New Insurance Schemes to Mitigate Agribusiness Throughput Risk

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Abstract: This paper analyzes different institutional structures for mitigating the systemic risk faced by processing firms. Specifically, it describes how cooperatives can hedge against catastrophic losses while at the same time delivering farm level crop insurance.

1. Introduction

Throughput risk, the uncertainty of decreased or uneven input flows, is an increasingly serious issue for agricultural processing firms. The marginal profits of such firms are becoming progressively more sensitive to operation levels; anything less than full capacity can diminish profits (Boehlje). This paper considers the throughput risk associated with firms which process field crops, although the results can be generalized to fit the situation of most other types of processing firms. The most common source of throughput risk for this type of firm is yield risk. Widespread crop failures will, at a minimum, result in higher commodity prices and thus, firm costs. The use of call options can reasonably mitigate this price risk, although the firms will face basis risk. However, when the raw commodity is not traded on any commodity market (e.g., sugarbeets or special purpose crops), crop failures may result in diminished throughput since alternative sources of product may not be available. Furthermore, many processing plants now require their inputs to exhibit specific characteristics and quality, which make finding replacement supplies that meet the firm's specific criteria and demand difficult. In these situations, even if the supply was available, the price risk could not be mitigated since option markets are not available.

Firms that both purchase area yield insurance contracts and implement forward pricing mechanisms should better mitigate their throughput risk, which is the first hypothesis explored in this paper. In the case of farmer-owned businesses (cooperatives or limited liability companies), processing firms could go one step further and offer individual insurance to their farmer-members. Allowing farming-owned businesses (FOBs) to administer the federal crop insurance program could help diminish two problems that continue to plague the program: moral hazard and high monitoring costs. Interestingly, this idea has already captured the imagination of some politicians (Long Thompson). Since the farmer-owners would act as both agent and principle in this arrangement, they would have greater incentives to control moral hazard and adverse selection. In addition, the FOB would theoretically have access to more complete information on farm production, reducing the costs of monitoring and underwriting.

FOBs should be motivated to implement such a two-tier insurance scheme since it mitigates both firm and farm-level risk. Assume that the farmers are obligated by contract to delivery a certain quantity and/or quality of product (an increasingly common practice for processing firms). If the farmer is unable to fulfill the contract, he or she is charged for the cost the firm faces by acquiring the product elsewhere. This can be a costly process that sacrifices the liquidity of both the processing firm and its farmer-owners.

This specific example considered in this paper includes the use of Group Risk Plan (GRP) insurance, which is an area yield contract based on county yields. Each farmer-owner purchases GRP coverage and signs the indemnity payments over to the FOB. The GRP protects the FOB against low throughput originating from numerous unfulfilled contracts (e.g., the case of widespread drought) and the systemic risk of individual crop insurance offerings. In return, the FOB provides each farmer with an individualized policy in the form of a yield hedge. The yield hedge was first introduced by Koch Industries in 1997 and is currently being utilized in limited areas on the private market. The hedge is implemented on a field-by-field basis, and can be used to protect from independent risk those farms whose yields do not correlate well with the county. With this policy, the farmer receives payment when yields are low and pays a share of the crop in good years only. There are no premium payments in bad years. The FOB thus receives an influx of capital (from indemnity payments) when area yields are below the insured level, making the purchase of necessary raw product less of a financial burden for both the firm and the farmer. The farmer would not be charged the additional cost of procurement, since it is covered by the insurance and would be further protected from yield risk. The proposed scheme is empirically tested with simulated data.

2. The Model

The GRP payment is triggered when the realized yield (*y*) on a farm falls below an established "critical yield," *yc*, based on adjusted county averages. More formally,

$$(1) \qquad yc = yfcast \times cov$$

where *yfcast* is the insurer's forecast of the area yield, and *cov* is the coverage level. The coverage level is chosen by the insured from a range of 70 to 90 percent of the forecasted area yield.

