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Safety First, Short Hedging and the Commodity Credit Corporation*

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Introduction

The purpose of this paper is to explore one possible area of inquiry into the effects of government price support operations for storable agricultural commodities such as cotton and wheat. This area has to do with the intra-year holding and use of these commodities. In the first part of the paper, evidence is presented which suggests that CCC operations have in fact significantly affected both seasonal price movements and the quantity of short hedging. In the second part of the paper, the outline of a theory of short hedging is presented which rationalizes this evidence and which aims at providing a meaningful framework within which effects of government programs might be further analyzed. In the third part, additional work which seems indicated by these results is suggested.

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* I wish to acknowledge the many helpful suggestions made by George Tolley. In addition, I have benefitted from discussions with T. W. Schultz and D. Gale Johnson. They are not responsible for the opinions in this paper.

Section 1. Some Empirical Evidence

How would prices move during a crop year in the absence of the CCC? If the final demand for the commodity is expected to remain unchanged during the crop year then we would expect prices to rise through the crop year to cover storage costs. If this did not occur then all of the consumption would occur at once at the beginning of the crop year because no one would be willing to hold stocks. However, if the demand curve shifted during the crop year or if the expectations of farmers or merchants changed, this simple price movement would not occur.

Some interesting facts emerge when we consider the prices received by farmers during years of large CCC stocks compared with years of little or no CCC stocks. In the following table we computed the deviations of monthly prices received by farmers from the average price received by farmers for the entire crop year.*

TABLE 1.

Cotton: Deviations of Monthly Average Prices from Crop Year Average Price Received by Farmers (cents per pound)

	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July
1920-29	1.72	1.70	1.01	-.12	-.58	-.48	-.53	-.63	-.59	-.54	-.39	-.53
1933-44 1948-49	-.31	-.11	-.28	-.47	-.48	-.32	-.15	.32	.15	.22	.38	1.03

The first row of Table 1 covers a period of no CCC loans. The second row of Table 1 covers the years 1933-44 and 1948-49 when CCC stocks of cotton were very high. We note that there seems to be no consistent pattern of price deviations in the period of no government operations. However, in the second period the price movement is close to what we would expect in the idealized

* Let $p_i(t)$ = price received by farmers in the i^{th} month of the t^{th} crop year. Let $\bar{p}.(t) = \frac{1}{12} \sum_{i=1}^{12} p_i(t)$ so that $\bar{p}.(t)$ is equal [i=1,...,12,

(continued on page 3)

case discussed at the outset. It is clear that the movement of prices in the two periods are different. The increase in prices from their seasonal low in December to their level in June is .86 cents per pound. If we take storage costs to be.37 cents per bale per month, then the storage cost per pound is .074 cents per month. For a seven month period this comes to .518 cents. If we take the interest rate to be 4 per cent per year and the price of cotton to be roughly 30 cents per pound then interest charges are approximately .6 of a cent. Hence the total carrying cost is roughly 1.1 cents per pound as compared with an increase in the price of .9 cents per pound.

Table 2 is obtained by ranking the deviations in the two periods from 1 to 12, giving the biggest deviation the lowest rank.

TABLE 2.

Cotton: Ranked Deviations

	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July
1920-29	1	2	3	4	10	6	7	2	11	9	5	8
1933-44 1948-49	9	6	8	12	11	10	7	3	5	4	2	1

If there were perfect correlation between seasonal movements in the two periods then each month would have the same rank in the two periods. It can be seen that they are quite different.

A similar computation was done for wheat prices received by farmers and is shown in Table 3.

$t = 1, \ldots, T]$ to the average price received by farmers in the t^{th} crop year. Then $p_i(t) - \bar{p}.(t)$ is the deviation of the price of the commodity in the i^{th} month of the t^{th} year from the average price in the t^{th} year. We have computed the following:

$$\frac{1}{T}\sum_{t=1}^{T} [p_i(t) - \bar{p}.(t)] = \text{deviations of monthly average prices}$$

from crop year average prices.

TABLE 3

Wheat: Deviations of Monthly Average Prices from Crop Year Average Price Received by Farmers (cents per bushel).

