CHAPTER 4.

ECONOMIC DETERMINANTS OF THE AMOUNT, TIMING, AND LOCATION OF DELIVERIES

The preceding two chapters have examined aggregate monthly deliveries on the CBOT and other futures contracts in relation both to other measures of overall trading activity and to levels of concentration in the cash as well as the futures markets. Now the delivery process itself is considered and the extent to which various aspects of it reflect underlying economic variables is analyzed.

Delivery on the CBOT grain and soybean futures contracts is undertaken at the seller's initiative, as in most futures contracts with physical settlement.[1] The seller also chooses the quality, timing, and location of any deliveries. An explicit model of the simultaneous valuation of all the seller's options involves evaluation of at least four decisions: whether, when, where, and what quality to deliver. This chapter undertakes the simpler task of describing how each decision may be explained by the economic incentives observed in the market, in other words, prices. The more successful such descriptions are, the more confidence may be placed in observed prices as guides to potential policy changes. For example, if the timing of deliveries during the month is found to be responsive to the current basis, then policies affecting the basis will also influence the timing of deliveries in the delivery month. The subsequent sections examine the amount, timing, and location of deliveries on the CBOT markets, with comparisons as appropriate.[2] The process of delivery is described first.

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[1] Among physical settlement futures contracts, several of the energy futures contracts of the New York Mercantile Exchange are buyer's option as to time of delivery.

[2] The seller's option as to which quality of grain or soybeans to deliver is not examined because available data do not indicate what qualities were delivered each month. Thus, there was no way to see how much the amount of a #3 yellow corn delivered in each delivery varied with the prevailing market price differences between #2 and #3 corn.

THE DELIVERY PROCESS

On the CBOT, delivery requires three days to complete. Holding a warehouse receipt for grain eligible for delivery (in an approved storage facility, of allowable grade, in an approved location), a firm that has an open short futures contract apprises the clearinghouse of its intention to deliver. This day is called position day. At this time, the firm also provides the clearinghouse with as much detail as possible as to the specifics of the delivery—amount, location, and grade. On the next day, notice day, the clearinghouse notifies an individual with an open long futures position that delivery is to be made. At the CBOT, purchasers are identified by the date they bought contracts that are still open, and the clearinghouse selects the individual (more precisely, the clearing member) whose position has been open longest to receive the delivery. Once notified, the purchaser may accept the notice and prepare to complete the purchase the next day, or may notify the clearinghouse of an intention to redeliver the as-yet-not-delivered warehouse receipt. If redelivery is the choice, notice day becomes a position day for the purchaser, triggering the start of another three-day sequence. Whether the notice is accepted or redelivery is initiated, the clearinghouse considers both futures positions—the seller's and the purchaser's—to have been closed, and the open interest is reduced accordingly at the end of the day.[3]

Delivery occurs on the third day, delivery day. The seller passes the warehouse receipt to the identified purchaser and payment takes place. Whether or not the purchaser intends to redeliver, payment must be made to the holder of the receipts. If the receipt is redelivered, this delivery day is also notice day for the redelivery, with payment anticipated the following day. In effect, the purchaser who redelivers must pay for at least one day's interest (funds borrowed overnight) and warehouse fees (because the warehouse certificate must be "current" when delivered the following day), even if the redelivery is initiated on the same day the notice was received.

Delivery on the CBOT contracts may occur on any business day in the expiration month. The first delivery day for each contract expiration is the first business day of the month. Thus, the delivery process can actually begin two business days before the first business day with the "first position

[3] Exact delivery procedures vary among futures exchanges. A particularly important difference for analysts is the individual exchange's custom for subtracting deliveries from the open interest. Comex, for example, reduces the open interest on position day, not on notice day as at the CBOT. In addition, the procedures are modified to permit more rapid delivery and redelivery at the expiration of trading.

day" and the "first notice day." Deliveries can continue throughout the delivery month, including the last seven business days when trading in the contract has ended. Positions still open at the close of a contract's trading must be settled through deliveries.

For each market, contract specifications include detailed descriptions of the grades, varieties, and locations of the commodity acceptable for delivery at the contract price and establish what is expected as par delivery. In addition, the specifications also include details of additional varieties, qualities, and locations that are permitted and the associated premium or discount. For example, #2 yellow is the par grade of corn that is deliverable on CBOT corn futures contracts, but #3 yellow is also deliverable at a discount to the contract price. The par delivery location is Chicago, but corn is also deliverable in Toledo and St. Louis.

THE AMOUNT DELIVERED

For a merchant with a warehouse and grain in a deliverable location, the decision to deliver depends upon the financial benefit of alternative sales opportunities. These include an outright sale with its consequent loadout of the grain (as into barges for shipment to the U.S. Gulf); delivery into the futures market; and continued storage, either hedged or unhedged, in order to sell the grain later. The gross return from an outright sale for delivery to the U.S. Gulf, for example, is the value of barged grain in New Orleans less barge freight. The gross return from delivery into the futures market is the current futures price (adjusted by premia or discounts for locations or grades), plus the official warehouse fees for storage (until the receipts are canceled), and the anticipated loadout fees is the grain when actually moved. The gross return is uncertain because it is not known in advance when the warehouse receipts against the stored grain will be canceled and shipment requested. The third alternative, to store the grain in order to sell it later, also has an uncertain gross gain, depending on the market price of storage, the interest expense, and the ultimate sales price. If currently quoted prices are good reflections of expected prices and merchants are risk neutral, deliveries will occur when they are the best sales opportunity.

Obviously, as the stocks available in the deliverable locations become greater, deliveries can grow larger. Some positive correlation between deliveries and deliverable stocks is therefore not surprising. For example, free stocks of wheat in Chicago "explained" some 35 percent of the variation in wheat deliveries in Chicago from May 1976 through May 1987. Chicago stocks of corn explained 50 percent of the variation in corn deliveries from December 1976 through September 1987, and those of soybeans 64 percent from November 1979 through September 1987. In Toledo, the comparable statistics were 28, 18, and 35 percent. If deliveries occur in response to

comparative assessments of returns, several economic variables should also contribute to explaining the relation between stocks and deliveries. The expected returns depend upon the current basis (the cash price in the delivery location minus the expiring futures price), the carrying charge as represented by the spread to the nearby future (the price of the nearby future minus that of the expiring future), and interest costs.

