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PRICE RELATIONSHIPS BETWEEN WHEAT FUTURES MARKETS: IMPLICATIONS FOR HEDGING†

Wheat hedgers can hedge cash positions on any of the three major United States wheat futures markets. The relative hedging effectiveness of the three markets is a pervasive question which continues to trouble producers, millers, elevator operators, and others involved in the marketing of wheat and wheat products. Wilson (1983) measured the effectiveness of hedging by calculating covariances between cash prices and alternative futures prices in the three wheat markets, in which he assumed that hedging effectiveness increases with equal or parallel movement in cash and futures prices, i.e., constant basis. The position taken here is rather that hedging effectiveness is enhanced with disparate, yet predictable changes in cash-futures price relationships (Working, 1953).

But wheat hedgers are confronted with a unique problem that transcends the importance of basis as the sole criterion of hedging effectiveness. Price relationships between the three futures markets (intermarket spreads) respond to changes in fundamental factors of supply and demand for individual classes of wheat. Further, intermarket price spreads change during the marketing (hedging) season due to temporal variation in planting and harvesting of winter and spring wheat varieties.

There are indications that intermarket price relationships between the three futures markets have become more volatile in recent years (Gray and Peck, 1981). This is consistent with structural changes which have occurred in the production and utilization of various classes of wheat, as well as changes in the methods and scope of governmental intervention in the U.S. wheat economy. Increased variability in relative prices between the three wheat futures

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markets has important implications for wheat hedgers. The objectives of this paper are to address the following questions.

1. What factors have contributed to increased variability in relative prices?
2. Do seasonal patterns in relative prices exist, and if so, how reliable is such seasonality?
3. How can hard red spring wheat hedgers use changing price spreads to increase the effectiveness of their hedging programs?
4. Can fundamental factors of supply and demand be used to predict relative prices, and thus guide hedgers in selection of the most advantageous hedging market?

U.S. WHEAT ECONOMY

Five distinct classes of wheat are produced in the United States. Each class has its own specific qualities and attributes; substitution between classes is limited by differences in physical (baking) characteristics (Wang, 1962). Hard red winter (HRW), the predominant bread wheat, is planted in the fall and harvested in the Central Plains states surrounding Kansas. The Kansas City Board of Trade wheat futures contract specifies delivery of HRW. Hard red spring (HRS) is planted in April and May in the Northern Plains states of North Dakota, Minnesota, and Montana. Wheat futures at the Minneapolis Grain Exchange reflect the price of HRS. The high protein content of HRS is suitable for specialty breads and blending with lower protein HRW to produce different types of flour.

Soft red winter (SRW) and white wheat (WW) are relatively low in protein; ideal for cakes, cookies, pastries, and oriental noodles (Chai, 1972). Most SRW is produced in the Eastern Corn Belt states. Wheat futures at the Board of Trade in Chicago typically reflect the value of SRW, although certain grades of HRS and HRW are also deliverable on the Chicago wheat futures contract. White wheat production is concentrated in the Pacific Northwest. The final class of wheat is durum, a high protein spring variety which is milled into semolina. Seventy-five percent of the durum crop is grown in North Dakota.

Supply and Demand

Fundamental factors of supply and demand for the three major classes of wheat (HSW, SRW, and HRS) are shown in Table 1. HRW production has averaged more than 45 percent of total wheat production since 1978/79, followed by SRW (17.9 percent) and HRS (17.2 percent). But SRW has become much more important in recent years. Note the sizable (420 million bushels) increase in SRW production between 1978 and 1982, more than 200 percent. HRW and HRS production has increased 51 percent and 32 percent, respectively, during the same period.

Total wheat demand has increased steadily since 1978/79, but not commensurate with increases in total supply. The result has been a large increase in carryover stocks. Total ending stocks for 1982/83 were in excess of 60 percent of total annual utilization. It is interesting to note the disproportionate share of ending stocks accounted for by HRW and HRS. During the five-year period, HRW and HRS ending stocks combined have averaged almost 80 percent of total ending stocks. Moreover, HRW and HRS ending stocks represented 73 percent and 100 percent of their total annual utilization, respectively, at the end of 1982/83.

It is instructive to compare variability of fundamental supply and demand factors among the three major wheat classes to expose the heterogeneous and dynamic relationships within the wheat economy (Table 2).[1] Scanning the column of coefficients of variation, it is evident that SRW fundamentals are most variable in relative terms.[2] This is not surprising since SRW is typically produced on smaller farms with limited storage capacity and other capital investments (Gray, 1962). Hence, SRW producers enjoy more freedom to move resources into competing crops such as corn and soybeans than HRW and HRS producers.

Domestic demand appears to be the most stable fundamental factor and variation is approximately equal across all classes. However, note the variation in exports, particularly for SRW. Several factors may contribute to this high variability. SRW is generally the least expensive of the three major wheats (flat price). Many importing countries such as China are notorious "price shoppers." They are in and out of the SRW market unexpectedly with major purchases. Additionally, SRW competes with corn and other feed grains at times, which can result in unpredictable increases in export demand for SRW in feed use. Thus, SRW exports are affected by worldwide fundamentals for both wheat and feedgrains.

As measured by coefficients of variation, HRS and HRW run a distant second and third, respectively, in "fundamental instability." HRS fundamentals appear to be slightly more variable than HRW's, probably due to HRS' more specialized uses and its geographically concentrated production area. Abnormal growing conditions in the Northern Plains can affect a much larger proportion of the HRS crop, whereas HRW production is dispersed over a much larger area.

With such marked variability in fundamental factors of supply and demand for individual classes of wheat, it is not surprising that relative prices of the three closely related yet imperfectly substitutable commodities are so volatile.

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[1] Note that underlying supply and demand data of Table 2 are for the ten-year period between 1973 and 1982.

[2] The large coefficients of variation in SRW are partially attributable to the sizable increase in SRW production and utilization in recent years.

Table 1.—Supply and Demand for Hard Red Winter Wheat (HRW), Soft Red Winter Wheat (SRW), and Hard Red Spring Wheat (HRS): 1978/79 to 1982/83
(Millions of bushels)

Crop year beginning June 1	Beginning stocks[a]	Production	Total supply[b]	Domestic use	Exports[c]	Total demand	Ending stocks[d]
1978/79							
HRW	632	830	1,462	429	610	1,039	423
SRW	71	189	260	138	95	233	27
HRS	335	380	715	163	232	395	320
Total[e]	1,178	1,776	2,955	837	1,194	2,031	924
1979/80							
HRW	423	1,089	1,512	347	725	1,072	440
SRW	27	317	344	150	154	304	40
HRS	320	363	684	182	217	399	285
Total	924	2,134	3,060	783	1,375	2,158	902
1980/81							
HRW	440	1,181	1,621	379	701	1,080	541
SRW	40	435	475	138	299	437	38
HRW	285	312	598	153	188	341	257
Total	902	2,374	3,279	776	1,514	2,290	989
1981/82							
HRW	541	1,117	1,658	364	755	1,119	539
SRW	38	676	714	194	460	654	60
HRS	257	468	726	172	206	378	348
Total	989	2,799	3,791	854	1,773	2,627	1,164

1982/83[f]							
HRW	539	1,255	1,794	358	680	1,038	756
SRW	60	610	670	271	325	596	74
HRS	348	500	852	186	240	426	426
Total	1,164	2,809	3,980	928	1,511	2,439	1,541

Source: U.S. Department of Agriculture, various years. *Wheat Outlook and Situation.* Economic Research Service, Washington, D.C.

[a] Beginning stocks may not exactly equal previous year's ending stock due to periodic revisions made by USDA.

[b] Total supply includes imports.

[c] Exports include flour and other production in wheat equivalent.

[d] Ending stocks include "free" and government-owned or controlled.

[e] Totals for each crop year include white wheat and durum.

[f] Estimated.

