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# Establishing Peanut Purchasing Contract Terms With Uncertain Market Prices and Input Supplies*

by

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First handlers of agricultural commodities encounter inseparable input-supply and product disposal risks when buying and selling the commodity. Uncertain supplies from farms affect the proportion of expected production a handler can safely forward contract to manufacturers. A shortage of input supplies could leave the handler unable to fulfill forward contracts while a surplus of farm supplies might cause product disposal difficulties in a period of depressed prices.

Several authors have explored issues related to first handler's risk. Forward contracting of a fixed quantity of a single commodity was examined under differing pricing provisions [3]. Multi-period mean-variance analysis has been applied to determine forward contracting strategies with credit constraints [1]. Non-linear input costs can make the decision maker's risk-aversion a determinant of the recommended hedging ratio [2]. Other research [12, 14, 21] has concentrated on optimal hedging ratios with futures contracts. A restrictive premise underlying the above papers is production certainty [19]. In particular, first handlers are concerned with production uncertainty attributed to uncertain input supplies.

Risk programming with uncertain input supplies has concentrated on variations of chance-constrained programming (CCP). CCP is a method of protecting against insufficient acquisition of essential inputs that have free disposal [4, 22]. The magnitude of the CCP safety margin, however, has not been linked to the firm's utility function [7]. Considerable parameterizing must occur with CCP if uncertain prices are also present.

A risk-programming formulation based on sampling was recently presented [15]. The formulation relaxed constraining assumptions on the utility function and the distributions of uncertain parameters. This paper presents a methodological approach that allows simultaneous consideration of uncertain constraints and variance in the objective function. A multi-period stochastic programming method is

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constructed based on Monte Carlo sampling to determine the ratio of domestic to export peanuts that a peanut shelling firm should contract with farmers. The firm's uncertain input supplies (the constraints), uncertain prices received (the objective function), and risk preferences are considered. An hypothesis is advanced that limiting uncertain input supplies increases business risk if the final product is sold before the input is received. Validity of the hypothesis is demonstrated with a case study of peanut buying and shelling.

## Background

For an input supply to be considered uncertain, two requirements must be met. First, the input must have been purchased or endowed at an earlier period but yield an uncertain flow of services in the future production period. Second, the firm must not be able to purchase readily more of the input during the production period. Rainfall, solar radiation, and available field hours are traditional examples of farm inputs with uncertain supplies.

Non-enforceable purchasing contracts are associated with stochastically available inputs for first handlers of agricultural products. A non-enforceable contract is defined for this study to be a contract in which the seller is not required to deliver but the buyer is required to purchase the contracted commodity. As will be shown later, the contract between a peanut sheller and peanut farmers is of this nature. Rarely are these terms explicit in the contract. Some Canadian fisheries, sugar beet cooperatives, and peanut shellers are exceptions. However, act of nature clauses may be considered implicit when dealing with almost all natural commodities. For example, if a heat wave or disease destroys a grower's chickens, a vertically integrated poultry firm will suffer economic losses. A farm supply firm may extend credit to farmers in drought years rather than lose customers. Examples can be found for most any firm, in which non-delivery of a contracted input causes economic losses to that firm. Farmers do not necessarily cover any or all losses of the first handlers.

During the future production period, the amount acquired of such a stochastically available input is not a decision variable. Prior to the production period, however, the firm may initiate or react to events that influence either the endowment or the firm's future requirements for that input. The influencing factors are termed exogenous decision variables (EDV) since exogenous events and decisions occur prior to the production process. EDV are determined prior to the production period and are fixed during the production period. For a commodity marketing firm, an example of an EDV that affects the endowment and that will be examined in this study is the tonnage contracted with farmers. An example of an EDV that affects future input requirements would be forward contracting of the output to manufacturers. EDV are associated with the long run risk and profit position of the firm rather than with immediate production decisions.