The nearby futures spread represents a return of variable duration depending upon the number of months between the contract expirations, the timing of deliveries within each month, and interest rates. Calendar spreads in the wheat and corn markets are of two and three months duration; those in soybeans are of one and two months. The timing of deliveries within months varies, however. If this timing can be anticipated, it will add variability to the duration of the calendar spread.[4] A simple anticipatory model suffices: The timing of delivery is merely associated with the sign of the more distant spreads. If the difference between the September and December futures prices (observed on September 1) is positive, deliveries will occur early in September. If the difference is negative, they will take place late in that month. Similarly, if the difference between the December and March prices (observed on September 1) is positive, December deliveries are anticipated to occur early in December. In this way, price indicators are used to measure the expected number of actual months between deliveries in order to adjust the observed price spreads to a per-month return.

Interest costs have been calculated using prime interest rates and the expiring futures price converted to a per-month cost (again, in cents per bushel).[5] The monthly interest cost of storage together with the anticipated number of months between deliveries provide an estimate of the interest cost in the price difference between the two futures. In the final adjustments,

[4] For example, the difference in time between the September and December corn futures is three calendar months. If deliveries within each month are both early, the actual time between deliveries is also three months. However, if deliveries in the September future occur late in September, and those in December are early, the actual time between the quoted prices is only two months. If September deliveries are early and December late, the time is four months. Analysis of the timing option later in this chapter shows it is important and can be explained by price spreads. Additional analysis also shows that the timing of deliveries may be anticipated because spreads are reasonably forecastable, especially within cropyears. See Williams and Peck (1991), a previous version of which was presented at the First International Conference of the Centre for Research in Finance, IMI Group, in Rome, September 3–4, 1990.

[5] Interest cost was also calculated using the 90-day Eurodollar interest rate for the substantial (but not complete) portion of the period that Eurodollar rates were available. There was virtually no difference in the results of the analyses because the two rates are so highly correlated.

this cost is subtracted and the net spread expressed as a per-month return (in cents per bushel).

The interest cost, spread, and basis are measured on the first of the delivery month, and in the case of stocks, on the nearest Friday. Thus, deviations from the expected levels of deliveries do not feed back on these variables as they would if they were measured at the end of the month. Of course, the anticipated level of deliveries does influence the spread, basis, and stocks on the first of the month. Thus, regression estimates, strictly speaking, are reasonable estimates of the degree of association rather than of causality between the so-called independent variables (which are themselves related) and the dependent variable, namely the level of deliveries. Sensitive to this issue of simultaneity, prices were also measured one week (five business days) before the first of the delivery and as their average over the entire week preceding delivery. Neither of these alternatives changed significantly the results reported here.

The estimates from the basic model explaining the amount of deliveries each month are shown in Table 4.1. The analyses provide confirmation that economic variables are important in firms' decisions to deliver, although their contributions vary by commodity and by time periods. Separate results are reported for the months in which Toledo has been a delivery point. For purposes of comparison, estimates for Kansas City wheat (both original and total deliveries) and Comex copper are also reported.[6]

Several points deserve notice. The estimates for wheat from the pre-Toledo era clearly support the overall model. The overall explanatory power is comparatively high (an R^2 of 0.77), and both the (adjusted) nearby futures spread and the basis add significantly to explaining the relation between (deliverable) stocks and levels of deliveries. A larger spread is associated with increased deliveries, reflecting the more attractive market-determined returns to storage. The basis affected deliveries as expected—cash prices further above futures were associated with lower deliveries, and prices further under futures were associated with more deliveries. Interest costs had no significant effect on the amount delivered for reasons probably relating to the comparatively little variation in rates and wheat prices for

[6] Estimates reported in Table 4.1 are uniformly from linear regressions for ease of interpretation. Occasionally, a different functional form provided a slightly improved fit. Tobit models were estimated for the relations in the Toledo era for both Toledo corn (where no deliveries occurred in 16 of 65 delivery months) and Toledo soybeans (where no deliveries occurred in 14 of 70 delivery months). In no case did the alternative estimates change the nature of the reported results substantively. A number of potential econometric problems were also explored and corrected, for example, serial correlation and heteroskedasticity whenever indicated. The corrected estimates did not lead to different interpretations of the results.

Table 4.1—The Influence of Economic Factors on the Amount of Deliveries

	Period	Adjusted nearby futures spread	Basis	Interest cost	Total free stocks	R^2
Wheat						
Chicago	1964/65–1972/73	0.59	−0.63	−0.20	1.68	0.77
		(2.10)	(1.96)	(−0.05)	(6.95)	
	May 1976–1988/89	0.61	0.36	2.28	1.50	0.51
		(1.78)	(2.57)	(2.32)	(5.39)	
Toledo	May 1976–1988/89	0.30	−0.02	1.50	0.74	0.50
		(1.87)	(0.22)	(3.06)	(3.75)	
Corn						
Chicago	1964/65–1975/76	1.48	0.54	4.98	1.41	0.56
		(2.27)	(−1.36)	(2.67)	(4.51)	
	1976/77–1988/89	1.58	0.22	2.25	2.14	0.65
		(3.09)	(1.14)	(1.65)	(5.38)	
Toledo	1976/77–1988/89	0.47	−0.06	1.48	0.64	0.43
		(1.97)	(−0.55)	(2.07)	(3.56)	

