significance of interaction terms included in a state-wide model specification. The contribution of the variation in transportation rates and monthly corn usage, as represented by the stocks to storage ratio, to the rate at which the basis strengthens is region specific.

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[9]Independent variables are held constant at mean values for 200 observations.

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Table 1. Multiple Regression Equations Explaining the Variation in Local Corn Basis for Four Illinois Crop Reporting Regions.

Independent Variables	Crop Reporting Regions			
	North	South Central	St. Louis	Wabash
Intercept	−19.463	1.738	−7.592	−12.108
	(2.08)[a]	(0.42)	(−1.629)	(−2.94)
STOCKST	0.942	4.944	2.137	0.287
	(3.85)	(5.74)	(8.050)	(5.22)
TRANS	0.920	0.763	0.636	0.432
	(6.85)	(5.41)	(3.51)	(2.63)
GULFBAS	0.463	0.603	0.539	0.495
	(7.32)	(11.03)	(8.65)	(7.87)
DINDEX			0.474	0.649
			(2.2)	(2.95)
INT	0.320			0.235
	(2.77)			(2.40)
PRODST	6.884			
	(2.16)			
R^2	.943[b]	.923	.922	.952
DW	1.902	1.769	1.948	1.927

[a]t-statistics in parenthesis.
[b]$\bar{R}^2$ = R^2 corrected for degrees of freedom.

Table 2: Tukey's HSD Statistic for Comparison of Means for Independent Variables Considered for State-wide Model Specification

	Independent Variable			
	INT	TRANS	STOCKST	PRODST
Regional Means:				
North (N)	19.99	27.85	11.36	3.00
South Central (SC)	20.48	25.57	3.36	1.20
St. Louis (ST)	20.54	19.59	12.22	1.79
Wabash (W)	21.21	18.30	70.62	2.90
Test Statistics[a]				
MSD	5.99	3.34	6.39	0.16
MSE	133.88	4.57	152.05	0.94
Mean Groupings[b]	N,SC,ST,W	N,SC	N,ST	N,W
		ST,W	SC	SC
			W	ST

[a]Tukey's HSD computes the minimum significant difference (MSD) as follows:

$MSD = q_\alpha \, (MSE/n)$

where q_α = 3.665, critical value of standardized range statistic for α = .05 and 196 degrees of freedom, n = 50.

MSE = mean squared error

[b]grouping of means with non-significant differences

Table 3. Multiple Regression Equations Explaining the Variation in the Local Corn Basis in Illinois.

Independent Variables	Regression Specification	
	OLS	ALS
Intercept	−6.523	−3.823
	(−2.9)[a]	(−1.3)
STOCKST	1.739	1.590
	(12.6)	(7.7)
STW	−1.529	−1.405
	(−13.1)	(−8.2)
STSC	2.932	2.604
	(7.6)	(4.9)
TRANS	0.671	0.623
	(7.0)	(5.6)
TILL	0.147	0.156
	(3.0)	(3.2)
GULFBAS	0.499	0.523
	(13.5)	(12.6)
INT	0.160	0.215
	(2.9)	(2.8)
DINDEX	0.426	0.323
	(4.1)	(2.2)
R^2	.94	.89
D.W.	1.211	1.97

[a]t-values in parenthesis.

Fig. 1. Location of Illinois Regions

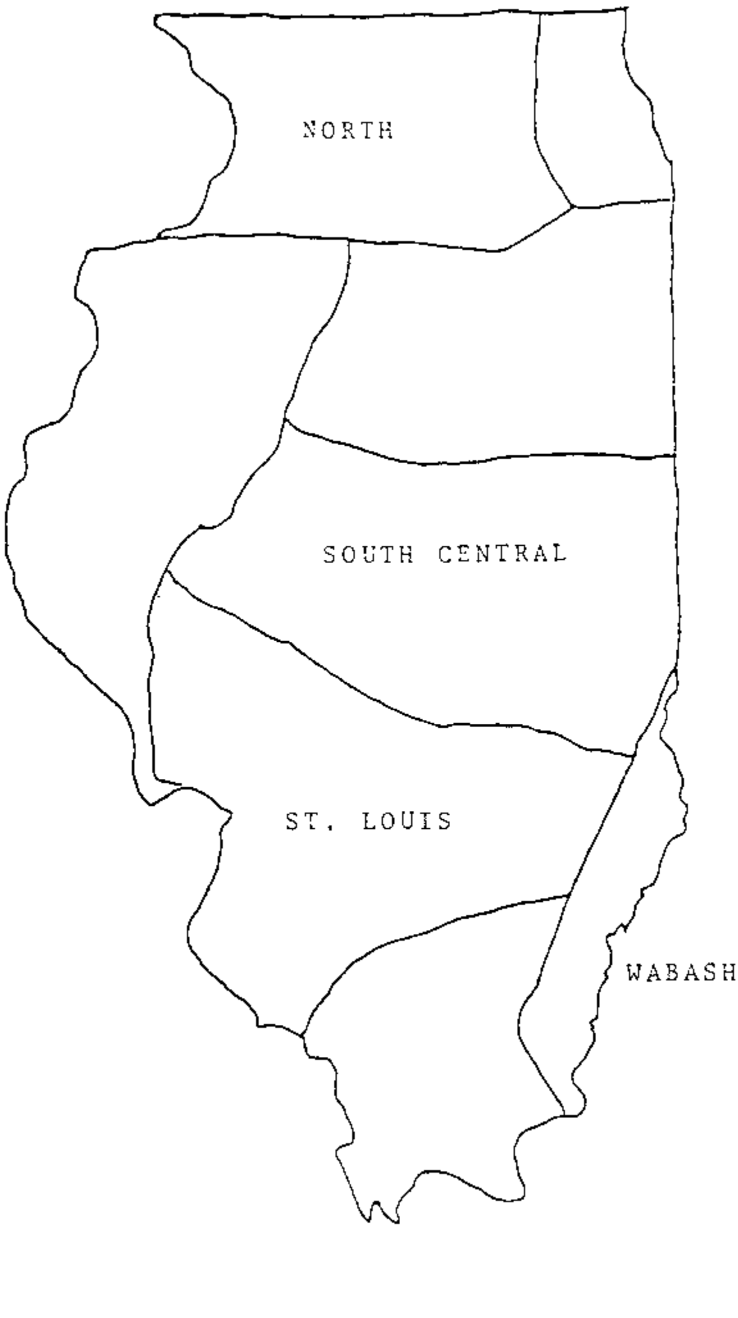

Fig. 2. The Narrowing of the Illinois Corn Basis Due to Interaction of TRANS and STOCKST with Region, in cents under July