	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
1920-29	7.25	3.93	-1.77	1.09	-1.95	-1.50	2.01	3.83	2.22	-2.15	-1.00	-11.99
1930-38	.92	.52	-.19	-1.38	-1.45	-.87	1.42	1.23	-.50	-.83	1.06	-2.03
1939-43 1948-51	-9.84	-11.18	-5.73	-5.06	-1.73	3.38	4.38	5.27	6.38	7.27	6.27	.49

The difference in the size of deviations seems to be related to the magnitude of average prices during the years covered. There were no government support operations or loan rates for wheat in the two periods 1920-29 and 1930-38. In both periods there does not appear to be any regularity in the seasonal movement. However in the period 1939-1943 and 1948-1951 there were large CCC stocks. In those years the seasonal movement is quite striking and remarkably similar to what we observed for cotton. The rise in price from August to April, an eight month period, is approximately 18 cents. Taking storage costs to be one cent per month we estimate 8 cents to cover this cost. An interest rate of 4 percent per year would bring interest charges to 6 cents per bushel, assuming a wheat price of $2.00 per bushel. Hence total carrying cost comes to 14 cents per bushel compared to the steady price increase of 18 cents per bushel.

If we rank the data as in cotton we find no apparent relationship between the heavy-loan periods and no-loan periods. There seems to be a closer relationship between the two periods of no CCC stocks. It must be admitted, however, that the agreement is the seasonal movements of price between the period 1930-38 and 1920-29 is not so high as to establish such a conclusion definitely.

When we add to these figures the fact that price movements are much less variable in the years of large CCC stocks than they are in years of small CCC stocks we come to the conclusion that the seasonal pattern observed for the CCC stocks-period is even more significant. Prices do not move very far from their support levels when CCC stocks are high, whereas in periods of high prices and no CCC stocks, prices fluctuate a great deal from month to month.

Thus, CCC operations have altered and established a definite seasonal movement of prices. This seasonal movement is close to what we would expect when the final demand is stable and prices rise during the year just enough to cover carrying costs.

We may now consider a second question: Has the quantity of short hedging been affected by CCC operations? Two regressions were computed for cotton using monthly data covering a period from August 1946 to July 1952, a total of 68 observations.*

Let x_t = basic index in the t^{th} month. Here we use the absolute value of the basis so that the logarithm might be taken.**

v_t = CCC stocks in the t^{th} month. This includes both CCC loans and CCC inventories and is measured in thousands of bales.

z_t = Free market stocks in thousands of bales.

g_t = cash price of middling 15/16 cotton at Houston divided by the CCC loan rate for 15/16 middling cotton.

y_t = total short hedging commitments in the t^{th} month.

m_t = mill stocks in the t^{th} month.

s_t = total stocks in the t^{th} month.

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* Data for some months weren't available.

** The reason for using the basis as a variable and its definition is presented in section 2. For the details involved in constructing this index see H. S. Houthakker, L. G. Telser Commodity Futures III: Some Empirical Results of Hedgers' Behavior, Cowles Commission Discussion Paper, Economics 2091, December 15, 1953.

We first note that we have an identity

1) $s_t = m_t + v_t + z_t$

In estimating free market stocks this identity was used. The free market stocks are not quite the correct variable because no distinction is made between the stocks owned by farmers and the stocks owned by merchants. However, figures giving this breakdown are not available so we use what we have.

The first regression estimated relates the total short hedging commitments and the basis.

2) $$\log y_t = (-.231 \pm .037) \log x_t + (.521 \pm .250) \log g_t$$
$$+ (.804 \pm .059) \log y_{t-1} + .511$$
$$R^2 = .9064 \text{ and } R = .9520$$

The second term in the brackets is the standard error of the estimate of the coefficient which is the first term in the bracket. For each 1 percent increase in the basis there is a decrease of .231 percent in short hedging. Further for each increase of 1 percent in the ratio of the market price to the support price there is an increase of short hedging of .52 percent.

The second regression we present for consideration relates stocks and the basis.

3) $$\log x_t = (-.047 \pm .038) \log v_{t-1} + (-.158 \pm .088) \log z_{t-1}$$
$$+ (.860 \pm .136) \log x_{t-1} + (-.359 \pm .115) \log x_{t-2} + .844.$$
$$R^2 = .6356 \text{ and } R = .797$$

In this regression we observe that the basis varies inversely with CCC stocks and free market stocks.