Table 2.—Measures of Central Tendency and Dispersion in Fundamental Supply and Demand Factors for Hard Red Winter Wheat (HRW), Soft Red Winter Wheat (SRW), and Hard Red Spring Wheat (HRS): 1973/74 to 1982/83*

	Mean (million bushels)	Standard deviation (million bushels)	Coefficients of variation[a] (percent)
Production			
HRW	1,033	132	12.8
SRW	369	165	44.7
HRS	378	68	18.0
Total supply			
HRW	1,458	225	15.4
SRW	414	168	40.6
HRS	611	144	23.6
Domestic use			
HRW	360	45	12.5
SRW	154	20	13.0
HRS	168	19	11.3
Exports			
HRW	629	118	18.8
SRW	204	125	61.3
HRS	190	45	23.7
Total demand			
HRW	987	123	12.5
SRW	364	156	42.9
HRS	358	62	17.3
Ending stocks			
HRW	471	182	38.6
SRW	50	19	38.0
HRS	253	115	45.4

Source: Derived from Table 1.

* Calculations for beginning stocks are not included since previous year's ending stocks reflect the same thing.

[a] Coefficient of variation equals the standard deviation divided by the mean.

SEASONAL ANALYSIS OF INTERMARKET PRICE RELATIONSHIPS

Alleged seasonality in futures prices has received considerable attention in the literature. J. M. Keynes (1923) developed the theory of "normal backwardation," arguing that futures prices rise during the life of the contract in order to provide typically "net long" speculators with a risk premium for absorbing risk which hedgers transfer to them. Keynes' theory has been vigorously debated by a host of researchers (Working, Gray, Rockwell, Samuelson). The current consensus favors the theory that futures prices fluctuate more randomly. But, this does not preclude price relationships between futures markets from exhibiting seasonal behavior.

The indexes of intermarket spreads between Minneapolis and Chicago (Mpls/Chgo) and between Minneapolis and Kansas City (Mpls/KC) for May and September futures contracts are shown in Charts 1–4. The spreads are calculated in ratio form (Minneapolis as numerator) using weekly (Thursday) prices between 1974 and 1983.[3] The simple average price ratio during each year is divided into the weekly price ratios for that year to produce weekly index numbers. Weekly index numbers are then averaged across years to ascertain the typical behavior of May spreads between January and the end of April and September spreads between January and the end of August.[4]

May Futures Price Spreads

It is evident from Charts 1 and 2 that Minneapolis tends to increase relative to Chicago and Kansas City May during the first four months of the year. The Mpls/Chgo price ratio is typically about 98.3 percent of its seasonal (four month) average in early January, strengthening to more than 103 percent of the seasonal average by the end of April. The increase in the Mpls/KC spread during the same period is less dramatic: 99.3 percent to almost 102 percent of the seasonal average price ratio. This seasonal strength in relative Minneapolis prices in the early spring roughly coincides with the reopening of the upper Mississippi River and Great Lakes to HRS barge and vessel traffic. Minneapolis strength in March and April may also be fostered by pending harvesttime pressure on winter wheat futures prices in Chicago and Kansas City. HRS harvest,

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[3] Analyzing spreads in ratio form as opposed to absolute form (cents/bushel) enhances analytical simplicity. Deflation is unnecessary and statistical problems which arise as the mean spread approaches zero cents/bushel are avoided.

[4] Although the indexes are not true seasonal indexes since the observation periods are only four and eight months for May and September spreads, respectively, the word "seasonal" is used in the text for convenience. Any reference to seasonal behavior should be interpreted in the context of the specific four and eight month "seasons" analyzed.

Chart 1.—Index of May Futures Price Ratios, Minneapolis to Chicago: January–April, 1974–83

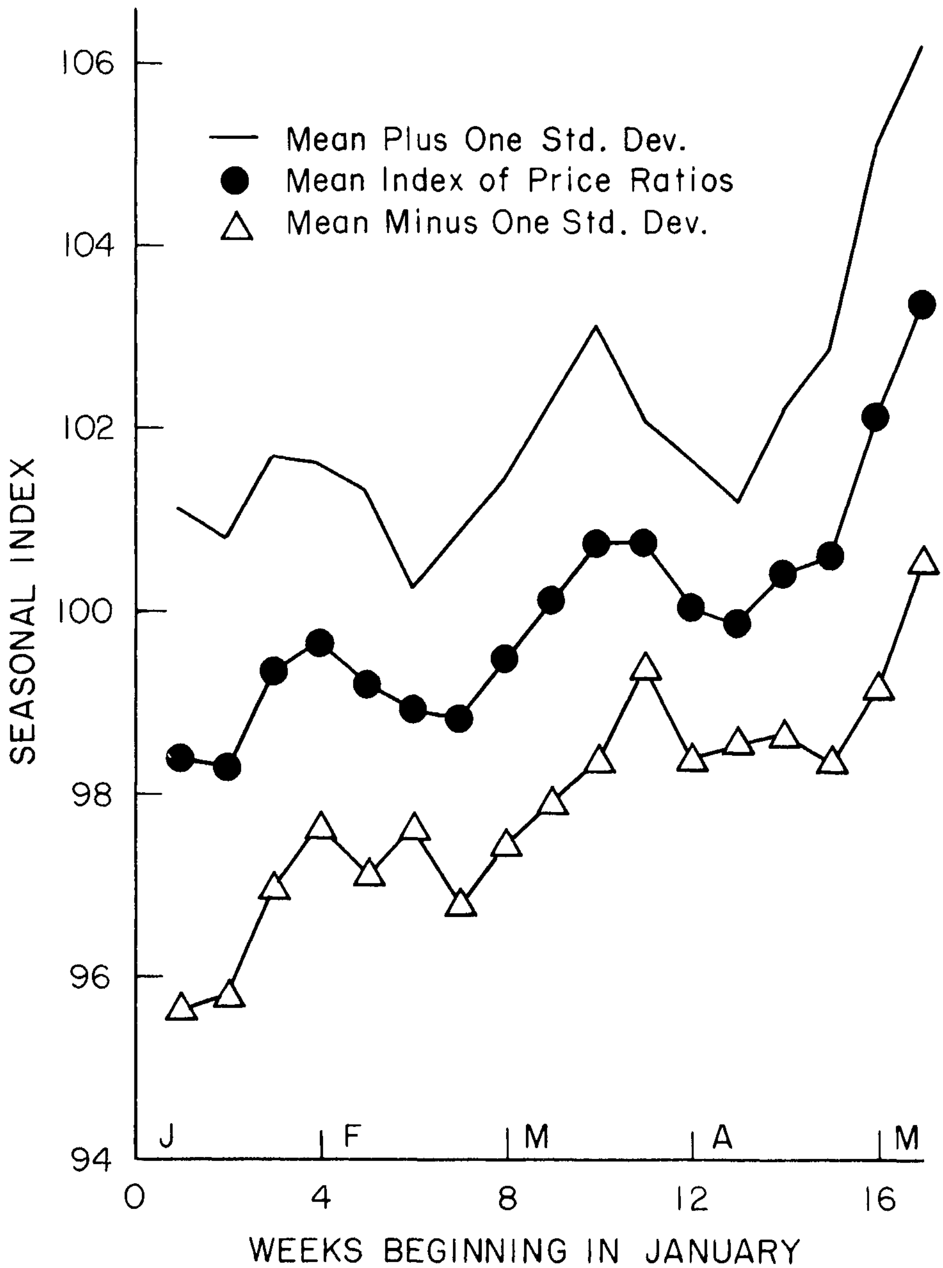


Chart 2.—Index of May Futures Price Ratios, Minneapolis to Kansas City: January–April, 1974–83