The GRP indemnity payoff (*indem*) is specified by the following equation, derived from Skees, Black, and Barnett:

$$(2) \qquad indem = \max\left[\left(\frac{yc - y}{yc}\right)(yfcast)(scale), 0\right]$$

where *scale* represents a range of 0.9 and 1.5 and is chosen by the insured. The *scale* is multiplied by the *yfcast* so those farms that average more or less than the forecasted yield can be "scaled" up or down. For example, if the area forecasted yield is 100 bushels per acre and an individual farm averages 150 bushels per acre then the farmer could choose a *scale* of 1.5 to raise the trigger yield to 150 bushels per acre.

The pure premium rate for the yield hedge is equal to the sum of the indemnities (H_t^I) and premiums (H_t^P) divided by the number of years (*T*) and farms (*N*), as represented by the following equation:

(3) Yield Hedge Pure Premium Rate = $\frac{\sum\left(H_t^P, H_t^I\right)}{T * N}$

The FOB model is based on a closed-membership cooperative or LLC. An optimal capacity (C^O) for the firm was calculated by taking 90%[1] of all members' average yields ($\overline{Y}$) for all acres of production (A^N) on the simulated farms (N). This calculation took place as follows:

(4) $C^O = N * A^N * \overline{Y} * .9$

Where:

(4a) N=1000 farms

(4b) A^N=1000 acres/farm

(4c) $\overline{Y}$ =125.2 bushels/acre

This resulted in a total capacity of roughly 112.5million bushels. It was then assumed that one share in the NGC gave a member the right to deliver 100 bushels of corn, and that all participating farms were homogeneous (meaning each farmer-member purchased the same number of shares (1,125). The farmer-member was also obligated to purchase GRP coverage from the government and sign the indemnities over to the cooperative as well as participate in a yield hedge with the cooperative. In return for participating in the crop insurance program, the cooperative would assume the responsibility of buying grain in the open market to complete unfilled contracts rather than require the farmer purchase more grain.

Since this cooperative will only be acting as a grain elevator for reasons of simplicity[2], a formula for the purchase price of grain (P_t) must be constructed. This was a simple formula that includes the market price (P_t^M) and a profit margin (a) that can be easily varied within the

[1] The percentage of capacity utilized in calculating the optimal level of throughput should be equal to the required GRP coverage level.
[2] It is recognized that NGCs are typically value-added firms, not grain elevators.

model. The profit margin represents a percentage of profit withheld to maintain the insurance pool. The formula is as follows.

(5) $P_t = P_t^M - aP_t^M$

The cooperative is then assumed to sell the grain at market price. The cooperative also receives income from the GRP indemnities signed over to it by its farmer-members as well as from the yield hedge.

The cooperative's revenue (R_t^C), cost (E_t^C), and net profit (Π_t^C) functions are defined in equations six, seven and eight respectively.

(6) $R_t^C = (Q_t^{sold} * P_t^M) + H_t^P + I_t^{GRP} + G_t^{sp} + (1+g)\Pi_{t-1}^C$

where:

(6a) $Q_t^{sold} = Q_t^f + Q_t^S$ = Quantity of corn sold by the NGC in year (t)

(6b) P_t^M = Market price in year (t)

(6c) $H_t^P = \sum_{i=1}^{N} H_i^P$ = Yield hedge premium in year (t)

(6d) $I_t^{GRP} = \sum_{i=1}^{N} I_i^{GRP}$ = Total GRP indemnity payments in year (t)

(6e) $G_t^{sp} = \sum_{i=1}^{N} G_i^{sp}$ = Government subsidy in year (t) paid to the insurance provider

(6f) $(1+g)\Pi_{t-1}^C$ = The interest earned from the cooperative's insurance pool balance from year (t-1)

(7) $E_t^C = (Q_t^f * P_t) + H_t^I + O_t + D_t + (Q_t^S * (P_t^M - P_t))$

where:

(7a) $Q_t^f = \sum_{i=1}^{N} Q_{it}$ and $Q_i = \dfrac{Q^f}{N}$ = Quantity of corn sold in year (t) by the farmer-members to the NGC (all farmers assumed homogeneous).