Soybeans						
Chicago	1964/65–1978/79	0.19	−0.27	1.53	1.55	0.59
		(2.43)	(−2.20)	(2.62)	(5.63)	
	1979/80–1988/89	1.27	0.02	1.96	1.93	0.54
		(3.28)	(0.10)	(1.78)	(4.35)	
Toledo	1979/80–1988/89	0.06	−0.43	−0.78	0.84	0.48
		(0.39)	(−4.04)	(−1.64)	(3.45)	
Kansas City Wheat						
Total	Sept. 1972–Sept. 1990	0.15	−0.09	0.98	0.17	0.46
		(1.33)	(−1.55)	(1.77)	(2.89)	
Original	Sept. 1972–Sept. 1990	0.05	−0.07	0.54	0.17	0.48
		(0.66)	(−1.81)	(2.65)	(4.20)	
Copper						
Total	March 1976–Dec. 1989	4.65	n.a.	74.41	0.36	0.75
		(1.09)		(3.94)	(10.16)	

Source: Based on data provided by the exchanges, the U.S. Department of Agriculture, or the Commodity Futures Trading Commission. Entries in the table are from least squares regressions of deliveries on the indicated independent variables and a set of intercept shifters for the individual delivery months. Figures in parentheses are t-statistics. Deliveries and stocks are measured in units of one million bushels or pounds, and prices in cents per bushel or per pound, so that the coefficients are roughly comparable across the commodities.

most of period before Toledo became deliverable in 1973.

The results from both the corn and soybean markets before the addition of Toledo as well as the KCBOT wheat and copper markets are similar. The amount of stocks available for delivery is clearly the principal determinant of deliveries, always statistically significant at the 1 percent level. The interest-adjusted futures spread is consistently important as well. In these results, interest costs generally are also important determinants of the amount delivered, presumably because the periods over which the estimates were made had substantial variability in both interest rates and commodity prices. When variable, interest cost clearly affects delivery decisions. Finally, when it is statistically significant, the basis has the expected sign.

As indicated in Table 4.1, the model was also applied separately to deliveries in Chicago and Toledo for the period in which both were deliverable locations.[7] The stocks variable was redefined to include only those in the specific location in the individual regressions and, in the Toledo regressions, the basis is the Toledo basis. The results are in many ways similar to those for the pre-Toledo periods in each market.[8] Stocks in the deliverable location are the consistently most significant factor determining the amount of deliveries, but the economic variables contribute significantly as well. Interest rates are also generally significant explanatory variables, the adjusted spread is usually important, and the basis is less regularly important.

The most interesting aspect of these results, however, is in the clear contrast between Chicago and Toledo deliveries in the amount by which stocks available to be delivered in each location affect deliveries. In wheat, for example, and holding constant for the effects of the other economic variables, an additional million bushels of stocks in Chicago increased Chicago deliveries by 1.50 million bushels, whereas an additional million bushels of wheat in Toledo increased Toledo deliveries by only 0.73 million bushels. The result is consistent in all three markets—increases in stocks in Chicago increase deliveries by more than twice as much as do increases of stocks in Toledo. Because this effect is shared by all three markets, it cannot be caused by the differential discounts applied to delivery in Toledo for the

[7] Data distinguishing the location of deliveries were provided by the CBOT beginning with the May 1976 delivery. Thus, they include the entire period Toledo has been deliverable for corn and soybeans; however, the July 1973 to May 1976 period when Toledo was deliverable for wheat cannot be included in these analyses.

[8] Note that for corn and soybeans in particular the coefficients reported in the table for the Toledo regressions are biased because of the number of instances when deliveries from Toledo were zero. Technically, Tobit estimators should have been used although the ordinary least squares (OLS) estimates can also be adjusted for the bias (see Kmenta, 1986, pp. 561–66, for details). They are reported here because the adjustments do not change the interpretations offered in the text.

three. More likely, it reflects the greater demand for grains and soybeans in Toledo for commercial purposes generally.

The results reported here use all the available data. Separately, estimates were made of the wheat, corn, and soybean relations in the Toledo era up through the 1986/87 cropyear, and then for the last two cropyears 1987/88 and 1988/89. In four of the relations, wheat and soybean deliveries in Chicago and corn deliveries in both Chicago and Toledo, there were no significant changes in the most recent two years. For wheat deliveries in Toledo, in contrast, the overall explanatory power of all the variables increased markedly in the last two years. The relation for soybean deliveries in Toledo likewise shifted in an important way, and here the change amounted to a decided switch in the contributions of specific variables to the explanatory power of the model. In 1987/88–1988/89, stocks of soybeans in Toledo did not influence the amount of soybeans delivered there; only the basis was a significant determinant of deliveries in this period. This finding stands in marked contrast to the other results reported here and the only instance when stocks were unimportant. The evidence confirms there was some change in soybean delivery patterns in these two years.

TIMING OF DELIVERIES DURING THE DELIVERY MONTH

The CBOT futures contracts also give the deliverer substantial choice in the flexibility of the day of delivery within the delivery month. Hoffman's account (1932, p. 27) of the evolution of futures trading in the mid-nineteenth century indicates the one month period emerged as the standard for grain futures contracts very early; it was well-established by 1864 and became regular practice during the next four years. The patterns in soybean deliveries in May 1986 and later that same year in September 1986, shown in Figure 4.1, demonstrate the timing option is exercised. Deliveries in May 1986 were a comparatively large 16.9 million bushels, and some 30 percent of them occurred on the first business day of the month. By contrast, deliveries in September 1986 were only 0.5 million bushels, and the first delivery did not occur until the fourteenth business day in the month, just two days before the close of trading in the September contract.

The delivery patterns evident in Figure 4.1 suggest that both the day deliveries begin and their pace are important in describing the distribution during a particular month. A single number summarizing the possible configuration is provided by the area under a curve describing the complete cumulative distribution. That is, if the cumulative amounts of deliveries on the vertical axis are converted to cumulative proportions of deliveries and the business days recorded on the horizontal axis are converted to cumulative proportions of time in the delivery month, the resulting delivery pattern is the cumulative distribution, sometimes also called a Lorenz

curve.[9] The area under a Lorenz curve is a proportional measure of the complete distribution.