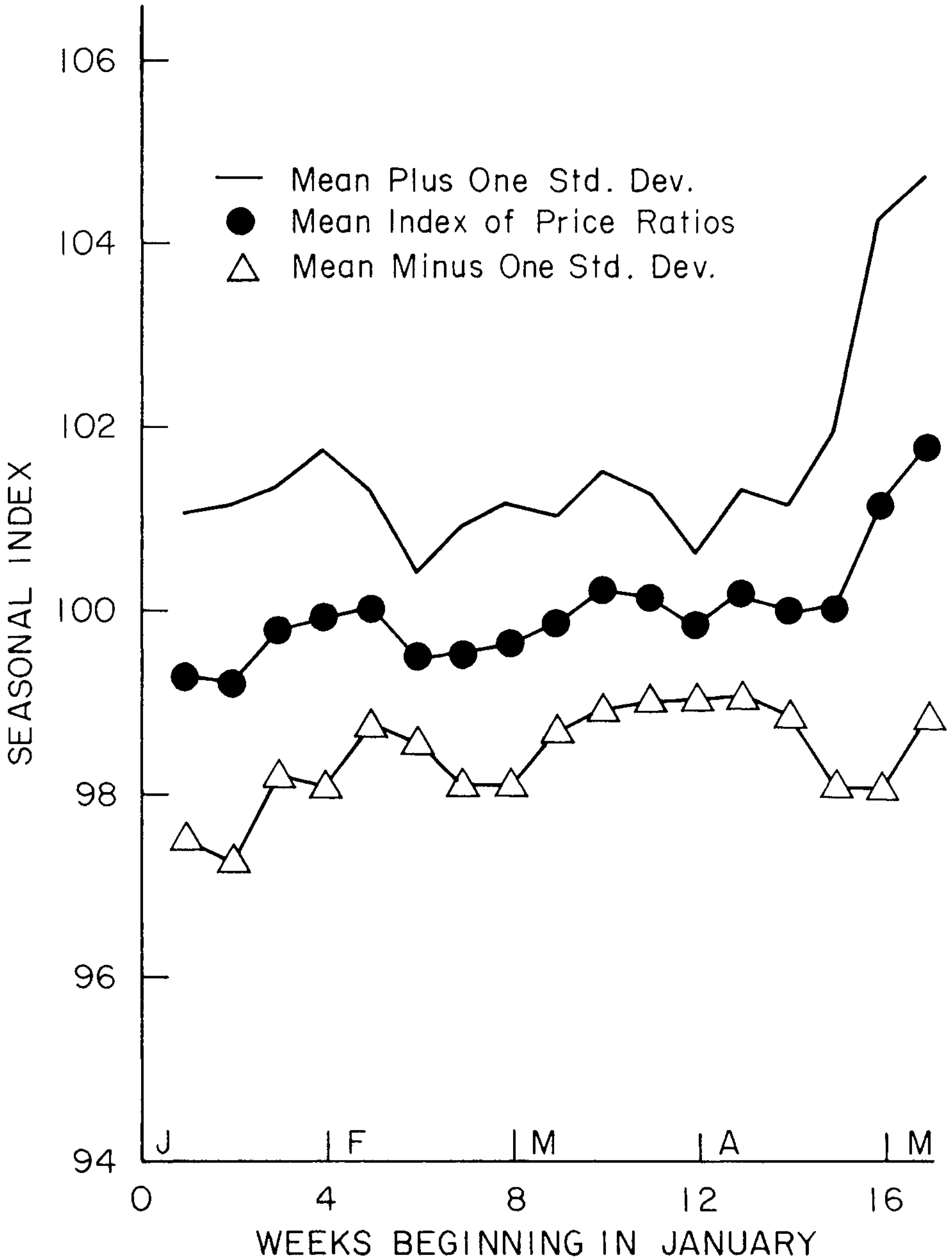


Chart 3.—Index of September Futures Price Ratios Minneapolis to Chicago: January–August, 1974–83

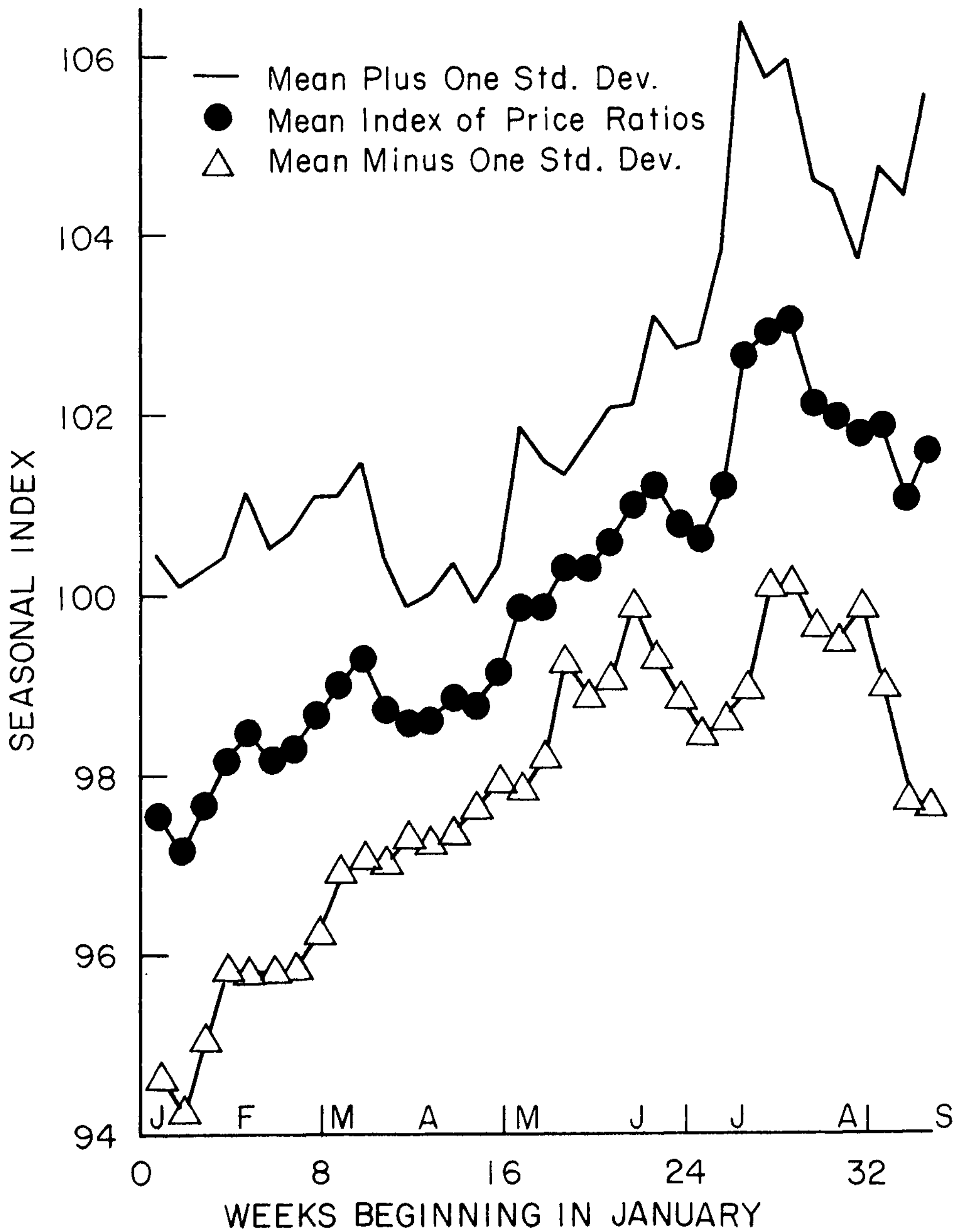
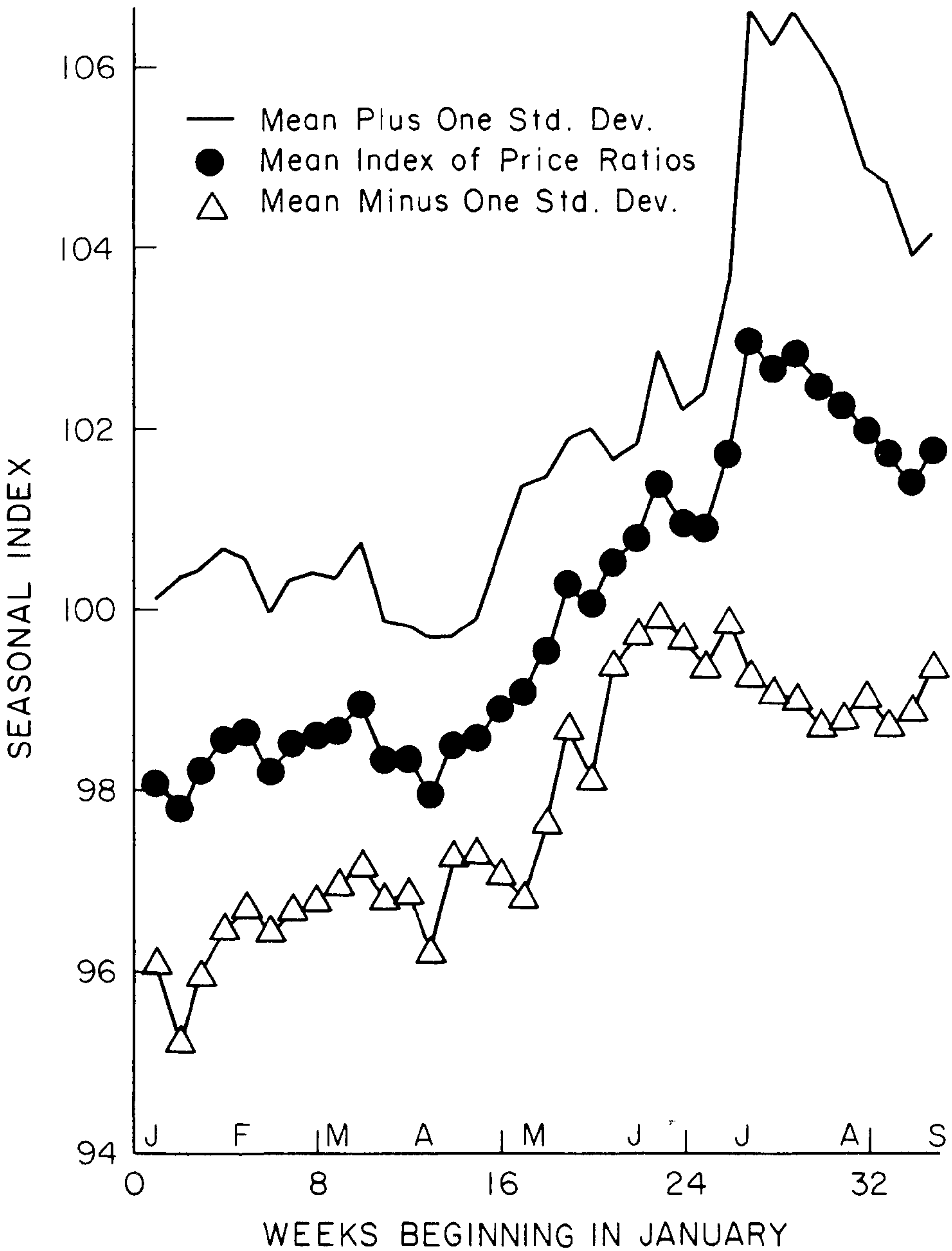