We shall later introduce the first regression as part of a theory of short hedging. The second regression is presented to establish a relation between free market stocks and spreads.

It would also be important to have a relationship between the level of CCC stocks and loans and the cash-support price ratio. We would like to be able to predict how much the loans to the CCC will increase when the cash price approaches the support level. We regard the position of the variable g_t in the first regression as unsatisfactory but still interesting and useful.

Since both of these regressions are logarithmic, the percentage change in the dependent variable following a given percentage change in the independent variable, is given by the coefficient of the independent variable.

If CCC stocks increase by 1 percent then the basis will decrease by .047 percent and short hedging will increase by .0104 percent. This apparently means that increases in CCC loans will not result in a decrease in short hedging. However, because of identity (1) an increase in CCC stocks will be accompanied by an equal decrease in free market stocks, the smaller will be the percentage decrease in free market stocks and the smaller the initial level of CCC stocks the greater will be the percentage increase in the CCC stocks.

When will the two effects of the increase in CCC stocks and decrease in free market stocks cancel out so as to have no net effect on short hedging? The two effects will cancel out when

$$-.047 \times \text{percentage increase in CCC stocks} =$$
$$.158 \times \text{percentage decrease in free market stocks.}$$

$$\frac{-.047}{15.8} = -26.1 \text{ percent.}$$

Therefore whenever free market stocks decrease by more than 26.1 percent for each increase in CCC stocks of 1 percent we would expect the effect via the free market stocks on short hedging to outweigh the effects of the direct increase in free market stocks.

In addition we note that presumably the increase in CCC stocks was associated with a fall in the cash price relative to the support level. Hence g_t would be expected to decrease. For each decrease in g_t of 1 percent short hedging will decrease by .521 percent. If we knew by how much g_t changes for each change in CCC stocks of 1 percent we could arrive at a closer estimate of the net effect on short hedging.

Taken in all the evidence seems to be that when prices approach their support level and CCC stocks are very high then the basis will tend to increase and short hedging will tend to decrease.

Section 2. Suggested Theory

In this section the outline of a theory of short hedging is presented together with some remarks on the effect of CCC operations on the holding of stocks and short hedging.

In some economic problems the existence of uncertainty plays a major role in determining the behavior of individuals. One such case arises when we consider the problems a firm faces in holding stocks. The entrepreneur would like to buy stocks when he thinks prices will rise and then sell the stocks when he thinks prices have reached their peak. However, he doesn't know what prices will be, therefore he has to try to do the best he can in the face of ignorance regarding the future.

There is one group of entrepreneurs in the economy for whom this type of problem is particularly important, namely merchants of storable agricultural commodities. The cotton merchant and the owner of a grain elevator will buy, store, and later sell the commodities in which they deal. Since production of cotton, corn, and wheat tends to occur discontinuously while consumption takes place at a fairly steady rate throughout the year, these entrepreneurs perform the service of holding the crops through the year and selling to the final consumers during the year. In addition the producers of these commodities can store them on their own farms or they can sell them to the elevator owners.

What sort of assumptions shall we make about the behavior of these groups of entrepreneurs acting under uncertainty. A. D. Roy* has suggested that in many important cases a "safety first" rule of behavior seems a plausible one. This means in the above context that an entrepreneur considers all possible actions that he could take on the basis of what he expects prices to be. However because he doesn't how what prices will be, he attaches to each estimate of prices a second quantity, the variance of his estimate. Speaking roughly, with each expected price he associates a range in which he thinks it is likely that the real price will lie. With each possible action he computes his expected net revenue. However, he would not like his actual net revenue to fall below a certain predetermined amount because if it did then he might face bankruptcy or other less unpleasant but still undesirable consequences. Since he cannot guarantee that his net income will always be greater than this minimal amount he tries, instead, to insure that his actual income will always exceed this minimal income with a probability close to one. Hence he rejects all those courses of action which could lead to an actual income less than this minimal income with an uncomfortably high probability. Out of all of the admissible actions remaining he then chooses the one which will maximize his expected net income. In estimating the probability of a particular outcome the Tchebycheff inequality is very useful.