The area is a proportion, since both axes in the diagram have been converted to cumulative proportions, and is called here the timing proportion.[10] Cumulatively, no more than 100 percent of total deliveries can occur in 100 percent of the available days. If all the deliveries occur on the first day, the area under this curve is 1.0 and the timing proportion is 1.0. If no deliveries occur until the very last day, the area under that curve is zero and the timing proportion is 0.0. In the specific cases diagrammed in Figure 4.1, the timing proportion for the September 1986 deliveries is 0.2, a late delivery, whereas that for May 1986 is 0.8, a comparatively early delivery.

The average timing of deliveries for each of the markets is shown in Table 4.2. Perhaps the most striking aspect of these averages is their similarity. Although not indicated by the averages, the timing of deliveries on all these markets ranges widely, from nearly complete delivery in the first few days to virtually no deliveries until the end of the month. In the CBOT markets, this variation in timing affects Chicago and Toledo nearly equally. When Chicago is experiencing early deliveries, so also is Toledo, and conversely. The distributions of the timing proportion over all delivery months are skewed as well, with more early than late delivery situations. The nearly identical averages in Table 4.2 along with the other tests indicate the pattern of daily deliveries in Chicago and Toledo is essentially the same. This close relationship is important, for it means that the frequency of redelivery of the receipts issued in the two cities must also be similar.

The same economic variables that affect the amount of deliveries should also affect the seller's choice as to the timing of deliveries. The costs of delay are the interest and storage costs that the deliverer must continue to pay on stocks being held for delivery. The benefit from delay is the use, if any, to which the stock may be put in the interim. Working has termed this yield the "convenience yield"; it is the fee a firm would require in order to lend stocks to another firm for the month.[11] The yield is reflected in both

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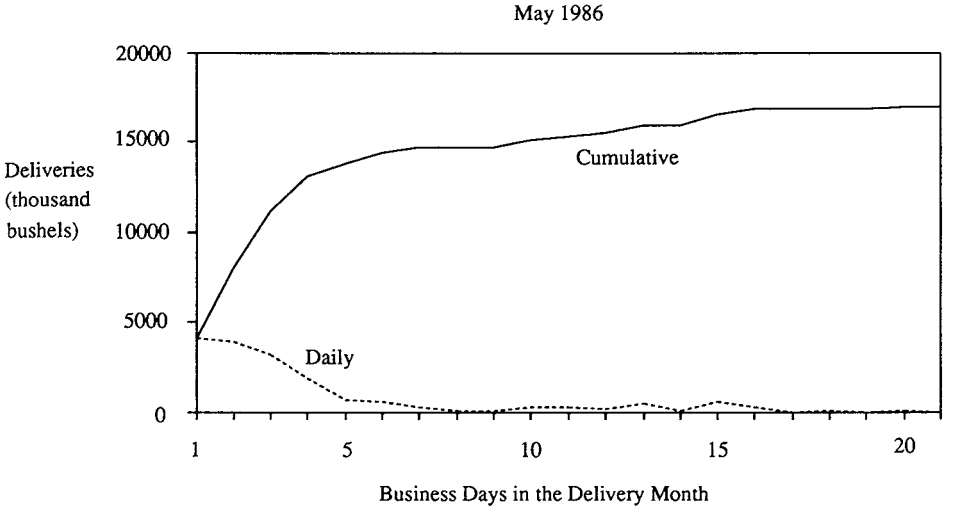
[9] Lorenz curves are widely used in describing income distributions (see Bonnen, 1968).

[10] In terms of various alternative cumulative measures examined, it was most closely correlated with the proportion delivered within the first ten business days in the delivery month.

[11] Working defines the convenience yield and shows its effects in "The Theory of Price of Storage" (1949) and "The Theory of the Inverse Carrying Charge" (1948). In the absence of a positive convenience yield, Boyle shows deliveries will always occur as early as possible because it never pays to delay (1989). Silk develops a formal evaluation of the timing option when the convenience yield is important (1988), showing that the optimal timing of deliveries varies with the amount of the convenience yield.

Figure 4.1–Examples of Different Timing of Soybean Deliveries



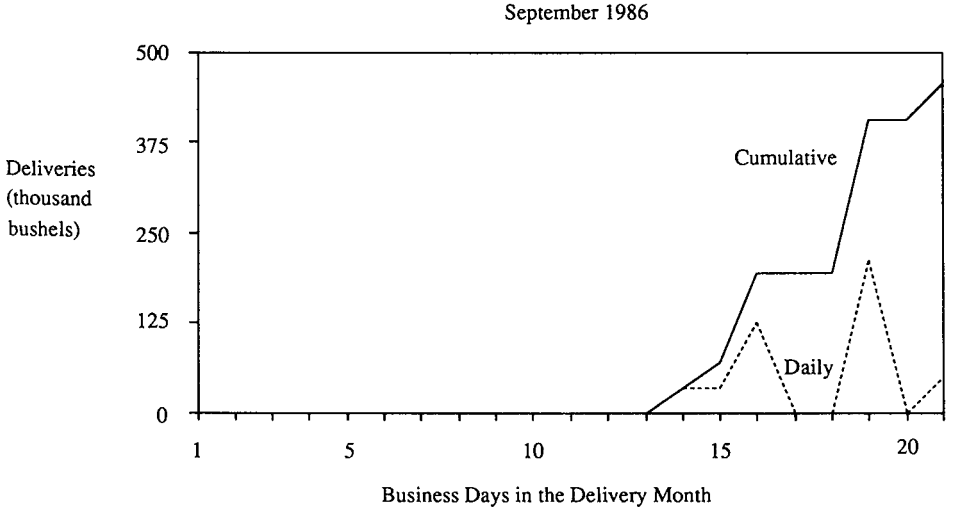


Table 4.2--The Average Timing of Deliveries in the Delivery Month

		Timing proportions		
	Period	Total deliveries	Chicago deliveries	Toledo deliveries
Wheat	May 1976–Sept. 1989	0.69	0.69	0.67
Corn	Dec. 1976–Sept. 1989	0.60	0.60	0.58
Soybeans	Nov. 1979–Sept. 1989	0.66	0.65	0.68
Kansas City wheat	Sept. 1972–Sept. 1990	0.66		
Copper	Mar. 1976–Dec. 1989	0.70		

Source: Based on daily delivery data provided by the Chicago Board of Trade, the Kansas City Board of Trade, and Comex. The timing proportion is the area under the Lorenz curve describing the pattern of cumulative daily deliveries in the delivery month.

the basis and the adjusted nearby spread.