Forward contracting reduces price uncertainty; however, forward contracting a large proportion of expected future production increases the risk associated with uncertain input supplies. Five prominent factors influence the amount of an uncertain input to contract: price uncertainty, input supply uncertainty, the correlation between prices and input supply, the firm's risk preferences, and the difference of expected cash price minus the forward contract price (the expected basis). A balance of these factors should be determined. Research should be able to quantify that in general, increased amounts of uncertain inputs increase the uncertainty of profits and that greater forward contracting implies more risk associated with uncertain input supplies for a risk-averse firm. The technique presented next maximizes expected utility while considering all five factors.

## The Risk Management Technique

The distribution of profits in the presence of limiting uncertain inputs is not transparent. Let Y be a stochastically available input with a given probability distribution. Profits, $\pi$, are a function of Y, random prices, other non-stochastic inputs, and the EDV.

The distribution of profits is then dependent on the distributions of Y and prices, the stochastic variables. In typical mathematical programming models price risk is reflected in the primal objective function and input supply risk is contained in the right-hand-side (rhs). Assuming prices have a normal distribution, the variance of profits in the presence of only uncertain prices is a linear combination of the squared prices. However, the path of inputs from the rhs through the technical matrix to the objective function presents a more complicated formulation. The input supply must limit production to affect profits. Furthermore, infeasible solutions might occur at extreme input levels.

The goal is to determine the level of the EDV that maximizes the firm's expected utility. Expected utility is a function of profits and the distribution of profits: $E(U) = \int U(\pi)F(\pi)d\pi$. Maximization of this formula with respect to the objective function variables, using facilitating premises, can be achieved with quadratic programming [10]. However, maximizing with respect to an EDV requires a different approach. The approach in this study employs the axiom that a continuous profit distribution can be approximated by a discrete sampling procedure.

The optimization procedure requires several components. A profit maximizing linear programming (LP) model is needed which incorporates the time span and production activities influenced by input supply uncertainty. Since the farm contracting decisions are made prior to the production period, both input supply and uncontracted prices must be considered stochastic. The parameters of the probability distributions of input supply and uncontracted prices are used to generate random samples that could represent actual prices and input supplies. If prices and input supply are correlated, the generated sample values can reflect this correlation [5, 20]. Finally, the firm's utility function with respect to profits is required. Some firms may be considered to know or to describe their utility functions while others can be estimated through elicitation methods.

The steps in the technique were as follows. First, the EDV was set to a specific level. A profit was determined using one sample of the generated random prices and input supply in the linear programming model. Repeated solutions were then obtained with the remaining random values until sufficient sample profits were given to describe adequately the profit distribution. One hundred trials appeared adequate for the case study; one thousand trials did not change the distribution significantly. A discrete expectation formula, $E(u) = \Sigma U(\pi)F(\pi)$, was then applied to the utility function and estimated profit sample points to determine an expected utility for that specific level of the EDV. All the previous steps were then repeated in a systematic search of all levels of the EDV. An expected utility for each EDV level was furnished and a maximum determined. This expected utility maximizing level of the EDV will likely differ from the expected profit maximizing level of the EDV.

The linear programming model and technique are useful for setting farm contracts prior to production. However, after the stochastic inputs are acquired, input supply will no longer be uncertain. More conventional methods such as mean-variance analysis could be applied to the LP model to analyze the effects of only uncertain prices.

An obstacle in this technique is the volume of linear programming tableaus that need to be maximized. To overcome the computing hurdles, the revised simplex algorithm using the product form of the inverse [11] was written in vectorized Fortran for use with a CDC Cyber 205 computer. The Cyber 205 is a supercomputer with hardware structure designed for vector operations; it can operate in excess of 400 megaflops (million floating point operations per second). This algorithm and computer proved to have the speed necessary to do the iterations in a reasonable amount of time. In the next section, the above approach is applied to determine the amount of export peanuts a large peanut sheller should contract to buy from peanut farmers.