Chart 4.—Index of September Futures Price Ratios, Minneapolis to Kansas City: January-August, 1974-83



on the other hand, remains several months away.[5]

The zone of irregularity surrounding the mean index of price ratios defines the range within which 68 percent of the actual observations are expected to fall. Careful inspection of Charts 1 and 2 reveals that the zone of irregularity around the Mpls/Chgo spread is wider than that of the Mpls/KC spread in all but the final two weeks (16–17). This is consistent with risk-return indifference theory since profit opportunity implied by the change in the Mpls/Chgo spread is larger. The average minimum Mpls/Chgo May simple price ratio during the January–April period is 99.54 percent; the average maximum is 108.21 percent. Thus, at the \$4/bushel (bu) price level the Mpls/Chgo spread typically moves 35 cents/bu (\$4(108.21 − 99.54) = \$.347). The average minimum and maximum Mpls/KC May simple price ratios are 100.34 and 106.57 percent, respectively. This implies an average change in the spread of 25 cents/bu during the January–April period at the \$4/bu price level. The tighter zone of irregularity and smaller change in the Mpls/KC May spread may reflect closer substitution between HRS and HRW, as well as the greater likelihood of physical transfer between the two major milling centers.

During the ten-year period between 1974 and 1983, Minneapolis May futures were weakest relative to Chicago during January and February 70 percent of the time (Table 3).[6] Minneapolis achieved its maximum relative to Chicago 60 percent of the time during the last five weeks preceding the May delivery period (weeks 13–17). A similar demarcation is evident in the Mpls/KC May spread.

September Futures Price Spreads

Charts 3 and 4 indicate a very strong seasonal tendency for Minneapolis September to gain on Chicago and Kansas City September. In fact, the two seasonals are virtually identical in terms of changes in spreads and zones of irregularity (reliability of the seasonal). The simple average minimum and maximum Mpls/Chgo September price ratios during the January through August period are 98.8 and 108.7 percent, respectively, implying an average change of 9.9 percent or 40 cents at the \$4/bu price level. Simple average minimum and maximum Mpls/KC September price ratios during the same eight-month period are 98.9 and 108 percent—an approximate change of 36 cents/bu in the Minneapolis premium. Much of the Minneapolis strength vis-à-vis Chicago and Kansas City September futures occurs between April and mid-July (weeks 12–29).

Table 4 shows the timing of maximum and minimum September spreads during the last four months preceding contract expiration: May– August (weeks 18–35). There is a strong tendency for Minneapolis to be weakest relative to

[5] In fact, planting of the new HRS crop is still in the early stages during April and May.

[6] Keep in mind that the relevant time frame is January–May. Spread behavior prior to January is not analyzed.

Table 3.—Timing of Maximum and Minimum May Price Ratios for Minneapolis to Chicago and Minneapolis to Kansas City Price Spreads, by Weeks from January 1974 to 1983

Number of times occurring in weeks:	Minneapolis to Chicago		Minneapolis to Kansas City	
	Minimum	Maximum	Minimum	Maximum
1–4 (January)	4	2	6	1
5–8 (February)	3	1	1	2
9–12 (March)	1	1	1	1
13–17 (April)	2	6	2	6

Chicago and Kansas City during May. Eighty percent of the time Minneapolis is strongest vis-à-vis Chicago and Kansas City during July and August (weeks 27–35), shortly before the HRS harvest.[7]

Average variation in the September spreads is larger than that of the respective May spreads, which may be attributable to greater supply and demand uncertainty associated with the new crop (September) contracts. And while the zones of irregularity show some tightening in March–May, there is no general tendency for the zones to continue narrowing as the season progresses. In fact, they typically widen as contract maturity approaches. This is consistent with the notion that technical factors often distort otherwise "normal" price relationships during the delivery month. As the final trading day is approached and traders scramble to offset open positions, prices of maturing futures contracts depend largely on the magnitude and ownership of deliverable stocks in the major terminals (Houthakker, 1957). For this reason, hedgers are wary of maintaining futures positions during the delivery month.

Seasonal strength in Minneapolis September futures relative to Kansas City and Chicago is more difficult to understand than the relative strength in the Minneapolis May contract. On the surface it would seem reasonable to expect relative weakness in Minneapolis September since the delivery period corresponds so closely with the timing of the HRS harvest. However, behavior of the May and September spreads closely track one another while the May contracts are still trading (weeks 1–17). Relative Minneapolis September strength

[7] Incidentally, if one considers the entire January through August period, about 70 percent of the Mpls/Chgo and Mpls/KC minimum September price ratios occurred in January and February during the 1974–83 period, as implied by Charts 3 and 4.

Table 4.—Timing of Maximum and Minimum September Price Ratios for Minneapolis to Chicago and Minneapolis to Kansas City Intermarket Spreads, by Weeks from January 1974 to 1983

Number of times occurring in weeks:	Minneapolis to Chicago Minimum	Minneapolis to Chicago Maximum	Minneapolis to Kansas City Minimum	Minneapolis to Kansas City Maximum
18–22 (May)	6	1	6	2
23–26 (June)	2	1	0	2
27–30 (July)	0	6	1	4
31–35 (August)	2	2	3	4

continues well beyond the May delivery period and on into the middle of July (weeks 28–29). At that point, Minneapolis prices tend to break relative to Chicago and Kansas City. The winter wheat harvests are virtually completed and Chicago and Kansas City futures have discounted the impact of the newly realized production. Minneapolis prices, on the other hand, are beginning to feel the pressure of the forthcoming HRS harvest.

A detailed discussion of interdelivery (and in this case intercrop year) price relationships is beyond the scope of this analysis. However, an interesting point is evidenced by the way in which the relevant May and September spreads tend to parallel one another. It is often argued that a decline in, for example, the September 1984 futures relative to the May 1984 futures reflects prospects of a large forthcoming harvest which could only depress new crop, i.e., September futures prices. But, empirical analysis has disproven this common misconception. It is now acknowledged that expectations regarding the coming crop will affect the May futures to the same degree as the September futures, perhaps more. The only thing that affects the relationship between two temporally separated prices, i.e., cash futures or futures-futures, is the quantity of stocks currently in existence (Working, 1949).[8] Given that May and September futures prices are responding simultaneously to fundamental factors for HRS, HRW, and SRW in Minneapolis, Kansas City, and Chicago, respectively, it is not surprising that the intermarket spreads for the different delivery months behave so similarly while the May contracts are still trading, i.e., during weeks 1–17.