Coefficients from the estimates of the relation between timing of deliveries and the three economic variables appear in Table 4.3. The clear message is that the shorts' decisions as to when to deliver respond to economic variables as expected. Deliveries are earlier the greater is the nearby spread, the lower the cash price premium relative to the futures price, and the higher the interest costs. Estimates of the timing of Toledo and Chicago deliveries separately are not provided; they did not differ especially from the results reported in Table 4.3. Similarly, there were no significant differences between these results and those for just the last two years.

Taken together, the results confirm the importance of the timing option, its wide use, and its value as reflected by the available economic variables. Indeed, these results document the need, as explained earlier in this chapter, for adjustment of the per-month spread. They also foreshadow one of the difficulties in studying basis convergence (as done in the next chapter) since the time of month by which convergence should be expected is so variable.

THE LOCATIONS OF DELIVERIES

Along with timing, the other important option included in the current CBOT contracts is where to deliver. Optional delivery points such as Toledo were added by the exchange as so-called safety valves to prevent futures prices from following an abnormal price in Chicago. With delivery possible elsewhere, the cash price in Chicago could deviate, but because Chicago would not be the delivery location that month, futures

Table 4.3—Economic Determinants of the Timing of Deliveries Within the Delivery Month

	Period	Adjusted nearby futures spread	Basis	cost	R^2
Wheat	May 1976–Sept. 1989	0.09	−0.02	−0.03	0.60
		(6.11)	(−2.35)	(−0.63)	
Corn	May 1976–Sept. 1989	0.18	−0.02	0.02	0.58
		(6.57)	(−1.53)	(0.31)	
Soybeans	May 1976–Sept. 1989	0.04	−0.02	0.04	0.48
		(4.41)	(2.84)	(1.57)	
Kansas City wheat	Total deliveries	0.06	−0.05	0.15	0.66
	Sept. 1972–Sept. 1990	(3.26)	(−4.72)	(3.02)	
Kansas City wheat	Original deliveries	0.08	−0.05	0.22	0.65
	Sept. 1972–Sept. 1990	(3.36)	(−4.49)	(3.52)	
Copper	March 1976–Dec. 1989	0.45	n.a.	−0.73	0.56
		(7.83)		(−2.50)	

Sources: Based on data provided by the exchanges or available in their yearbooks or from the U.S. Department of Agriculture. Entries in the table are the coefficients and R^2's are from logistic regressions where the dependent variable, the timing proportion, is expressed as the log of the ratio of proportions. Regressions also included a set of shifters for the various delivery months. Figures in parentheses are t-statistics.

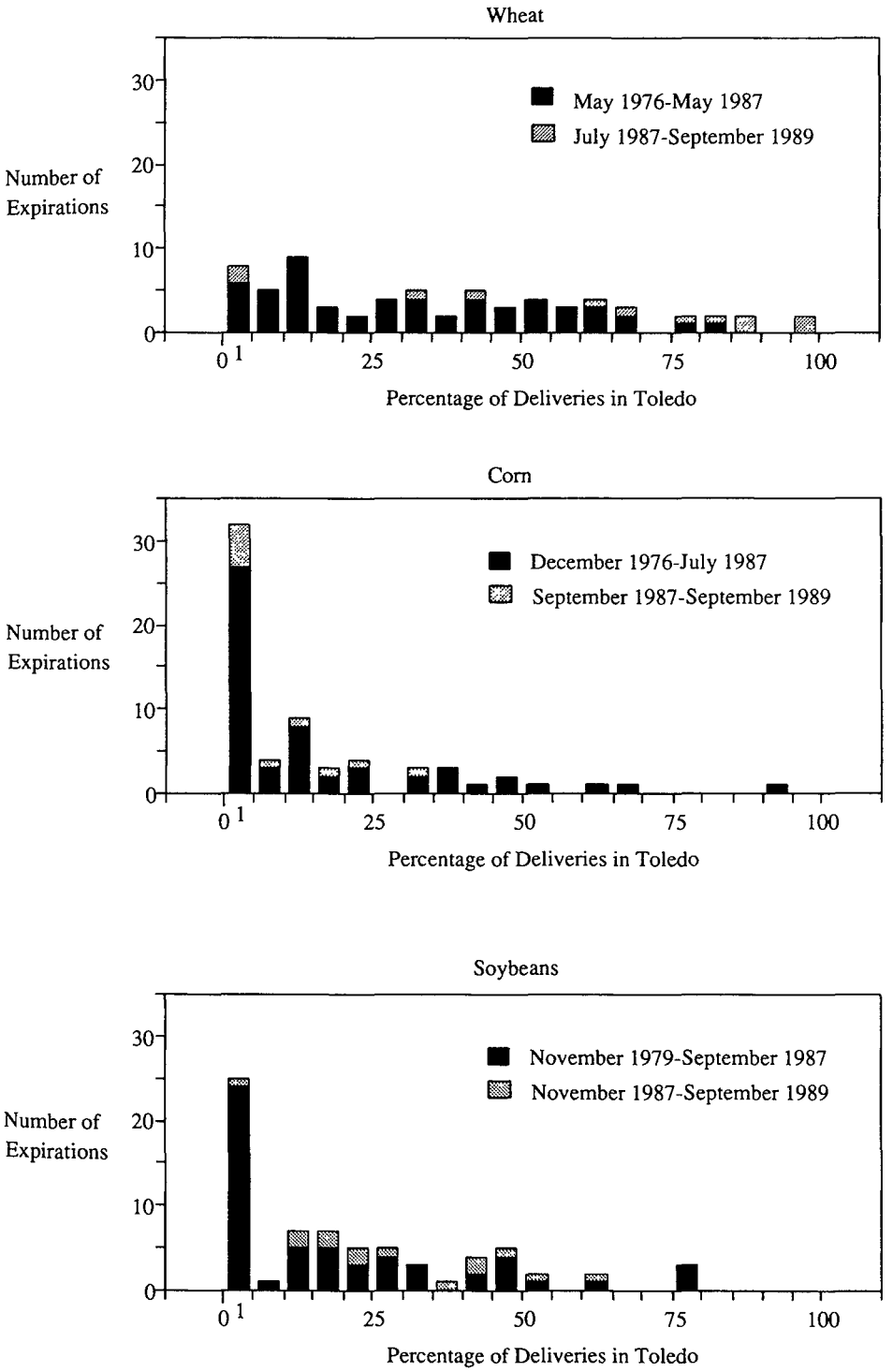
prices would converge to the cash price in the alternate location. It appears that the CBOT intended to set the discounts for Toledo deliveries at the same relative level in all three markets, so that 70–75 percent of the deliveries would continue in Chicago. The principal analyses underlying the choice of specific premiums or discounts were studies of the differences in cash prices between the two locations.[12] Implicit in these studies is the belief that the differences in observed prices between the two locations affect the choice of a delivery location.