Let Y be the income which the entrepreneur actually receives. He would like to buy, sell and store the commodity in such a way as to make Y as large as possible. However Y is a random variable. Let us denote the expected value for Y by EY and let R be the "disaster" level of income. From the Tchebycheff inequality we have

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* Roy, A. D., "Safety First and the Holding of Assets", Econometrica, July, 1952, 20: 431-449.

$$P_r\,[\,|Y - EY| \geqq EY - R\,] \leqq \frac{Var\ Y}{(EY-R)^2}$$

$$\therefore\ P_r\,[EY - Y \geqq EY - R] = P_r\,[Y \leqq R] \leqq \frac{Var\ Y}{[EY-R]^2}$$

Let α = Probability that the actual income falls below R. Then the entrepreneur will never choose an action which permits Y to fall below R with a probability greater than α. This corresponds to maximizing expected income subject to the restraint

$$\frac{Var\ Y}{[EY-R]^2} \leqq \alpha\,.$$

Having assumed this sort of behavior for each entrepreneur we would like to derive the supply curves for the producers of the commodity and the supply and demand curves for the merchants. We assume that the farmers have harvested their crops and are holding it on their farms while they consider how best to sell it, i.e. when and how much to sell of their harvest at each point in time. The greater the current price the more each producer will want to sell this month. That is, the supply curve of the farmers in a particular month will have the usual upward slope. For present purposes it doesn't matter too much how we obtained the aggregate farmers' supply curve.*

For the merchants, matters become interesting. We assume that each merchant knows how much he is willing to buy for each expected price that he thinks will exist t months hence. The effect of uncertainty regarding each merchant's estimates of prices to be can be looked at in two ways. First, if the merchant expected prices to rise then the effect of his uncertainty regarding this rise would result in a decrease in the total quantity that he would

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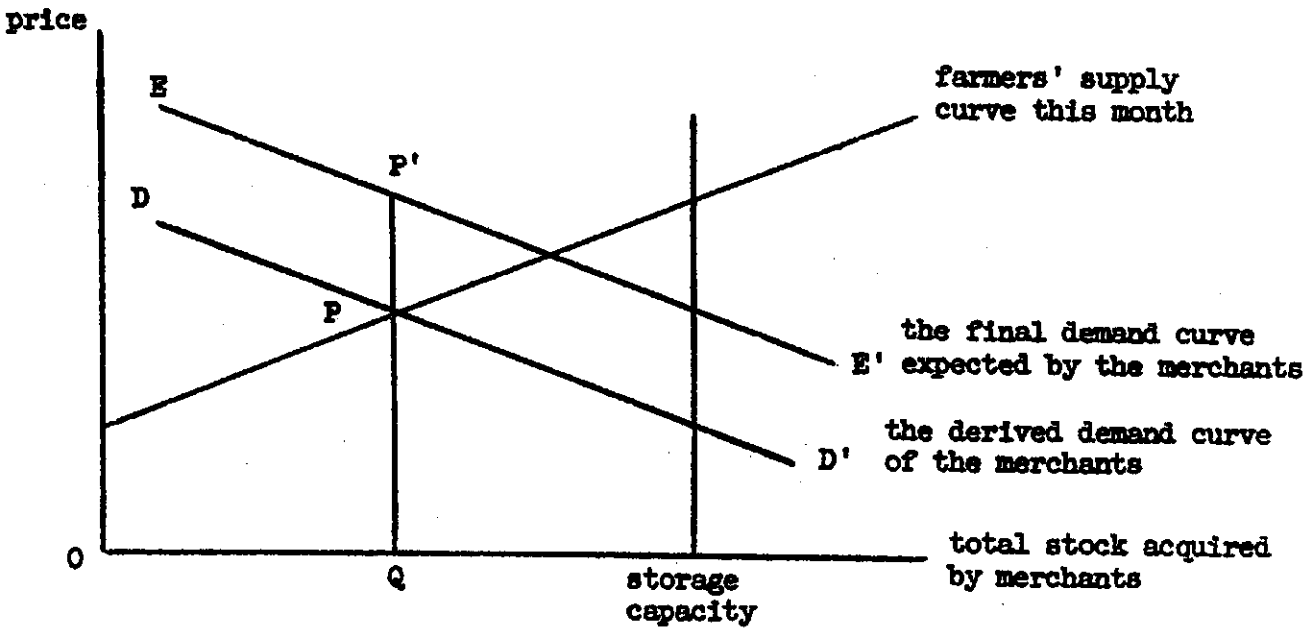
* In a more detailed study an attempt to estimate this supply curve is planned.

buy. That is, the more certain he would be of a rise in prices the more he would be willing to buy for any given expected rise.