**Application to a Peanut Sheller**

In-shell peanuts are the major limiting stochastically available input in a peanut sheller's production function. Knowledge of farm yields is necessary to formulate strategies and plans for marketing and forward contracting. However, annual yields have fluctuated as much as 50 percent from average and current techniques for forecasting peanut yields are not of sufficient accuracy for early-season (prior to August) marketing analysis. Marketing decisions must be made with imperfect information.

Current peanut program provisions require a sheller to contract with farmers in order to export peanuts. Further, the sheller usually combines a farm contract to deliver additional peanuts for export with a contract to deliver quota peanuts for the domestic market. Remarkably, the typical contract between a sheller and a farmer states that the farmer is not required under penalty to deliver the contracted poundage of peanuts. In effect, farmers are not penalized for being an uncertain input supply. In fact, evidence indicates that farmers may underplant on acreage needed to fulfill the combined farm contract if export prices are low. The sheller, on the other hand, must purchase all the contracted peanuts and, if profitable, will procure the remaining peanuts produced by the contracted farms.

In-shell peanuts qualify as an uncertain input supply. The only established source of in-shell peanuts is from U.S. farms since imports are restricted. These peanuts are purchased or endowed prior to the mandated farm contracting deadline of July 31 but are not delivered until after harvest in September. Farm plantings, yields, and subsequent deliveries are unpredictable. The market among peanut handlers for in-shell peanuts is insignificant; peanuts purchased from other handlers are already shelled. Excess capacity in the shelling industry creates a desire for each firm to shell all the peanuts it handles.

Peanut marketing [8, 16, 17] and peanut price discovery mechanisms [18] have been documented. The Food Security Act of 1985 [9] continued a two-tiered pricing system with domestic production quotas and import restrictions. According to price support policy, all additional peanuts (contract additionals or uncontracted additionals bought back for export) must either be exported, or crushed for oil and meal. Only quota peanuts (farm quotas or uncontracted additionals bought back for domestic consumption) may be sold domestically.

For this analysis, the marketing firm is defined to include only the activities from the farm purchases of in-shell peanuts to the selling of shelled peanuts. The marketing period for one year's crop is approximately fifteen months long and lasts from September of the current year to November of the following year. The harvest season (September-December) is the period when farm deliveries are ordinarily made. During the first months of the following year (January-August) in-shell peanuts must come from storage. These dates may change by a week or two depending on the location of the sheller and when the peanuts are harvested.

An appropriate model of the flows of peanuts through the firm and the time of their occurrence can be achieved through linear programming techniques. The model [6] was designed specifically to analyze risk in farm contracting and represented the major activities and constraints of a peanut sheller. A more disaggregated analysis of daily plant operations would not assist in the long range planning arena in which most major risk decisions are made.

The model was a multi-period multi-product planning model with a one crop year horizon. The combination of farm production, forward contracts, open market sales, and farm purchases of shelled peanuts that maximize the firm's marketing margin with regard to the 1986-87 peanut program was determined. The non-stochastic technical matrix consisted of only +1, 0, or -1 to represent the flow of peanuts through the firm. Old and future crops were connected in this model through the beginning and ending inventories. The model assumed that the firm will have peanuts on-hand from the previous crop and might not sell all of the current crop during the current crop year. Generally, shellers must divest the beginning inventory by November because of an export deadline on additionals and the expiration of aflotoxin insurance on domestic peanuts. Storage between crop years is not an option.

Shellers typically forward contract a proportion of the next crop and sell the remainder by cash sales. Forward contracts in this study were limited to be shelled peanuts sold to manufacturers or other handlers before September 1 but delivered in September through December or in January through August. Cash transactions were shelled peanuts both contracted and delivered within one of these periods. These strict definitions may not precisely match those of shellers; however, the definitions reflect the risk in forward contracting from input supply. No input supply risks are in contracts made after harvest. After harvest (in January through August), the sheller sells only peanuts on-hand.