A direct evaluation of the effects of the current system of discounts is to examine the distribution of deliveries themselves. In all, the focus is on the role of Toledo as an alternate delivery point. Toledo was added to the wheat contract in July 1973, to the corn contract in December 1976, and to the soybean contract in November 1979. For corn and soybeans, the analysis covers the entire period Toledo has been a deliverable location. For wheat, the first three years of Toledo deliveries are excluded because CBOT data identifying location do not begin until May 1976. The analysis also ignores the role of St. Louis as a delivery location for corn, although it was added with Toledo as an alternative location in the December 1976 contract changes. There have been no deliveries in St. Louis since July 1981. Between December 1976 and July 1981, deliveries in St. Louis were as much as 10 percent of total deliveries on only three occasions, in September of 1977, 1978, and 1979. The maximum amount of a St. Louis delivery was only 4.9 million bushels. Clearly, the present analysis is not unduly affected by excluding these deliveries. Figure 4.2 presents the distributions of the proportions of each month's total deliveries that were in Toledo for each of the three commodities. For example, of the 68 delivery months in wheat from May 1976 through September 1989, eight were months when 5 percent or less of the total deliveries were in Toledo. At the other extreme, deliveries in two months were between 85 and 90 percent in Toledo and in two months between 95 and 100 percent. For corn and soybeans, the distributions are much more skewed. Some 25 of the seventy soybean delivery months from November 1979 through September 1989 were months where less than 5 percent of the total deliveries were in Toledo. In corn, 32 of 65 delivery months occurred with less than 5 percent of the total in Toledo.

Two messages are apparent from the distributions in Figure 4.2. First, the delivery months from the last two cropyears, which are indicated in the figures with the lighter portion of the bars, do not differ substantially from

[12] Similarly, each of the CBOT's *Studies* has a chapter that presents the annual distributions of price differences between Chicago and Toledo. The distributions are examined for consistency, the current discount for Toledo delivery is compared to how frequently differences of more than that amount were observed each year, and then the level of difference that would account for 75 percent of the observation is also calculated.

Figure 4.2—Distributions of the Percentage of Deliveries in Toledo



those from the preceding years. Thus, the analyses of economic determinants of the delivery location include all the data. Second, Toledo has been a source of deliveries much more variably than was apparently intended, by almost any measure of "significant deliveries," if the CBOT was trying to treat each commodity similarly. For example, to conclude that Toledo was a significant source of deliveries only 25 percent of the time in the wheat market, only months in which Toledo deliveries were more than 55 percent of the total could be counted. In corn, the count would include months where Toledo deliveries were more than 25 percent of the total; in soybeans, the cutoff would be 30 percent. Put differently, deliveries of wheat in particular have been much more evenly distributed between Chicago and Toledo, suggesting Toledo is more nearly a multiple delivery location, not a safety valve. By contrast, corn and soybean deliveries were much more concentrated in Chicago, the pattern expected when the second location is a safety valve.

The tests of the responsiveness of deliveries to relative price incentives are summarized in Table 4.4. The proposed explanatory variables are only two, because the purpose is in explaining the amount of deliveries in Toledo relative to those in Chicago, that is, the proportion each delivery month originating in Toledo. Neither the total level of stocks nor the interest cost affect deliveries differentially and so neither is included in these regressions.[13] The principal economic determinants of the location of deliveries should be, first, the difference in price between Chicago and Toledo (called the Chicago cash premium in the table) and second the Toledo basis. Both were computed as of the first of the delivery month using the U.S. Department of Agriculture's series for the two locations.

The first row of results for each commodity attempt to explain the proportion of the total deliveries each month that occurred in Toledo. The overall lack of explanatory power of the difference in price between Chicago and Toledo is striking and is one of the most surprising findings of this study. For none of the commodities was this difference—the Chicago cash premium—related at all to the proportion delivered in Toledo. That is, delivery months with USDA's reported cash prices in Toledo a great deal below those in Chicago were no more associated with relatively large deliveries in Toledo than were ones with Toledo prices close to or even above those in Chicago.

The lack of relation in the statistical results is readily evident in Figures 4.3, 4.4, and 4.5 where the percentage of total deliveries in Toledo each month is plotted against the difference in price between Chicago and Toledo. On each figure, the vertical line indicates the price difference at which Toledo is the cheaper source of the commodity. In Figure 4.3 for wheat, it

[13] Moreover, both stocks and interest costs were included in preliminary analyses of the location decision, but they were never significant.