(7b) $P_t =$ Price that farmer-members receive in year (t) from NGC (equation 7)

(7c) $H_t^I = \sum_{i=1}^{N} H_i^I$ = Total yield hedge indemnities for year (t)

(7d) $O_t =$ \$1 or \$2 million = Operating expenses in year (t)

(7e) $Q_t^S = \sum_{i}^{N} (C_{it}^O - Q_{it}^F)$ = Quantity of corn purchased by the NGC on the open market to make up for the farmer-member inability to deliver the contracted quantity in year (t).

(8) $\Pi_t^C = R_t^C - E_t^C$

The balance of the cooperatives insurance pool (B_t^C) is calculated by subtracting the dividend payments (D_t) from net profit (Π_t^C).

(9) $B_t^C = \Pi_t^C - D_t$ or $(1-y)\Pi_t^C$

where:

(9a) $D_t = y(\Pi^C_{t-1})$ where $D_{it} = \frac{D_t}{N}$ and (Y = .63) = Dividend payments in year (t)

The cooperative has outlays from the yield hedge (H^I_t), the purchase of commodity from its members (Q^f_t), purchase of commodity from the open market (Q^S_t)[3], as well as operating expenses (O_t). Dividends were paid out as a percentage (y) of gross profit. While most NGCs return all profits in the form of dividend payments to its farmer members, this model assumes that 37% is retained in order to build the insurance pool. This percentage was derived from a recursive method in order to attain the highest dividend percentage possible while still maintaining the optimal level of throughput and a positive insurance pool. Operating expenses were assigned using reasonable values ($1 and $2 million/year) and the results evaluated. The interest rate (g) was fixed at four percent.

The farmer-members profit (Π^f_{it}) function is similar to that of the cooperative. It is as follows:

(10) $$\Pi^f_{it} = (Q^f_{it} * P_t) + H^I_{it} + D_{it} + G^{sf}_{it} - (H^P_{it} + R^{GRP}_{it})$$

where:

(10a) Q^f_{it} = Quantity of corn delivered by farm (i) to the cooperative in year (t)

(10b) H^I_{it} = Indemnity payments received by farm (i) in year (t) as a result of the yield hedge

[3] Commodity is only purchased by the NGC from the open market when the optimum level of throughput is not received from its farmer-members.

(10c) $D_{it} = \frac{D_t}{N} - \frac{Q_{it}^S}{100}$ = Dividends received by farm (i) in year (t)

where: Q_{it}^S = The quantity of corn that farm (i) fell short of meeting their contract in year (t)[4]

(10d) G_{it}^{sf} = The government subsidy received by farmer (i) in year (t) on the purchase of GRP coverage

(10e) H_{it}^{P} = Premium payments maid by farmer (i) in year (t) as a result of the yield hedge

(10f) R_{it}^{GRP} = Premium payments made by farmer (i) in year (t) for GRP coverage

Another performance criterion is the cooperative's average annual insurance pool or money holdings. This number was calculated as follows.

$$(11) \quad \text{Average Pool} = \frac{\sum_{t=1}^{T} B_t^C}{T}$$

Where the average pool equals the sum of the cooperative's insurance pool balances divided by the number of years (T). Not only is the average insurance pool important but it was decided that for the system to be successful, the pool must always be greater than zero.

3. Empirical Estimation

3.1 Farm Level Data Simulation

The average yield and standard deviation for the years 1948-1995 were gathered for Iowa corn[5]. The mean yields were corrected for technology and other production changes using 1994

[4] The shortfall in delivered corn is divided by 100 to put the number in terms of unfulfilled shares. This was done because the farmer does not receive dividend payments on unfulfilled shares.

as the base year. A distribution of 1,000 farms was then created for each year. The mean of each year's distribution is equal to the realized Iowa state corn yield average for that year. This process assumed that the farm-level data were evenly distributed around the year's mean. This means that the distribution dictates that even in the worst year, some farms have a high yield, and in the best years some farms are facing a loss of production.