The second way of considering the effect of uncertainty on the merchants behavior is from the point of view of prices. If each merchant expects the price later on to be a particular amount then the probability that the actual price will not fall below a certain level, will depend on the variance he attaches to his estimate of the future price. Hence to be sure that he will make a profit with a probability greater than his safety first plan required, he will offer the farmers the expected price less a certain amount which will depend on his safety first plan. Hence the price received by farmers will be the expected final price less a risk allowance.

How can we derive the demand for the commodity by all the merchants? That is, how can we obtain the aggregate demand of the merchants? We could conceivably ask each merchant the following questions: If the current price were so much,what is the maximum quantity you are willing to buy? We imagine the merchant to look at his expected price and answer our question. We then ask him what he expects prices to be. For each current price we can then obtain what the merchant expects the price to be in the future and how much he is willing to buy. We can then find two points. The first point is the point on the aggregate demand curve of the merchants. Secondly, we can average together all of the expected prices and we can determine a point on the merchants' expected final demand curve. This point on the expected final demand curve will have the same quantity ordinate as on the merchants' demand curve, but it will have a higher price ordinate attached to it because of the risk factor. We maintain that we can derive a well defined and useful expected final demand curve in this manner. Hence it will make sense to talk about a change in expectations and a change in uncertainty. This is illustrated in figure 1. The merchants' demand will be truncated by available storage capacity.



QP' = expected price for quantity OQ
QP = price offered by merchants
PP' = "safety first" discount

Figure 1.

This is one part of our story. An immediate question arises. Why don't the farmers sell directly to the final consumers and eliminate the safety first discount? One possible answer is that the merchants make a better estimate of the final demand than the farmers and therefore it is cheaper for the farmers to "forego" PP' than to run the greater risks attendant to estimating the final demand to one whose primary business is producing the crop.

The merchant has the alternative open to him of hedging his stocks. He does this by selling a quantity of futures equal to the quantity that he has purchased from the farmer. He doesn't always hedge his entire purchase from the farmer but he can always hedge part of it. When he wants to sell his stock he simply finds a final consumer, sells him the stock, and simultaneously buys in the futures contracts that he had outstanding. Let $F(0)$ denote the initial futures price at the time that the hedge is made and let $F(1)$ denote the futures price at the time that the hedge was lifted. Let $P(0)$ and $P(1)$ denote the price the merchants paid the farmers for the stock originally and let $P(1)$ denote the price for which the merchant sold the stock to the final consumer. We shall suppose that marginal storage costs have been deducted from the futures price so that $F(t) - P(t) \leqq 0$.* At the time the hedge is made the net revenue per unit of the commodity is $F(0) - P(0)$. At the time the hedge is lifted the net revenue will be $P(1) - F(1)$. Hence the net revenue from holding one unit of hedged stock will be $F(0) - P(0) + P(1) - F(1) = [F(0) - P(0)] - [F(1) - P(1)]$. The quantity $F(t) - P(t)$ is called the basis and we shall denote it by $B(t) = F(t) - P(t) \leq 0$. Hence in order to make a profit from a hedge it would be necessary that

$$B(0) - B(1) > 0 \quad \text{or} \quad B(0) > B(1)$$

In other words the absolute value of the basis should be greater when the hedge is lifted than when it was put on. We can regard $B(0)$ as the "cost" of a hedge where $B(0) \leqq 0$. The lower the cost of the hedge in absolute value the greater is the incentive to hedge. Hence we deduce a relationship between the quantity of short hedging and the basis.