Table 4.4—Economic Determinants of the Location of Deliveries

Dependent variable	Toledo basis	Chicago cash price premium	R^2
Wheat: May 1976–September 1989			
Proportion of total delivery in Toledo	−0.07 (−2.24)	−0.01 (−0.29)	0.09
Proportion of first day delivery in Toledo	−0.17 (−3.57)	−0.08 (−1.19)	0.22
Corn: December 1976–September 1989			
Proportion of total delivery in Toledo	−0.27 (2.45)	0.09 (0.64)	0.20
Proportion of first day delivery in Toledo	−0.33 (−3.78)	−0.05 (−0.48)	0.27
Soybeans: November 1979–September 1989			
Proportion of total delivery in Toledo	−0.19 (−2.83)	−0.08 (−0.75)	0.16
Proportion of first day delivery in Toledo	−0.22 (−4.36)	−0.10 (−1.35)	0.35

Source: Based on data provided by the Chicago Board of Trade or available in their *Statistical Annual*, or in the U.S. Department of Agriculture's weekly, *Grain Market News*. Coefficients and R^2's are from logistic regressions where the dependent variable, the proportion of deliveries in Toledo in a specific month, is expressed as the log of the ration of proportions. Regressions also include a set of shifter variables for the individual delivery months. Figures in parentheses are t-statistics.

is at a Chicago cash price premium of 2 cents per bushel. If location were the only option in the contract, all points to the right of the vertical line are points where the premium of the cash price in Chicago is more than 2 cents above the price in Toledo, Toledo would be the cheaper source of supplies for delivery, and the observed deliveries should all be along the top of the figure showing that 100 percent of them were in Toledo. Similarly, all points to the left of the vertical line are cash premiums less than 2 cents, Chicago would be the cheaper source of supply, and all deliveries should be from Chicago. All observations should be along the bottom of the figure, showing 0 percent delivered in Toledo. In Figure 4.4 for the corn market, the vertical line is at 4 cents and in Figure 4.5 for soybeans it is at 8 cents. As is evident, in each figure, there is no association between

Figure 4.3—The Relation Between the Location of Deliveries of Wheat and Relative Cash Prices, May 1976–September 1989

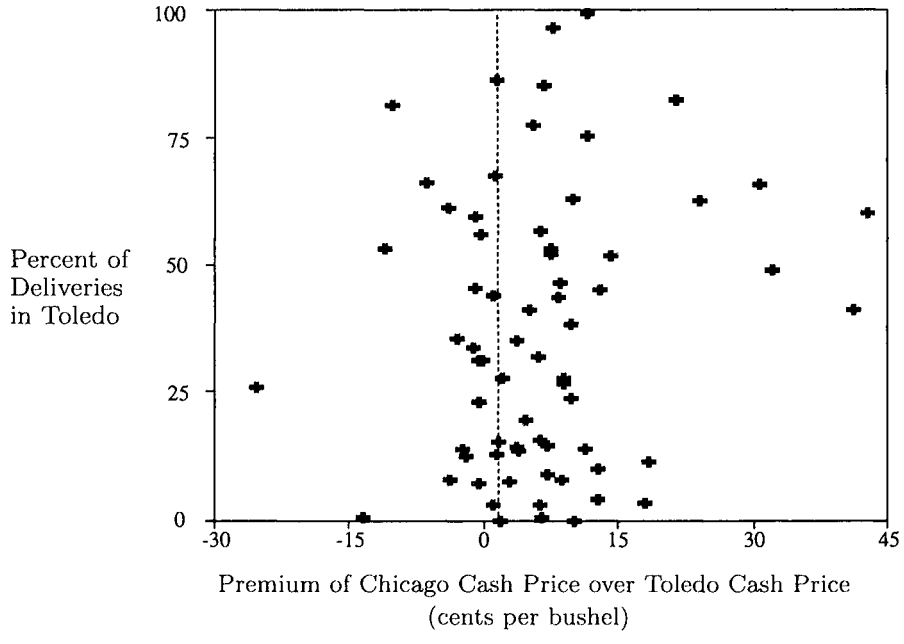


Figure 4.4—The Relation Between the Location of Deliveries of Corn and Relative Cash Prices, December 1976–September 1989

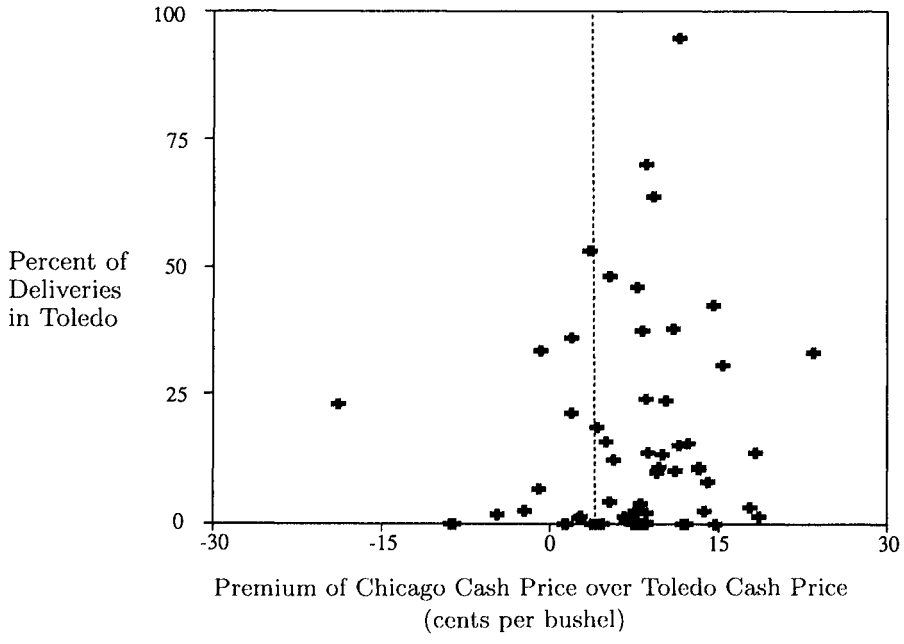
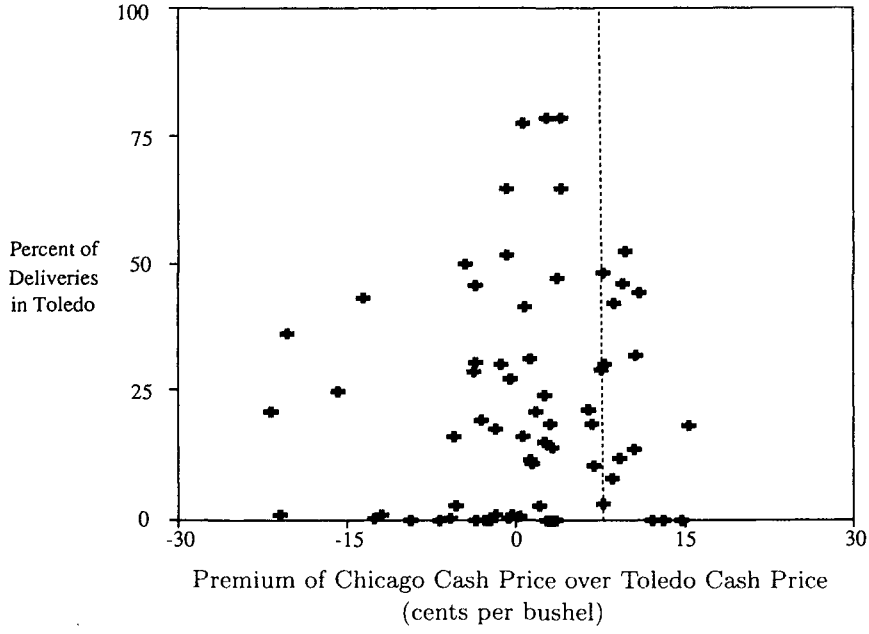