Figure one illustrates the theory behind this process. Distribution A includes all forty-eight years. The mean of this distribution is 125.2 bushels an acre. The one-year example used here (distribution B) is from 1948, when the corrected average yield is 150 bushels per acre and the standard deviation is 19.4 bushels. Based on the randomly generated numbers, mean, and standard deviation, 1,000 farm-level corn yields were assigned.

One of the primary concerns with using this method to simulate data was the possibility of overestimating the correlation of farm-level yield across space. This is a valid concern considering that the 1,000 farms were being generated around one state yield. If true, then the model would be overestimating the systemic risk faced by the cooperative. The average of the correlation between the farms and the state average over time was .42. This is consistent with number reported by (Harwood, et al. P.8).

Two different price data sets were applied to the model. The first was a fixed price equal to the 1999 Crop Revenue Coverage (CRC) loan rate of $2.40. This set was utilized in order to specify the results based only on yield risk. The second data set was detrended based on historical price fluctuations in order to allow some exposure to price risk in the model. Historic percentage deviations are used to vary the base price of $2.40.

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[5] Iowa corn was utilized because the data simulated from these methods were found to correlate with actual Iowa corn crop insurance losses at about 99%.

3.2 Insurance Simulations

The state corn yield was used to simulate an area yield payment for the 48 years that are simulated. The coverage level of 90 percent was chosen and payments were made just as with the GRP program. It was assumed that each farmer would take this contract and assign the indemnity payments to the co-op in exchange for a yield hedge.

There are several steps in the yield hedge process. First, a ten-year moving average is calculated over time to create a target yield. This target yield (90% of the average) becomes the payment triggering mechanism for the hedge. The current year's yield is then compared to the trigger yield. For every bushel the farm produces over the target yield, the producer pays one third of the value to the cooperative. For every bushel the farm produces under the target yield the cooperative pays two thirds of the value to the producer. Price is determined by one of the previously mentioned price data sets. This process, illustrated in table 2.2, covers the years from 1948 to 1967. There are no insurance transactions illustrated for the first ten years in order for the insured to establish a ten-year average[6]. The price of corn is held constant at $2.40 for reasons of simplicity and because this policy is concerned with hedging yield, not price. It is also important to note that the farmer's revenue per acre includes income from the sale of the corn plus or minus the result of the hedge, while the cooperative's revenue per acre only represents the results of the yield hedge.

Another aspect of the yield hedge is that it is only offered at the 90% coverage level and that the insured only pays a premium in good years. This is due to the policy's unique use of the yield distribution. As seen in figure two, the farmer member receives 2/3 of the difference for a given yield that is less than 90% of the ten-year moving average and the FOB receives 1/3 of the

[6] In this model, the data was looped so that 10 years of data would not be lost in establishing a trigger (e.g. 1948's trigger is 90% of the ten-year average from 1986 to 1995).

difference above this trigger value. Even though the FOB is paying a larger fraction of the difference, the area to the right of the 90% line (vertical line through distribution) is more than 2/3 larger than that on the left. This means that over time, the FOB will receive more dollars in premium than it will pay in indemnities. This hedge allows farmers to share some of their production risk with the processing firm.

This model was solved with and without the insurance scheme. The primary performance criteria constructed for this model were the average revenue per acre, the standard deviation of the average revenue per acre, the status of the cooperative's insurance pool or money holdings, and the ability of the cooperative and its farmer-members to maintain the optimal level of throughput.

4. Results

The yield hedge substantially reduces the variance in farm revenue per acre (table 2). Specifically, it lowers the standard deviation from $92.72 per acre to $51.47 per acre. Relative risk, as measured by the coefficient of variation, is reduced from 31% to 17%. Also, the least profitable year without the yield hedge was $181.20, and $256.90 with the yield hedge. This illustrates the effectiveness of the use of a yield hedge on limiting the variation in farm-level revenue. While the farmer does give up $0.90 per acre over time for this coverage, his/her chances of facing severe financial stress in a low production year are reduced.

The data in figure four included both the risk of not meeting the optimal level of capacity and the yield hedge liabilities. Basically the cooperative was double exposed, facing risk from throughput variability and farmer-member yield variability. This means that in a bad year, the cooperative could face losses from both purchasing commodity outside the cooperative to maintain the optimal level of throughput and paying the farmer-members their yield hedge indemnities. It is important to note that the yield hedge and GRP are linked. The effectiveness and usefulness of either in isolation is limited. These types of links are necessary when offering a yield hedge.