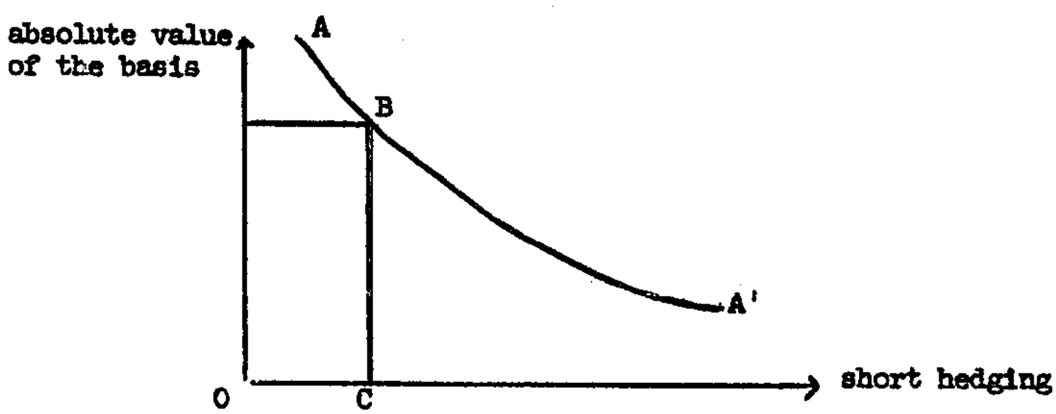


Figure 2.

* The reason we assume that $F(t) - P(t) \leqq 0$ after subtracting carrying costs from the futures price is as follows: Suppose that $F(t) - P(t) \geqq 0$.

(cont'd. on page 14)

In Figure 2, when the basis is CB then OC will be hedged. A fall in the basis will increase short hedging (cet. paribus). This corresponds to our first regression in section 1.

Since the merchant expects the price at which he will sell the stock to be greater than the price he paid for it, why should he hedge his stocks at all? The merchant has only a limited capital and credit resources. The more stock he buys at a given time, the greater is the possible loss he would sustain for a given fall in cash prices. That is, when he buys a large stock he ties up a large amount of capital in one venture and a fall in prices could result in quite a shrinkage of his assets.

When we apply the safety first rule to merchants' behavior, we will find that each merchant will determine the quantity of stocks that he will hold hedged and the quantity that he will hold unhedged so as to maximize his expected income subject to the risk constraint.

Let H_i = quantity of hedged stocks held by the i^{th} merchant

S_i = quantity of unhedged stocks held by the i^{th} merchant.

Then for each merchant we can derive two functions,

$$H_i = H_i\ (B,P)$$

$$S_i = S_i\ (B,P)$$

which will depend on the expected spot price P, and the expected basis B as well as the risk factors.

We can aggregate these functions over all the merchants to obtain the

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Then by buying the commodity from the farmer and selling an equivalent quantity of futures the merchant could assure himself of a profit simply by holding the stocks to the maturity date of the futures and then delivering them on the futures contract. If a sufficient amount of competition exists in the market this sort of arbitrage should result in the elimination of the excess of futures over the spot price.

merchants' demand curves for total stocks, hedged stocks and unhedged stocks.

$$H = H(B,P)$$
$$S = S(B,P)$$
$$H = \sum_i H_i \quad \text{and} \quad S = \sum_i S_i$$

For any given futures price and farmers' supply curve we can determine the spot price, the basis, the total stocks purchased and the total short hedges made.*

The factors held constant in determining the equilibrium would be expectations concerning the spot price, expectations concerning the basis, the variance of these quantities and the risk allowance.**

It should be noted that a merchant retains greater flexibility when he hedges some part of his stocks because if an opportunity should arise subsequent to the date at which the hedge was made to profit from a rise in the futures price he can do so. However, the extent of his loss on a hedge is limited by the initial basis.

We have not applied this theory to long hedging as yet. In a long hedge a merchant makes a forward sale of a particular quality of the commodity to a final consumer to be delivered at a specific time and place. However, the merchant has not yet purchased this stock so he buys futures contracts equal in quantity to his forward sale. We would expect that safety-first considerations would play an important role in determining the quantity of long hedging. Further work to investigate long hedging is planned.

Suppose we introduce the Commodity Credit Corporation and see how their policies modify the conclusions. At this stage we shall abstract from the details regarding the CCC loan program and simply suppose that each farmer can either sell the commodity to the merchant or he can lend it to the CCC.