Figure 4.5—The Relation Between the Location of Deliveries of Soybeans and Relative Cash Prices, November 1979–September 1989



the price differences and the observed delivery percentages each month, the visual confirmation of the statistical results in Table 4.4.[14]

Although no similar formal tests were attempted, the CBOT's *Studies* also presented data clearly showing the lack of relation between price differences and deliveries. In the 1986/87 cropyear in soybeans, for example, the CBOT *Soybean Study* noted that the USDA soybean prices in Toledo were no more than 7 cents below those in Chicago 95 percent of the cropyear. Separately, it reported that Toledo accounted for some 46 percent of the deliveries in the September 1986 contract, some 64 percent in November, and more than 75 percent in each of the January, March, and May contracts. These are surely not percentages consistent with the price differences indicating Chicago was nearly continuously the cheaper location at which to deliver.

Because the results in Table 4.4 and Figures 4.3–5 were so unexpected,

[14] Moreover, the estimates of Table 4.4 are from logistic regressions, an approach chosen specifically to accommodate the expected shape of the relation.

a large number of variations on the model and data were explored. In particular, concern centered on whether the prices reported by the USDA were representative of values in Chicago and Toledo. Thus, a number of alternative representations of value were assembled, compared to the USDA series and then included as possible reflections of economic determinants of the location of deliveries. Among the alternate representations of value in Chicago were U.S. Gulf export values (where the cost of barge freight from Chicago to the Gulf was subtracted from the price of the barge commodity in the Gulf), and for corn, the series of the highest bid prices in Chicago, as published in the *New York Times*. The Andersons in Toledo provided a long series of their weekly basis bids for soybeans. None of these alternative measures of prices proved to be associated with the location of deliveries each month.

With relative cash prices apparently unimportant in the location of deliveries, it is further surprising that the Toledo basis explains to even a small degree the location of deliveries, as indicated by its consistent sign and statistical significance in Table 4.4. This result is not strong, but it does suggest that deliveries are not totally unresponsive to relative prices—here, the difference in price between the expiring future and the cash price in Toledo.

Of course, the location option is not the only option the terms of the contracts give to the seller. As has been seen, the timing option is very important as well, both in theory and in fact.[15] To examine the extent to which the simultaneity caused by the two options was effecting the results because the delivery proportion was measured over the entire month, the delivery proportion was redefined to be just the proportion of the deliveries on the first day that were delivered in Toledo. The explanatory variables were already prices as of the first day and thus required no change. The results of these regressions are in the second row in Table 4.4 for each commodity, and there is an improvement in the explanatory power of the model. For each, the Toledo basis increases in importance as a factor in explaining the location and, in both wheat and soybeans, the cash price differential between Chicago and Toledo also increases in importance.

Thus, some part of the explanation for the observed lack of relation between the location of deliveries and the cash price differential is the interaction of the location and timing options.[16] This is surely not the entire explanation, however, as no result in Table 4.4 shows that more than one-third of the observed variation in the location of deliveries is explained. As for additional factors explaining the lack of relation, the evidence at hand

[15] It is precisely this joint valuation problem that both Boyle (1989) and Silk (1988) solved.

[16] Additional analyses also explored whether any of the other price series improved the explanation of first-day deliveries. None was noted.

is less clear. Other analyses clearly indicated the delivery decisions were rational in both their amount and their timing. Thus, other factors besides price must be significant determinants of the location decision. Whether the paucity of available stocks from which to make deliveries and thereby change the price difference observed in the markets to that dictated by the economic model is one of those determinants is beyond the scope of these analyses.

CONCLUSION

Taken together, these analyses indicate that the reported price differences between Chicago and Toledo are not associated with the location of deliveries as well as expected. This finding stands in contrast to the behavior of the level and timing of deliveries, which are sensitive to observable prices. Prices presumably do matter to the location of deliveries, and some hint of their relation was noted when only first-day deliveries were analyzed. Even so, the results suggest how futile it is to examine the price differences themselves to determine whether 2 cents, 4 cents, or even 8 cents is the discount that will lead to a specific desired distribution of deliveries. There appears to be some information in the delivery patterns themselves, but the reported prices provide little guide to the appropriate level of discounts. The distributions, shown in Figure 4.2, indicate Toledo deliveries have been much more regular in wheat than in corn and soybeans. Thus, the wheat contract has operated much more nearly as a multiple-delivery-location contract, whereas the corn and soybean contracts have remained effectively Chicago deliveries with safety-valve deliveries in Toledo.