By utilizing a crop insurance scheme that involves a yield hedge and GRP coverage, both the farmer-member and the NGC are able to reduce the variation in revenue per acre and average insurance pool balance respectively. In the case of price risk, either the farmer or NGC can use options or a futures contract to help mitigate risk. Effectively, throughput uncertainty is limited so that the odds of the NGC maintaining the optimal level of input are increased.

5. Conclusions

This paper proposes a two-tier insurance scheme whereby a farmer-owned processing firm offers individual yield insurance to its members while protecting itself against systemic risk. The system eliminates the need for farmers to purchase grain elsewhere to fill their contract in an already financially stressed year. The FOB organizes its risk management so as to obtain a consistent level of throughput. This structure also allows the farmer-members to collect on a federal insurance subsidy that is currently made available to insurance providers. Since the FOB acts as an insurance provider, it is eligible for this subsidy. This subsidy is then passed on to the farmer-member via dividends.

It also offers a diverse selection of coverage options. This policy, however, is only useful to those whose yields correlate well with their county yield movements (USDA, FCIC). Specifically, there could be good years in which an indemnity is received or bad years when one is not.

References

Black, J.R., B.J. Barnett, and Y. Hu. "Cooperatives and Capital Markets: The Case of Minnesota-Dakota Sugar Cooperatives." Principal Paper for 1999 Annual Meeting of the American Agricultural Economics Association, Nashville, TN. August 8-11, 1999.

Egerstrom, L.. *Make No Small Plans: A Cooperative Revival for Rural America.* Rochester, MN. Loan Oak Press. 1994.

Hardaker, J.B., R.B.M. Hurine, and J.R. Anderson. Coping With Risk in Agriculture. Cab International. Wallingford, UK. 1997.

Harwood, J., R. Heifner, K. Coble, J. Perry, and A. Somwaru. "Managing Risk in Farming: Concepts, Research, and Analysis." United States Department of Agriculture. Agricultural Economic Report #774. March 1999.

Peterson, H.C.. "Members are Investors Too!" *American Cooperation*. Pages 57-8. 1997.

Skees, J.R. *Agricultural Risk Management or Income Enhancement.* Volume 22, No.1 p.35 1999a.

Skees, J.R.. "Opportunities for Improved Efficiency in Risk Sharing Using Capital Markets." Principal Paper for 1999 Annual Meeting of the American Agricultural Economics Association, Nashville, TN. August 8-11, 1999b.

Skees, J.R., R.J. Black, and B.J. Barnett. "Designing and Rating an Area Yield Crop Insurance Contract." *American Journal of Agricultural Economics.* 79(May 1997): 430-38.

Stefanson, B., M. Fulton and A. Harris. New Generation Co-operatives: Rebuilding Rural Economies. Center for the Study of Co-operatives, University of Saskatchewan. September, 1995.

United States Department of Agriculture. "1994 Guide to Crop Insurance Protection." Federal Crop Insurance Corporation. United States Government. 1994.

Zeuli, K.A. "Analyzing Investment Decisions in Value-Added Enterprises." Chapter 2 of Doctoral Dissertation. University of Minnesota. July 9, 1998.

Zeuli, K.A. "New Risk Management Strategies for Agricultural Cooperatives." Principal Paper for 1999 Annual Meeting of the American Agricultural Economics Association. August 8-11, 1999.

Zeuli, K.A. and R.P.King. "An Analysis of Alternative Organizational Forms for Value-added Enterprises." University of Kentucky, Department of Agricultural Economics. Staff Paper No. 392 March 1999.