The objective function was arranged into four major sections. The export market, the domestic market, buybacks, and purchases of farm peanuts sections have a total of 42 activities (endogenous variables). The domestic market activities correspond to those in the export market. However, prices will be significantly higher and constraints on quotas differ from those on additionals. Therefore, another set of activities was included. Also, risk in peanut marketing is centered on export peanuts with respect to price variability and input supply uncertainty.

The export and domestic markets for shelled peanuts deal with sales and purchases among handlers and final sales to manufacturers. In the model, export and domestic peanuts can each be sold four ways, either for cash or by forward contract for delivery in either September through December or January through August. Further, by law, exports must be shipped by November. Thus, the sheller may face losses on any old crop export inventory that is on hand after August of the year following harvest.

Buy-ins (an industry term) were shelled peanuts purchased only from other domestic peanut handlers and were analogous to sales above. Commodity Credit Corporation (CCC) redemptions were considered as January through August cash buy-ins. The CCC sells peanuts placed into the Loan (uncontracted farm quotas and additionals) from January until June at competitive bids that are highly correlated to the open market price paid to other handlers for similar peanuts.

Quotas are domestic marketing limits for farmer's stock peanuts, not sheller marketing limits. The sheller can market more domestic quota peanuts than were purchased from its contracted growers. The buyback option allows sellers to pay quota prices for uncontracted additional peanuts in the CCC loan, thereby converting them into quota peanuts which can then be sold for domestic consumption. Three buyback activities were modeled depending on other actions of the firm and the final use of the buybacks.

Farmers produce peanuts classified three ways by the peanut program and deliver them to shellers in the most profitable order. First, domestic quota peanuts with a high support price (above free market equilibrium) are delivered. These are followed by contracted additional (export) peanuts with a lower price (near international free market levels). Last to be delivered are uncontracted additionals which must go into the CCC loan program (below world price levels) but can be immediately bought back (redeemed from the loan) for either domestic use or export. Uncontracted additionals for buybacks are rare after a drought year.

A distinct feature of peanut buying is that contracted, expected, and actual farm deliveries are not equal. Farmers tend to be risk-averse and produce additional peanuts primarily to be assured of making their quota. However, if additionals are not profitable for farmers, they may underplant for delivery on the combined contract. No penalty exists for farmer underplanting but a market and price are guaranteed for most of any excess peanuts produced. Thus, shellers expect to purchase less than the amount they contract with farmers. Actual farm deliveries are a function of random growing conditions and acreage planted.

The contract between a sheller and farmers usually stipulates that for every ton of quota peanuts the sheller purchases, the sheller will also take some amount of additional peanuts. Ratios of 3 to 1, 2 to 1, 1.75 to 1, 1.5 to 1, and 1 to 1 have been widely used in the industry. For example, with a 3 to 1 contract, for every three tons of quotas contracted, the sheller will also take one ton of additionals. The 1 to 1 will likely cause sheller losses during a high yield year. Alternately, a 3 to 1 contract will likely cause sheller losses during a low yield year.

Table 1 illustrates the effects of different contract ratios on peanut deliveries for five contract ratios for average, high, and low farm yields. The sheller is able to contract 75,000 tons of quotas. The contract ratio then decides the amount of contracted additionals the sheller must take. A higher contract ratio implies fewer contracted additionals. From the case study firm's experience, farmers usually underplanted acres 20 percent below contract levels. This caused uncontracted additional peanuts to be rare. In a high yield year, the sheller would acquire more than the expected amount of contracted additionals; a high contract ratio might be best. In a low yield year, the sheller may receive no contracted additionals and may have a shortage of quotas; a low contract ratio might be best.

Farm deliveries of the three types of peanuts created three stochastic input supplies in the rhs. Total farm production was not a sheller decision variable and was assumed to have a normal yield distribution for a given acreage planted. Based on the delivery order of peanuts, a separate algorithm was created to apportion farm production into input supplies of quotas, contracted additionals, and uncontracted additionals.