[8] Working coined the term "price of storage" for this relationship, a market-determined price which varies and guides surplus stocks into and out of storage.

Spread Behavior in Individual Years

While the May and September indexes indicate fairly reliable seasonal trends in Mpls/Chgo and Mpls/KC spreads, it is important to realize that the spreads do not always follow trend. The year 1978 is an excellent case in point (Chart 5). Not only did both 1978 Mpls/Chgo spreads work against trend and in favor of Chicago, but Chicago prices actually went to a premium over Minneapolis for the first time since the shortages of the early 1970s. The unusual strength in Chicago May and September futures was largely the result of an anticipated and then realized shortage of new crop (1978) SRW, brought on by drought, winterkill, and governmental set-aside programs (USDA, 1978). The 1978 SRW crop was pared to 189 million bushels from 350 million bushels in 1977. This, in conjunction with burgeoning supplies of HRS in excess of two years annual demand, helped move the May and September spreads 22 and 28 cents/bu, respectively, contra-seasonally in favor of Chicago.

Kansas City futures were unusually strong vis-à-vis Minneapolis in 1978 as well (Chart 6). The May and September spreads strengthened typically in favor of Minneapolis in January and February, but by early March (week 10) Minneapolis began to lose its premium. The People's Republic of China returned to the U.S. wheat market in the early spring with major purchases, predominantly HRW (USDA, 1978). This helped push 1977/78 HRW exports above year earlier levels by more than 25 percent. As the HRW export pace quickened and transportation bottlenecks developed, the HRW basis at the Gulf strengthened as did Kansas City futures. In the process, the Mpls/KC May spread narrowed by 18 cents as Kansas City May went to a four-cent premium over Minneapolis May.

With the winter wheat harvest approaching, Minneapolis September registered a modest increase relative to Kansas City in late April and early May (weeks 16–19) in the typical seasonal pattern. But as it became apparent that the 1978 HRW crop would be the smallest since 1972 (830 million bushels), Minneapolis gave up all of its premium, losing more than 10 cents versus Kansas City by the end of August. Of course, relative strength in Kansas City futures in 1978 was also exacerbated by the exorbitant stockpiles of HRS already noted.

Spread behavior in 1980 and 1982 conformed fairly closely with what would be expected from the seasonal indexes. Minneapolis May registered 30- and 36-cent gains relative to Chicago between January and April in 1980 and 1982, respectively.[9] Minneapolis gains compared to Kansas City May during the same periods were more modest—18 cents and 8 cents, respectively.

Minneapolis September prices posed gains of 68 cents and 53 cents versus Chicago September between January and August in 1980 and 1982, respectively, 38 and 37 cents of which came during the April through mid-July period (weeks 14–29). Minneapolis gains relative to Kansas City September were 71 cents and 38 cents during the first eight months of the year in 1980 and 1982, respectively.

[9] In price ratio terms, these gains are analogous to increases in the Mpls/Chgo May price ratio from 92 to 98 percent in 1980, and 101 to 113 percent in 1982.

Chart 5.—Minneapolis and Chicago Futures Prices
and Spreads, May 1978 and September 1978 Contracts
(Cents per bushel)

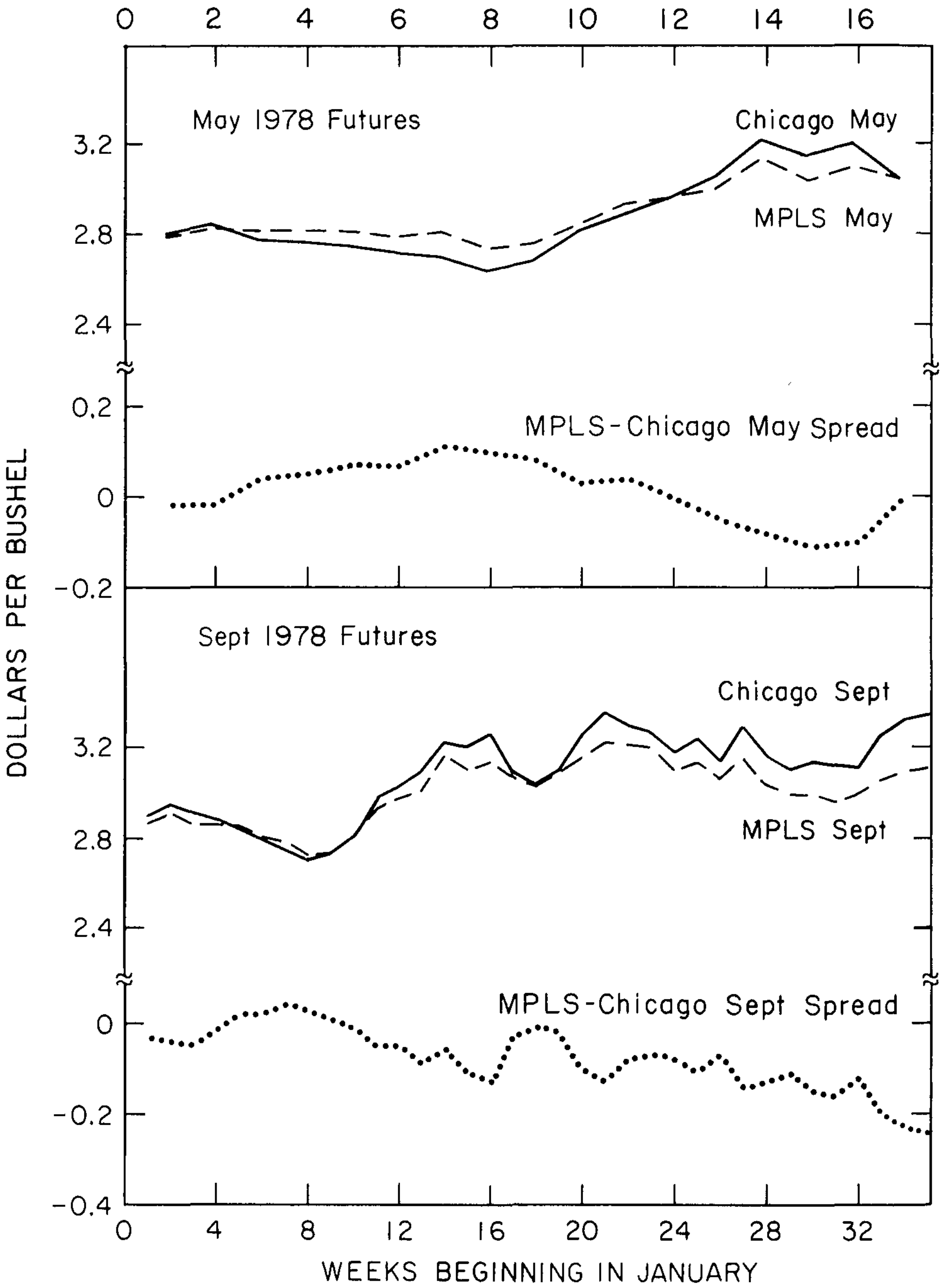
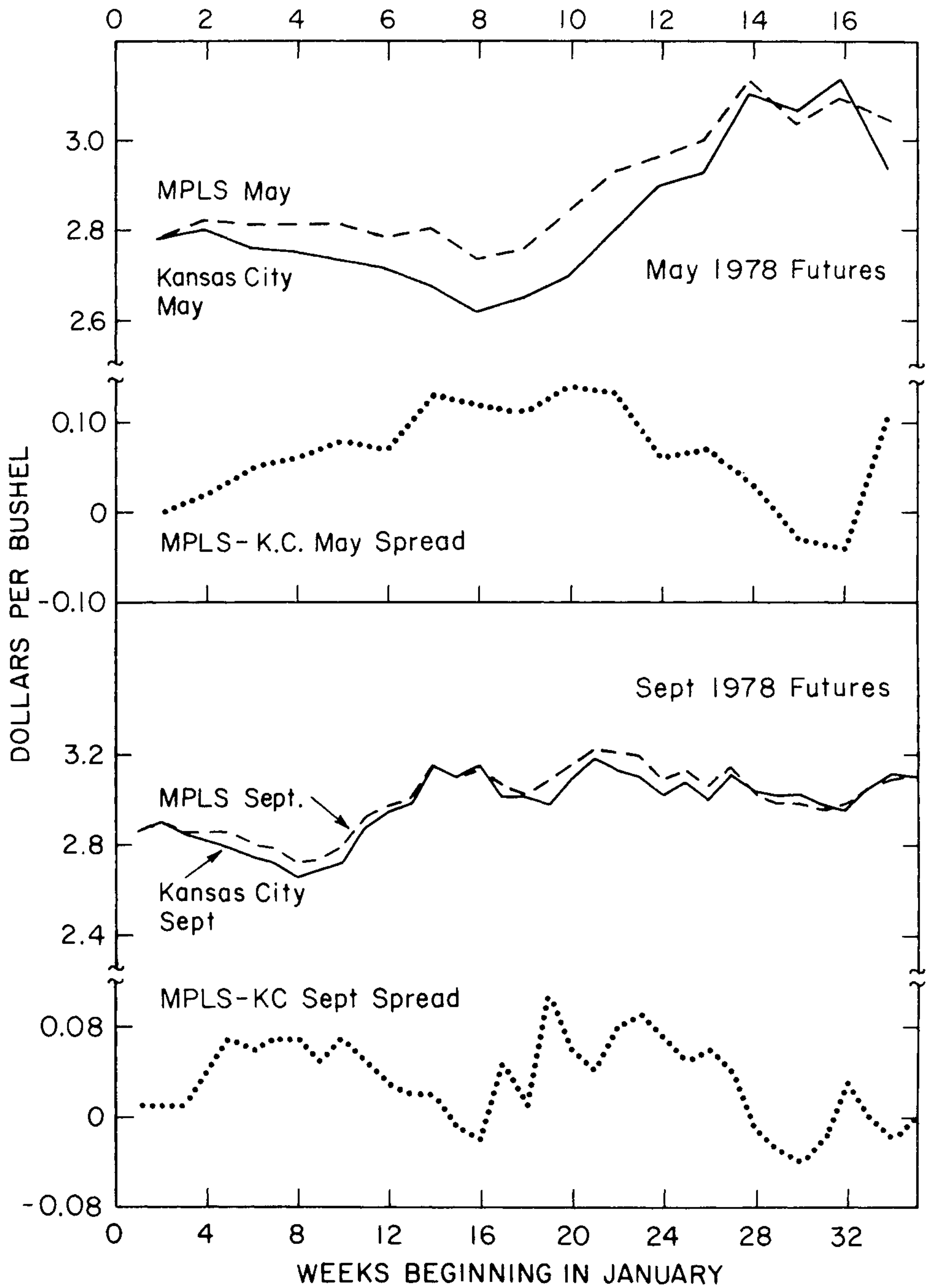