Figure 1: Illustration of Yield Simulation Process

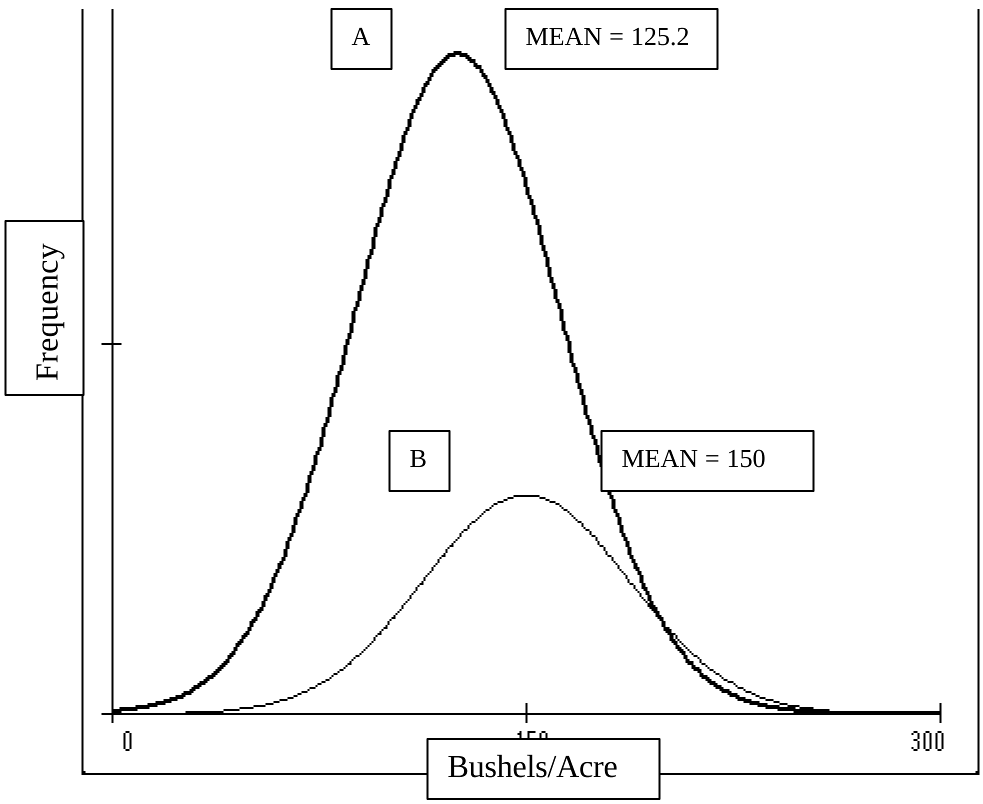

Figure 2: Illustration of Yield Hedge Production Distribution

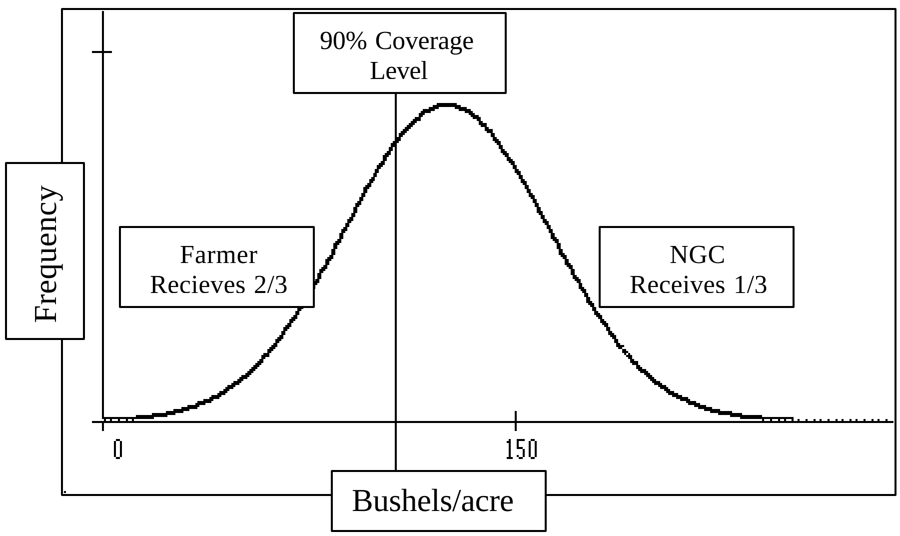

Figure 3: Average Revenue Per Acre with and without a Yield Hedge

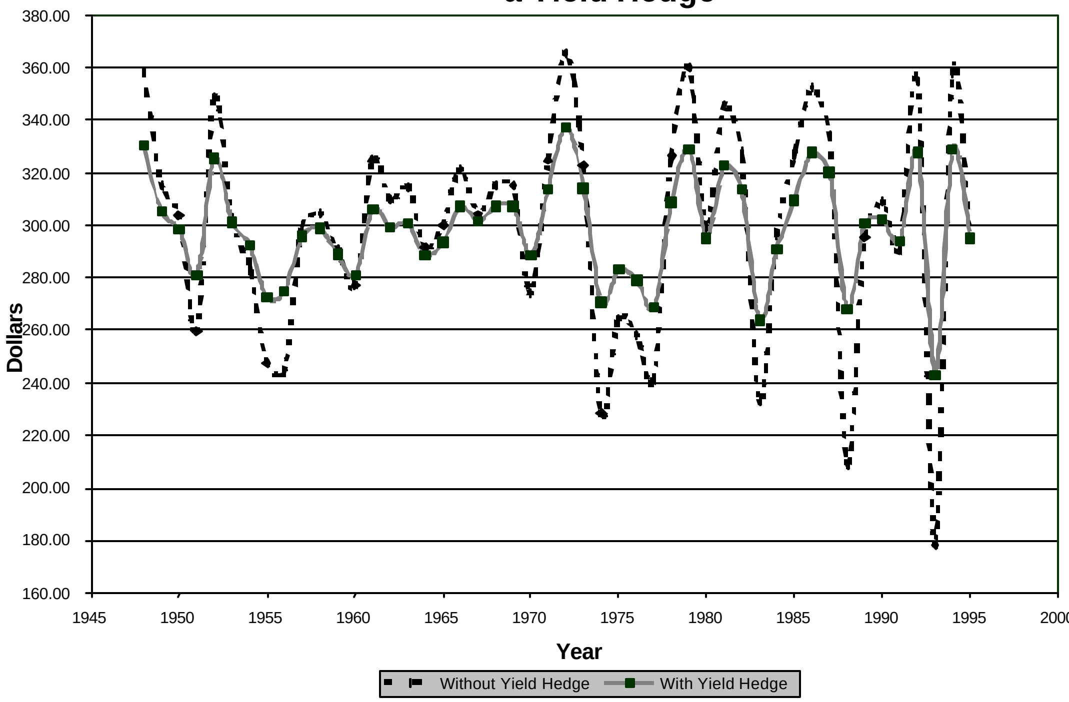

Figure 4: Average Insurance Pool Balance with and without the GRP

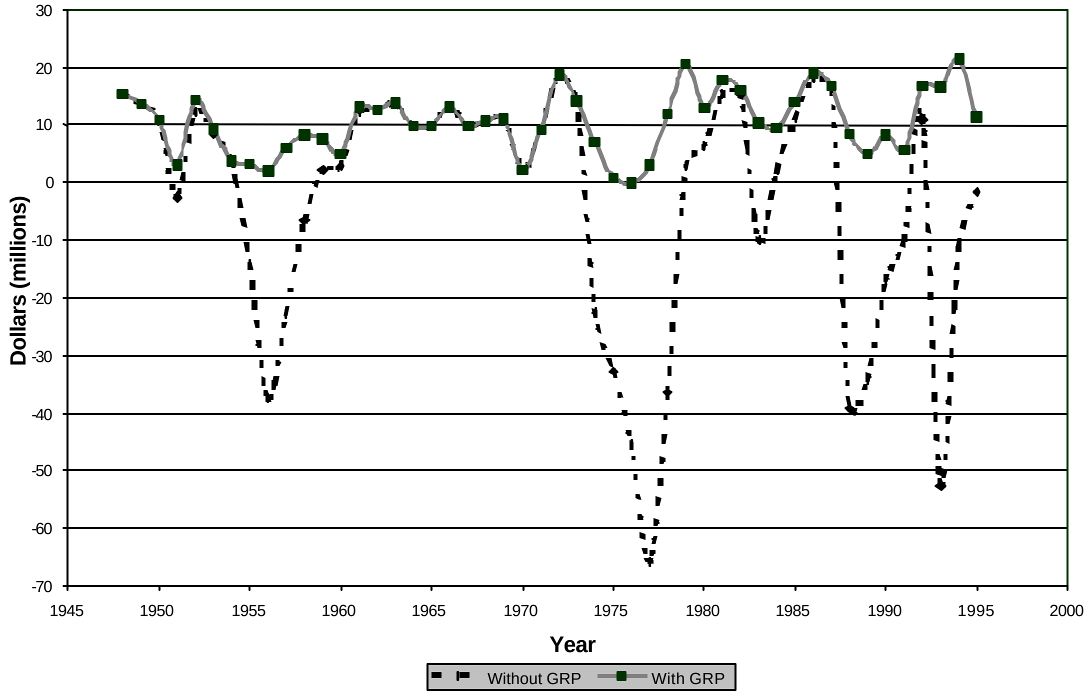

Table 1: Model Variable Definitions

Variables	Definition	Source
H_t^P	The yield hedge premiums paid by the farmer-members to the NGC in year (t).	Endogenous
H_t^I	The yield hedge indemnities paid by the NGC to the farmer-members in year (t).	Endogenous
T	Number of years covered in the data utilized for this model.	Exogenous: 48 years
N	Number of farms simulated for the model.	Exogenous: 1000 farms
C_t^O	The firms optimal throughput capacity.	Endogenous: 90% of farmer-members' average production
A^N	Average number of acres per farm.	Exogenous: All farms were considered homogenous at 1,000 acres per farm.