The sheller was required to purchase all contracted additional and quota peanuts. Uncontracted additionals could be used as buybacks if profitable or left with the CCC if unprofitable. These buybacks were limited to be less than the farm production of uncontracted additionals. The farm purchases section of the tableau is presented in Table 2 as an example of the coefficient structure of the model.

After the farm peanuts were purchased, two constraints accounted for delivery to the shelling plant. Two constraints directed uncontracted additional peanuts into the three buyback activities. Four constraints equalized the flow of peanuts within the firm between time periods. Two constraints set the level of beginning inventories of export and domestic peanuts. Two constraints transferred beginning inventories to later periods. Two constraints set limits on ending inventories.

The supply of in-shell peanuts was the major constraint to firm expansion; however, several other limits were set on the expansion of the firm and its ability to buy and sell peanuts. A plant capacity constraint was included although shelling plants tend to have large excess capacity. A capacity constraint would be limiting only after a high farm production year. Shellers also face a major implicit limit on their ability to expand operations. The concentrated structure of the peanut industry (Miller) is such that large firms cannot exceed their market share of domestic production without facing a reaction from other firms such as a destructive price war. Consequently, domestic farm purchases were limited to the amount of quota peanuts that the sheller normally deals with in a given year.

The amount of open market transactions was limited by the peanuts available for open market transactions at prevailing prices. Peanuts for buy-ins are scarce and expensive during a drought; in a high yield year buy-ins are available but not needed. Thus, two constraints limited the amount of shelled buy-ins that a sheller can expect to be available at usual price levels to be less than 10 percent of the actual farm production. The 10 percent was at the suggestion of a case study firm. Drought buy-ins with higher prices were unlimited.

Similarly, in a high yield year shellers will have an excess of peanuts to sell and

**Table 1**

Relationship of Contracted, Expected, and Actual Yields, Georgia, 1986 (All peanuts are in shelled tons*)

| Contract ratio | 1.00 | 1.50 | 1.75 | 2.00 | 3.00 |
|---|---|---|---|---|---|
| Contracted Farm Production | | | | | |
| contracted quota | 75,000 | 75,000 | 75,000 | 75,000 | 75,000 |
| contracted additionals | 75,000 | 50,000 | 42,857 | 37,500 | 25,000 |
| total contracted | 150,000 | 125,000 | 117,857 | 112,500 | 100,000 |
| Expected Farm Production | | | | | |
| percent underplanted | 20 | 20 | 20 | 20 | 20 |
| expected yield/acre | 1.1306 | 1.1306 | 1.1306 | 1.1306 | 1.1306 |
| expected total acres | 106,136 | 88,447 | 83,393 | 79,602 | 70,757 |
| expected total yield | 120,000 | 100,000 | 94,286 | 90,000 | 80,000 |
| uncontracted additionals | 0 | 0 | 0 | 0 | 0 |
| contracted additionals | 45,000 | 25,000 | 19,286 | 15,000 | 5,000 |
| contracted quotas | 75,000 | 75,000 | 75,000 | 75,000 | 75,000 |
| Actual Farm Production with a High Yield | | | | | |
| actual yield/acre | 1.300 | 1.300 | 1.300 | 1.300 | 1.300 |
| total yield | 137,977 | 114,981 | 108,410 | 103,483 | 91,985 |
| uncontracted additionals | 0 | 0 | 0 | 0 | 0 |
| contracted additionals | 62,977 | 39,981 | 33,410 | 28,483 | 16,985 |
| contracted quotas | 75,000 | 75,000 | 75,000 | 75,000 | 75,000 |
| Actual Farm Production with a Low Yield | | | | | |
| actual yield/acre | 0.750 | 0.750 | 0.750 | 0.750 | 0.750 |
| total yield | 79,602 | 66,335 | 62,544 | 59,701 | 53,068 |
| uncontracted additionals | 0 | 0 | 0 | 0 | 0 |
| contracted additionals | 4,602 | 0 | 0 | 0 | 0 |
| contracted quotas | 75,000 | 66,335 | 62,554 | 59,701 | 53,068 |
| additional shortfall | 70,398 | 50,000 | 42,857 | 37,500 | 25,000 |

* 1 ton of in-shell peanuts equals 3/4 ton of shelled peanuts.