Chart 6.—Minneapolis and Kansas City Futures Prices and Spreads, May 1978 and September 1978 Contracts
(Cents per bushel)



Fifty-five cents of the change in the 1980 spread and 31 cents of the change in the 1982 spread occurred between April and the middle of July. Supply and demand fundamentals might best be characterized as fairly typical in 1980 and 1982 in contrast to the unusual market fundamentals in 1978.

EMPIRICAL ANALYSIS OF INTERMARKET PRICE RELATIONSHIPS

In order to design more effective hedging strategies, it is important to be able to accurately forecast the magnitude and direction of forthcoming changes in intermarket price relationships. It is particularly important to identify those phenomena associated with contraseasonal spread behavior.

The Economic Model

Since changes in intermarket price relationships are largely the result of changes in relative supply and demand balances between individual wheat classes, the general economic model of relative price behavior is specified as follows:

$$\frac{P_i}{P_j} = f\left(\frac{BS_i}{BS_j}, \frac{PR_i}{PR_j}, \frac{TS_i}{TS_j}, \frac{DU_i}{DU_j}, \frac{X_i}{X_j}, \frac{TD_i}{TD_j}, \frac{ES_i}{ES_j}, \frac{USR_i}{USR_j}\right) \tag{1}$$

where

i = class i
j = class j
P = futures price
BS = beginning stocks
PR = production
TS = total supply
DU = domestic utilization
X = exports
TD = total demand
ES = ending stocks
USR = total utilization $\div$ *total supply*

The first seven predictor variables in Equation (1) are simple ratios of factors which constitute a supply and demand balance sheet for wheat. Demand ratios ($DU_{i/j}$, $X_{i/j}$, $TD_{i/j}$) are hypothesized to be directly related to the dependent variable P_i/P_j; supply ratios $BS_{i/j}$, $ES_{i/j}$, $PR_{i/j}$, $TS_{i/j}$ should be inversely related to the price ratio. However, since stocks data include government owned and controlled stocks, it is not expected that signs on $BS_{i/j}$ or $ES_{i/j}$ will be consistent or theoretically correct. The utilization/supply ratio

$USR_{i/j}$ is included to capture the overall supply and demand balance between classes. As the demand/supply ratio for class i increases relative to that of class j, the price ratio P_i/P_j should increase.

Two regression equations are estimated for each of the four spreads studied: one with the maximum price ratio P_i/P_j during the hedging period as the dependent variable, and the other with the minimum price ratio as the dependent variable.[10] Conceptually, the justification for regressing on maximums and minimums is to define a range within which a specific price ratio is expected to fluctuate during the upcoming hedging period, given current estimates of relative supply and demand (Chart 7). For example, in the simple bivariate case, an estimated total supply ratio of $R*$ is expected to result in a maximum price ratio of $PR*$ max and a minimum of $PR*$ min sometime during the forthcoming hedging period.[11] If the current price ratio at or near the beginning of the hedging period is PR_t, it is likely that P_i will increase relative to P_j during the hedging period. This information, together with an understanding of typical seasonal behavior in the price spread, form the basis from which hedgers can select the most effective futures market for hedging.

With prediction as the objective, a forward inclusion (stepwise) regression procedure is used to identify the three best predictor variables. In all but one regression the best model is achieved with two predictors, based on adjusted R-squares. Fundamental supply and demand data by class are USDA estimates which are published before the May hedging horizon and again early in the September hedging horizon.[12] The use of ex ante data complements the predictive nature of the regression parameters. Annual data for the 1973/74–1982/83 marketing years are used.

Empirical Results

Regression results for Mpls/Chgo and Mpls/KC spreads are shown in Tables 5 and 6. Four summary statistics are presented with each equation: coefficient of determination R^2, adjusted R^2, overall "goodness of fit" or regression

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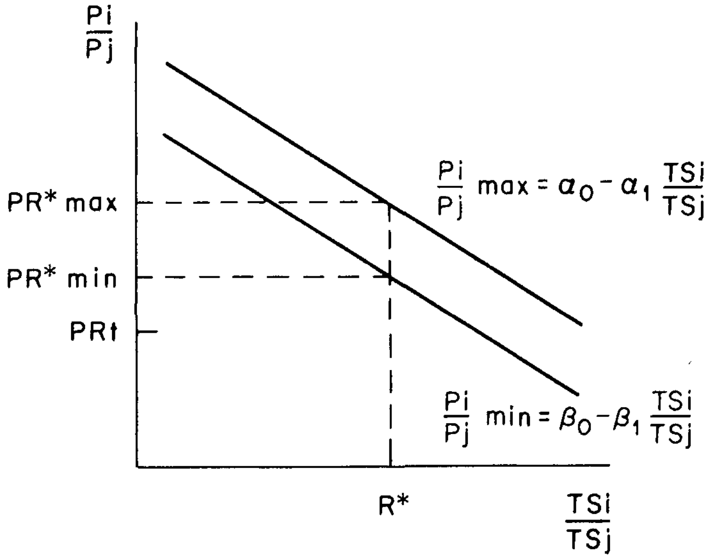
[10] The relevant hedging period refers to January through April (weeks 1–17) for May spreads and May through August (weeks 18–35) for September spreads. Minimum and maximum price ratios used are those occurring only during the relevant time frames.

[11] Note the slope of the regression equations in Chart 7. If a demand ratio is placed on the horizontal axis, the function should have a positive slope.