$\overline{Y}$	The average yield achieved for the one million acres utilized in the model.	Endogenous: 125.2 bushels per acre.
R_t^C	Total revenue for the NGC in year (t).	Endogenous
Q_t^{sold}	The quantity of corn sold by the NGC in year (t).	Endogenous
I_t^{GRP}	The GRP indemnities received by the NGC in year (t)	Endogenous
R_{it}^{GRP}	The GRP premium paid by farmer-member (i) in year (t).	Endogenous
P_t^M	The market price at which the NGC sells its corn in year (t).	Exogenous: (1) fixed at $2.40 and (2) detrended prices that vary.
Q_t^f	The quantity of grain sold by the farmer-member to the NGC in year (t).	Endogenous
O_t	The NGC's operating costs in year (t)	Exogenous: Model run with both annual operating expenses of $1 and $2 million.
D_t	The total dollar value of dividends paid by the NGC to its membership in year (t).	Endogenous
Q_t^S	The shortfall between the quantity of corn contracted to the NGC and the actual quantity delivered by the farmer-members.	Endogenous
E_t^C	The total expenses incurred by the NGC in year (t).	Endogenous
Π_t^C	The total profit earned by the NGC in year (t).	Endogenous
Π_{it}^f	The profit earned by farmer-member (i) in year (t).	Endogenous: (Does not include production costs.)
B_t^C	The balance of the cooperatives insurance pool in year (t)	Endogenous
g	The interest rate applied to the NGC's insurance pool.	Exogenous: 4%
y	The percent of total profit paid to the farmer-members via dividends.	Exogenous: 96%
a	The profit margin retained by the NGC from the price paid to the farmer-members at delivery.	Exogenous: ten cents per bushel.

Table 2. Farm Revenue ($ per acre)

	With Yield Hedge	Without Yield Hedge
MEAN	299.19	300.09
STANDARD DEV.	51.47	92.72
COEF. OF VARIATION	.172	.309
SKEWNESS	-.032	-.076

Table 3. Average Insurance Pool Balance ($ million)

	WITH GRP	WITHOUT GRP
MEAN	10.52	-3.06
STANDARD DEV.	5.40	21.17
COEF. OF VARIATION	.513	6.91
SKEWNESS	-0.02	-1.27