**Table 2**

Purchases of Farm Peanuts Section of Tableau

| Purchase Activity | | | | Uncertain Input Supply |
|---|---|---|---|---|
| A1 | A2 | A3 | A4 | |
| 0 | 0 | 0 | 1 | = quota farm production |
| 0 | 0 | 1 | 0 | = contracted additional farm production |
| 1 | 1 | 0 | 0 | ≤ uncontracted additional farm production |

where A1 = Export uncontracted additional buybacks
A2 = Domestic uncontracted additional buybacks
A3 = Additional farm purchases
A4 = Quota farm purchases

**Table 3**

Estimated Covariance Matrix of Prices and Yield, Georgia, 1986

| | X1 | X2 | X3 | X4 | X5 |
|---|---|---|---|---|---|
| X1 | 126 | | | | |
| X2 | 205 | 410 | | | |
| X3 | 0 | 0 | 47 | | |
| X4 | 0 | 0 | 61 | 100 | |
| X5 | -0.38 | -0.634 | -0. 043 | -0.055 | 0.0139 |

where: X1 = Export cash prices Sept-Dec
X2 = Export cash prices Jan-Aug
X3 = Domestic cash prices Sept-Dec
X4 = Domestic cash prices Jan-Aug
X5 = Farm yield/acre in shelled ton equivalent

most likely the manufacturers' demands for peanuts will be filled. Selling increasing amounts of peanuts becomes progressively more difficult. All shellers will be competing for a smaller market. Again, following the experience of a case study firm, two constraints limited open market sales of peanuts to be less than 10 percent of expected deliveries.

The amount of export peanuts forward contracted to each period was defined to be the proportion of expected farm deliveries of additional peanuts in a shelled equivalent measure. Analogous constraints were imposed on domestic forward contracting. The empirical example is presented next.

**Data**

The above model and risk management technique were applied to a large sheller with 1986-87 peanut program regulations and price and yield expectations. The majority of the data was provided by a case study firm, while the remainder was estimated from industry publications. Parameter estimates were both historical and subjective in nature.

Each activity in the objective function of the model required a price estimate. Expected prices of forward contract and cash sales for both export and domestic peanuts along with other nonstochastic prices were elicited from the marketing personnel of the case study firm. The responses were in May and an early season drought was apparent. No transactions were allowed to occur below the shelled equivalent support prices, although the expected market prices were significantly above the support prices.

Subjective estimates of the variances and covariances of prices [13] were formulated with information garnered from the case study firm. The overall covariance matrix (Table 3) included stochastic prices and farm yields. Farm yield was based on historical data. The expected yield per acre was 1.131 tons shelled equivalent with a standard error of 0.11768 tons shelled equivalent. For a large sheller with contracted farmers located over a wide area, a negative correlation exists between farm yield and prices. The covariances between prices and farm yield were estimated with time series data.

No correlation was assumed to exist between export and domestic prices. The domestic and export price determination factors appear independent. The export equilibrium was determined by international supply and demand factors. The domestic market was largely governed by the support price and production quota. Export prices varied more than domestic prices (Table 3) suggesting that export price risk is greater than the domestic price risk. January through August prices of the year after harvest varied more than September through December prices of the current year. This reflected both the thinness of the peanut market in January through August and the inability to forecast prices accurately farther into the future.

The negative exponential function, $U = 1-\exp(-\phi * \text{profits})$, [10] was a close representation of and was substituted for a concave utility function provided by the research department of the case study firm. A vital characteristic was that the managers received little additional satisfaction from profits above a target level. Thus, the risk-aversion coefficient, $\phi$, was set at $8*10^{-7}$. With this risk aversion coefficient, 99 percent of maximum utility is reached at $5.6 million. This was within the range of the firm's target profit.