[12] Since May and September contracts in the same year, i.e., 1983, reflect separate marketing years, i.e., 1982/83 and 1983/84, respectively, different supply and demand estimates are used to predict changes in intermarket price relationships for the two delivery months which fall in the same calendar year. Old crop fundamentals used for the May (time t) hedging horizon are taken from the November $t-1$ issue of "Wheat Outlook and Situation;"new crop fundamentals (September hedging horizon, time t) are taken from the July t or August t issue.

Chart 7.—Estimated Range of Price Ratio Fluctuation During Hedging Period



significance (RS), and prediction error or standard error of estimate SEE.[13] The significance (α level) of each estimated coefficient and overall regression is reported in parenthesis. The confidence level $(1 - \alpha)$ increases as α decreases. Hypothesized signs on coefficients are placed directly beneath column labels.

Signs on all coefficients are consistent with economic theory. R-squared values are generally quite high considering the simplicity of the model, ranging between 62 and 99 percent. All regression equations are significant (RS) with 96.5 percent or more confidence. Prediction errors are larger for Mpls/Chgo spreads, especially in the May contract. This is consistent with the wider zone of irregularity in the Mpls/Chgo May seasonal (Chart 1), and may also evidence closer substitution between the hard wheats.

It is interesting to compare prediction errors within each spread, i.e., between contracts and between maximums and minimums. In general, prediction accuracy is lower for maximum price ratios than for minimums. This may be

[13] Residuals for each equation were examined for violations of normal error assumptions. No major departures from normality were detected.

Table 5.—Regression Results for Minneapolis to Chicago Spreads, May and September Contracts, Minimum and Maximum Price Ratios*

	May		September	
	Minimum	Maximum	Minimum	Maximum
Constant	97.99 (.000)	127.58 (.000)	116.45 (.000)	126.56 (.000)
$\frac{BS_i}{BS_j}$	—	—	−.71 (.047)	−.89 (.051)
$\frac{PR_i}{PR_j}$	—	—	—	—
$\frac{TS_i}{TS_j}$	−7.96 (.007)	−14.07 (.007)	−7.11 (.005)	−8.60 (.006)
$\frac{X_i}{X_j}$	—	2.04 (.079)	—	—
$\frac{ES_i}{ES_j}$	—	—	—	—
$\frac{USR_i}{USR_j}$	21.47 (.066)	—	—	—
R^2	.76	.69	.79	.78
R^2 adj	.69	.60	.73	.71
RS(α)	(.007)	(.017)	(.004)	(.005)
SEE	4.15	5.00	2.61	3.34

*i = hard red spring wheat; j = soft red winter wheat. See text for form of regression.

associated with the greater intrinsic value of HRS. In years of HRS (protein) shortages, Minneapolis futures can go to sizable premiums over Chicago and Kansas City. However, pressure on Minneapolis prices on the downside is limited, even in years of abundant protein, by the intrinsic value of HRS. In any case, the differences in prediction accuracy may have implications for hedgers, depending upon which spread they need to predict. For instance, correctly timing the transfer of a hedge (or lifting one leg of an intermarket spread) may be easier when waiting for Minneapolis to lose relative to Chicago (M/C min) than it is when waiting for Minneapolis to gain on Chicago (M/C max).

Since May and September contracts are in different crop years, it might be expected that prediction errors would be smaller in the old crop (May spreads). This does not appear to be true in the case of Mpls/Chgo, although it does hold for the Mpls/KC spreads. This may be attributed to the fact that relative

Table 6.–Regression Results for Minneapolis to Kansas City Spreads, May and September Contracts, Minimum and Maximum Price Ratios*

	May		September	
	Minimum	Maximum	Minimum	Maximum
Constant	85.63	63.95	119.70	136.89
	(.000)	(.000)	(.000)	(.000)
$\frac{BS_i}{BS_j}$	—	−12.84	−18.26	—
	—	(.000)	(.012)	—
$\frac{PR_i}{PR_j}$	—	—	−25.13	—
			(.112)	
$\frac{TS_i}{TS_j}$	—	—	—	−101.78
				(.004)
$\frac{X_i}{X_j}$	—	46.37	—	45.24
		(.002)		(.178)
$\frac{ES_i}{ES_j}$	−5.66	—	—	—
		(.123)		
$\frac{USR_i}{USR_j}$	22.07	44.87	—	—
	(.013)	(.000)		
R^2	.88	.99	.62	.77
R^2 adj	.84	.98	.51	.71
RS(α)	(.001)	(.000)	(.035)	(.006)
SEE	1.71	0.72	2.09	2.38

*i = hard red spring wheat; j = hard red winter wheat. See text for form of regression.

prices between the closely substitutable new crop (September) hard wheats are also affected by quality attributes which are not accounted for in supply and demand estimates, i.e., average protein content.

Changes in Mpls/Chgo price ratios are most closely associated with changes in the total supply ratio of HRS over SRW. $TS_{i/j}$ is significant at the 99.5 percent confidence level in each of the four regressions. Interpreted literally, a unit increase in the ratio of HRS total supply/SRW total supply from its mean of 1.63 to 2.63, ceteris paribus, would result in a decrease of 14.07 and 7.96 percentage points in the maximum and minimum Mpls/Chgo May price ratios, respectively. Thus, the maximum price ratio appears to be more sensitive to changes in the supply ratio. Again, this may be associated with the greater intrinsic value of HRS vis-à-vis SRW. Demand-related variables $X_{i/j}$ and $USR_{i/j}$ also work in conjunction with supply ratios to explain variation in Mpls/Chgo May spreads, whereas beginning stocks ratios contribute to explained variance in the September spreads.[14] This is logical in light of the fact that supply variables are known with more certainty than demand variables early in the marketing year (September).

It is difficult to generalize about statistical associations discovered between predictor variables in Mpls/KC regressions. No single predictor is consistently significant, although beginning stocks and utilization/supply ratios each enter two equations with α levels of .013 or better. By the same token, it is difficult to argue with the summary statistics in the Mpls/KC models. Adjusted R-squared values are much higher; prediction errors are considerably smaller.

Perhaps the most peculiar aspect of the Mpls/KC results is the parameter on the total supply ratio, TS_i/TS_j, in the September spread. The coefficient on the total supply ratio implies a decrease of 101.78 percentage points in the maximum September price ratio for a unit increase in the supply ratio. Of course, this is very unrealistic, especially since the average maximum Mpls/KC September price ratio is only 107.9 percent. The coefficient on $TS_{i/j}$ is very large because the mean supply ratio (HRS/HRW) is only .41 with a standard deviation of .05. This implies a 10.18 percentage point decrease in the maximum price ratio as the supply ratio increases from .41 to .51.

Application of Empirical Results

Hedgers can increase the effectiveness of their hedging programs by correctly anticipating changes in intermarket price relationships. Consider a merchant who has recently purchased 10,000 bushels of HRS. He is uncertain of the direction in which prices will move between now (January 5, 1984) and the time that he will likely sell the wheat in May. Therefore, he decides to hedge against a price decline by selling two May wheat futures contracts today. Current prices for May contracts at the three exchanges are: Minneapolis, \$3.93/bu; Chicago, \$3.55/bu; Kansas City, \$3.63/bu. Thus, current price ratios are: Mpls/Chgo, 110.7 percent, and Mpls/KC, 108.3 percent.

Before selecting a hedging market, the merchant should assess the relative strength or weakness of each market in light of current supply and demand fundamentals (Table 7).

Fundamentals for 1983/84 indicate that production is off slightly from 1982/83 for each class. Total available supplies of SRW and HRS are lower for the 1983/84 marketing year, but HRW total supply is 151 million bushels above the previous year's record 1.79 billion bushels because of a 218 million bushel increase in 1982/83 HRW carryover. Note the projected increases in HRW and SRW domestic utilization. Winter wheat is expected to remain fairly competitive with feed grains as a result of high corn and soybean prices induced by

[14] Standardized coefficients (not shown) indicate that total supply ratios exert almost twice as much impact on the price ratio as the other predictor variables.