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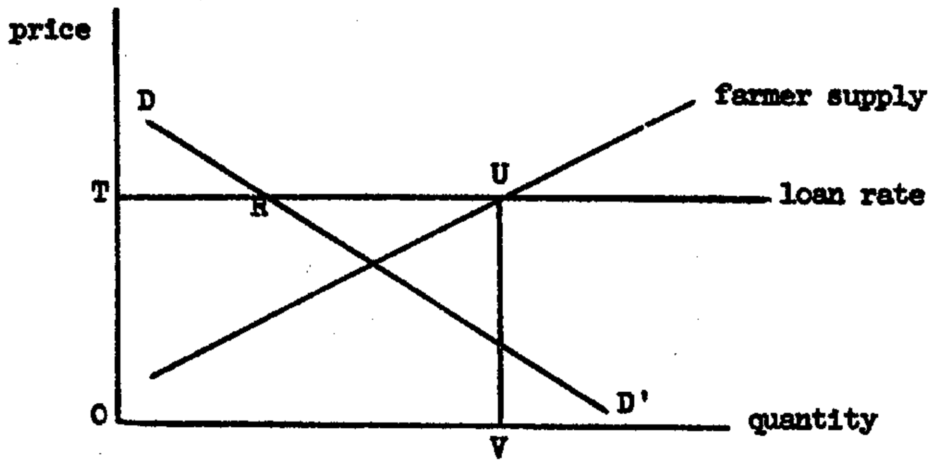
* We do not propose to examine the determination of the futures price.

** We are deriving behavior equations for a given merchant on the basis of safety first. It is hoped that these results will appear later.

Hence on the supply side we have the following picture:



We see that OT is the loan rate. No one would be willing to sell his crop for less than the support price which is OT. As long as the merchants' demand curve intersects the farmers' supply curve to the right of the point U, the price received by farmers would be greater than the loan rate and we would expect the analysis of the preceding section to apply after allowing for the effects on the schedules of the existence of the CCC. Suppose now that the merchants' demand curve intersects the farmers' supply curve to the left of the point U so that the price received by farmers is equal to the loan rate. We would like to know how much of the stock will go into the loan and how much will be sold to the merchants. At the loan rate the maximum amount the farmers will be willing to sell is TU. But at a price of OT the maximum amount the merchants will be willing to buy is TR. Hence the difference RU will go into the loan. Since the quantity purchased by the merchants is less than it would otherwise be we find that the amount of hedged stocks will be less and the basis will be higher in absolute value. The CCC will now be holding a portion of the stocks that would otherwise have been held by the merchants. The decrease in farm stocks will tend to be greater than it would have been had the free market price been equal to the loan rate.

Since our diagrams are drawn on the assumption of a fixed stock held initially by the farmers, this stock being released in a given month at the rate shown by the farmers' supply curve, the effect of the CCC loan program is to diminish the free market stocks held by the farmers and merchants in each month. Prices are higher than would be required to clear the market.

The existence of the Commodity Credit Corporation would have other effects on the model described. We have observed from the monthly movements of prices of commodities supported by the CCC a marked difference in the variability of prices in years of large CCC loans as compared with years of little or no CCC loans and inventories. Prices are much less variable in heavy-loan-years than in no-loan years. Hence we would expect that the risk allowance PP' would be less in those years. In addition we might expect the reduction in uncertainty to reduce the proportion of merchant stocks that are hedged. Alternative support schemes might have different effects on uncertainty. For example, a support scheme which relied on a fixed parity price formula might be expected to reduce uncertainty more than schemes of the Benson type which involved more discretion in fixing support levels. Further work would seem to be indicated along these lines.

Section 3. Further Lines of Inquiry

Further work would be done along the following lines: First, the relationship between CCC loans and the market price and support level could be estimated using regression techniques. This would involve work on the short run farmer supply curve and merchant demand curve. Second, more statistical evidence could be gathered which would throw light on the validity of the theory, particularly estimates of some of the structural relationships postulated. Third, a theory of long hedging could also be developed along the lines of the short hedging model. Fourth, the effects of CCC operations on short and long hedging and merchant stocks could be developed in greater detail. Fifth, some of the effects of different possible sales policies of the CCC could be explored with the aid of the model.