All data, with the possible exception of the utility function, are commonly known and used by the management of peanut shelling firms in long range planning operations. Data collection should not be difficult for a shelling firm desiring to apply this model.

**Results**

Compared to many common limiting inputs, sheller profits were not a monotonic function of total farm production. Thus, the sheller had a two-sided input supply risk. To maximize profits, the sheller must receive at least but no more than its expected farm production plus the amount above this that it can readily sell without discount. Any deviation from this amount leads to a drop in profits. In fact, the case study sheller experienced lower profits after the record high farm production year of 1985 than after the major 1980 drought.

An initial stochastic analysis omitted input supply risk. Farm deliveries were fixed at expected levels but sales prices were allowed to vary. The generated profit distribution appeared symmetric and was not rejected as a normal distribution using the Kolmogorov-Smirnov modified D statistic (D = 0.097 with n = 100). Inclusion of uncertain farm deliveries, however, visibly skewed the distribution to left; it was rejected as a normal distribution (D = 0.184). The sheller had possibilities of large losses without proportionate possibilities of large gains. Additionally, the dispersion of profits was greater with the inclusion of uncertain farm deliveries.

The optimal amount of shelled peanuts to forward contract to manufacturers for export and domestic use to both September through December and January through August was then investigated. The results suggested in all cases that no forward contracting gives the maximum expected utility. With an impending drought these results appear rational. Prices were expected to rise and the firm should not have been locked in at current low forward contract offers.

The final procedure was to determine which of the various contract ratios would maximize the firm's utility. Five levels of the contract ratio formed an EDV. The LP model was run 100 times for each of the ratios with no forward contracting to manufacturers. A profit distribution and, subsequently, an expected utility were calculated. With a 1.75 to 1 or lower contract ratio, the farmers almost always made their quota.

As indicated in the top line of Figure 1, the 2 to 1 ratio had the highest expected utility. At a 2 to 1 contract ratio, for every two tons of quotas contracted, the sheller must take (if the farmers deliver) one ton of additionals. Not surprisingly, a 2 to 1 contract ratio was very common at the time of this study.

At the higher 1 to 1 contract ratio, the sheller would suffer losses during a high yield year; farmers would force the sheller to take large amounts of additional peanuts at a time when the market was saturated and the sheller had no prearranged buyers. As indicated above, the sheller would have disposal problems. The expected utility of a 3 to 1 contract ratio was slightly lower than the 2 to 1 ratio. With a 3 to 1 ratio, the sheller would have fewer additional peanuts to sell. Consequently, sheller profits would be lower.