Table 7.—Supply and Demand Estimates
for Hard Red Winter Wheat (HRW), Soft Red Winter Wheat (SRW),
and Hard Red Spring Wheat (HRS): 1982/83 to 1983/84
(Millions of bushels)

	HRW	SRW	HRS
1982/83			
Beginning stocks	539	60	348
Production	1,255	610	500
Total supply	1,794	670	852
Domestic utilization	358	271	186
Exports	679	325	239
Total demand	1,037	596	425
Ending stocks	757	74	427
1983/84			
Beginning stocks	757	74	427
Production	1,188	508	313
Total supply	1,945	582	741
Domestic utilization	483	293	186
Exports	660	245	225
Total demand	1,143	538	411
Ending stocks	802	44	330

Source: U.S. Department of Agriculture, November 1983. *Wheat Outlook and Situation.* Economic Research Service, Washington, D.C.

the 1983 drought and PIK program (USDA, 1983). Exports are expected to weaken amid fierce competition from other major exporting countries and continued strength in the U.S. dollar. Total 1983/84 carryover is expected to fall, although HRW ending stocks may rise by about 50 million bushels. Crop quality information indicates that protein content of the 1983 HRS crop is unusually high; protein and baking quality of 1983 crop HRW is down from 1982. The 1983 SRW crop is higher in quality with better test weights than the previous year (USDA, 1983).

Supply and demand data from Table 7 can be used in the regression equations of Tables 5 and 6 to predict the probable magnitude of forthcoming changes in May price spreads.

Minneapolis to Chicago:

$$\begin{aligned}
\text{M/C max} &= 127.58 - 14.07\,\frac{TS_i}{TS_j} + 2.04\,\frac{X_i}{X_j} \\
&= 127.58 - 14.07\,\frac{741}{582} + 2.04\,\frac{225}{245} \\
&= 111.5 \text{ percent} \\
\text{M/C min} &= 97.99 - 7.96\,\frac{TS_i}{TS_j} + 21.47\,\frac{USR_i}{USR_j} \\
&= 97.99 - 7.96\,\frac{741}{582} + 21.47\,\frac{411/741}{538/582} \\
&= 100.7 \text{ percent}
\end{aligned}$$

Given the current (January 5) Mpls/Chgo May price ratio of 110.7 percent, a maximum predicted price ratio of 111.5 percent does not indicate much further potential strengthening in Minneapolis vis-à-vis Chicago.[15] Taking into consideration the standard error of estimate (5.0), approximately 68 percent of the maximum Mpls/Chgo price ratios, given current fundamentals, are expected to fall between 106.5 percent and 116.5 percent. However, there is still room for Minneapolis May to lose (contra-seasonally) relative to Chicago; the price ratio could weaken to 100.7 percent ± 4.15 percent (one standard deviation above and below the predicted minimum price ratio). In cents per bushel, Minneapolis could lose almost all of its current 38-cent premium between now and the end of April.

The hedger should also analyze the relative strength of Kansas City futures before selecting a hedging market. Maximum and minimum Mpls/KC May spreads predicted using the regression equations of Table 6 are as follows:

Minneapolis to Kansas City:

$$\begin{aligned}
\text{M/KC max} &= 63.95 - 12.84\,\frac{BS_i}{BS_j} + 46.37\,\frac{X_i}{X_j} + 44.87\,\frac{USR_i}{USR_j} \\
&= 63.95 - 12.84\,\frac{427}{757} + 46.37\,\frac{225}{660} + 44.87\,\frac{411/741}{1143/1945} \\
&= 114.9 \text{ percent} \\
\text{M/KC min} &= 85.63 - 5.66\,\frac{ES_i}{ES_j} + 22.07\,\frac{USR_i}{USR_j} \\
&= 85.63 - 5.66\,\frac{330}{802} + 22.07\,\frac{411/741}{1143/1945} \\
&= 104.1 \text{ percent}
\end{aligned}$$

[15] At current price levels, eight-tenths of one percentage point increase in the Mpls/Chgo spread translates into a three-cent increase in the Minneapolis premium.

Factoring in one standard error of estimate above and below each predicted price ratio, 68 percent of the maximum price ratios during the January-April period are expected to fall between 114.2 and 115.6 percent; minimum price ratios should fall between 102.4 percent and 105.8 percent. At current price levels, Minneapolis could gain approximately 20–25 cents on Kansas City if the price ratio strengthens to 114.9 percent. Minneapolis could lose about 15 cents if the spread weakens toward the predicted minimum of 104.1 percent. The current Mpls/KC price ratio (108.3 percent) is slightly closer to the predicted minimum. This might be an indication that further strengthening is likely. Furthermore, strong protein in HRS, unusually poor quality HRW, and a projected increase in HRW carryover should lend support to the typical seasonal tendency for Minneapolis May to increase relative to Kansas City May (see Chart 2).

Implications for Hedgers

Three simple alternative hedging strategies emerge for our prospective HRS hedger. First, in light of current strength in Minneapolis relative to Chicago, he might choose to place his short hedge directly in Minneapolis futures. Second, he might decide to place an intermarket spread on indications that Minneapolis is more likely to lose relative to Chicago than to gain. This strategy requires the hedger to sell Minneapolis May and buy Chicago May. The Chicago position can be liquidated (sold) later, retaining the short position in Minneapolis futures as a hedge. Any strengthening in the spread in favor of Chicago futures will effectively increase the short Minneapolis futures price cent for cent above the price established at $3.93/bu, i.e., the buying basis is weakened.[16] Of course, the hedger should keep in mind that the spread does not typically move seasonally in favor of Chicago. For this reason, very careful consideration of potential risks and returns should be made before deciding to place a spread which requires atypical seasonal behavior to be profitable.

Third, the hedger could elect to sell May futures in Kansas City in anticipation of transferring (rolling) the hedge to Minneapolis later once the Mpls/KC spread has widened in favor of Minneapolis. Again, the effective short price eventually established in Minneapolis futures will exceed the current Minneapolis May futures price by the amount that the spread widens. In the interim, the hedger is protected from a price decline by the temporary short position in Kansas City May futures. Since Minneapolis typically strengthens seasonally relative to Kansas City, and since prediction equations are decisively better for Mpls/KC spreads than for Mpls/Chgo spreads, most hedgers would probably prefer the third strategy.[17]

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[16] Commission costs are ignored for simplicity. Although commissions are higher for spread trades, current commissions charged by one major brokerage house are approximately 1.3 cents/bu for an outright round-turn and 1.5 cents/bu for a spread round-turn in wheat.

[17] Of course, the same results can be achieved in a number of ways by large firms

Long hedgers can also increase the effectiveness of their hedging programs by exploiting changes in intermarket price relationships. For example, an HRS exporter should attempt to establish a long futures position in Minneapolis when spring wheat futures are weak relative to winter wheat futures in Chicago and Kansas City. The long hedger can simultaneously sell Chicago or Kansas City futures because they are implicitly strong when Minneapolis is weak. The intermarket spread is lifted by covering the short position in Chicago or Kansas City and retaining the long Minneapolis position as a hedge until HRS is purchased in the spot market. Increases in the spread in favor of Minneapolis effectively decrease the price paid for the long Minneapolis futures position cent for cent. That is, the selling basis is increased by the amount that the spread moves favorably.[18]

SUMMARY

Relative prices between the three futures markets change due to temporal disparities in planting, harvesting, and marketing of spring and winter wheats, as well as changes in supply and demand balances between classes. An empirical model of relative price behavior was estimated using annual data for the 1974–83 period. Multiple regression results indicate that ratios of fundamental factors of supply and demand for individual classes of wheat are closely associated with changes in relative prices between the three futures markets. Statistical measures are particularly robust for Mpls/KC spreads. This may be due to closer substitution between HRS and HRW.

Taken together, the indexes and regression equations can guide hedgers into the most advantageous hedging market. However, it is obvious that these tools do not elicit discreet and perfect solutions to the problem of hedging market selection. Inferences, intuition, and subjective judgments inevitably enter the decision-making framework, and rightfully so. But, the equations and indexes do enable hedgers to estimate more accurately potential risks and returns from alternative hedging opportunities. As such, individual risk preferences can be better accommodated within the decision-making process.

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which are simultaneously hedging various classes, grades, and qualities of wheat for different time periods and different geographical locations. These are only the most simple and obvious strategies.

[18] After observing behavior of the Mpls/Chgo and Mpls/KC May and September spreads during 1984, it is evident that the actual behavior conformed very closely with the typical seasonal patterns indicated in Charts 1–4. But, the predicted maximum and minimum price ratios using the economic model were less reliable.

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