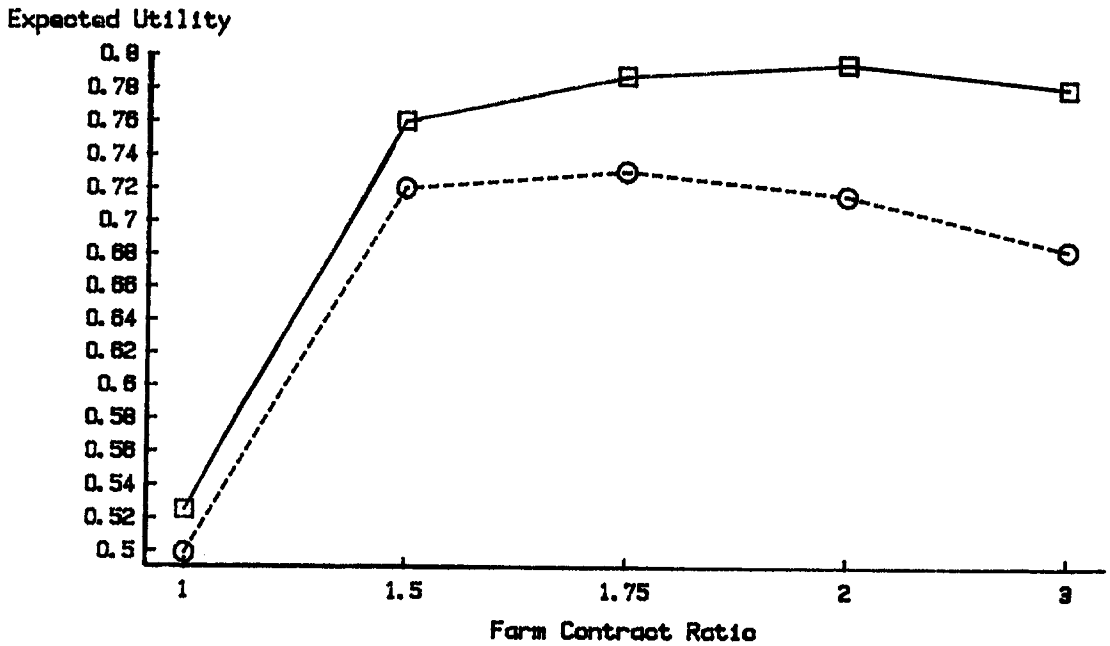
The analysis was repeated except that 20 percent of both the quota and additional peanuts were forward contracted to manufacturers (i.e., 10 percent of quotas to January through August and 10 percent of quotas to September through December). These peanuts have essentially been sold before being received. The lower line in Figure 1 shows that a 1.75 to 1 contract ratio has the highest expected utility.

The expected utility of a 3 to 1 ratio dropped comparatively more than the other ratios. The 3 to 1 ratio would provide an inadequate cushion of additionals since farmers may have few additionals during a drought year. With 20 percent of the additionals forward contracted to manufacturers, the sheller would have to enter the open market during a period of possibly high prices. The expected utility of the 1 to 1 and 1.5 to 1 ratios changed only slightly. Most of the change for these ratios was from forcing the sheller to take a lower forward contract price.

**Conclusions**

Based on the above results, one might conclude that input supply risk is greater with a higher contract ratio. Farmers produce a smaller amount of contracted additionals with the higher contract ratio. Input supply uncertainty also presents greater risk if the peanuts are sold prior to their acquisition. The expected utility dropped after 20 percent of the shelled peanuts were forward contracted to manufacturers.

**Figure 1. Expected Utility of Five Farm Contract Ratios at Zero and Twenty Percent Forward Contracted Case Study Data, 1986**




The study has yielded an analytical tool that can evaluate management decisions in the presence of both uncertain prices and input supplies. The technique may also be applied at other levels in the food marketing chain to determine long-run marketing and production strategies with uncertain limiting inputs. The uncertainty of peanut supplies to shellers was demonstrated in this study.

Sampling was combined with linear programming to describe a profit distribution. The distributions of the stochastic parameters were explicit, and no a priori restrictions were compulsory on the functional form of the utility function. An expected utility was then determined with the profit distribution. This approach accounted for the effects of uncertain input supplies on the distribution of profits.

The farm contract, in effect, shifts the farm yield risk from peanut farmers to shellers. In most other contracts, the seller would be the one required to buy the commodity on the open market to overcome a shortage of production. However, with peanuts, the sheller must enter the open market to overcome a farm shortage of peanuts. Input supply risk reducing approaches, such as inventories carried between years and yield forecasting, are not feasible options for shellers. Policy changes could create new marketing alternatives to mitigate input supply risk. Examples might be: eliminate the farm contracting deadlines, or simply require farmers to deliver on the contracts. Until changes occur, shellers should take a moderate approach to setting the contract ratio.

Uncertain supplies of limiting inputs are elemental sources of risk in agriculture. This study has given some insights on modeling uncertain input supplies and a technique that can be extended to other situations. As government farm policies trend toward reducing excess production, the issue of uncertain input supplies will appreciate in significance for farmers and first handlers.

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