PRICING SOYBEANS ON THE BASIS OF OIL AND PROTEIN CONTENT*

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Demand for soybeans consists of the derived demand for its use as an input in the production of soybean oil and meal. The marginal value product of any bushel is determined by its oil and protein content and the price of oil and meal. Until recently, traders have been forced to estimate the value of soybeans through a grading scheme based on visual inspection and measured moisture content. Instruments that provide a quick and accurate measurement of the protein and oil content of soybeans and other grains are becoming available. Their use will allow purchasers to adjust the price paid for soybeans that do not possess average protein and oil contents.

The purpose of this paper is to report the development of a system of discounts and premiums that would complement the use of these new instruments in the pricing of soybeans.

DEVELOPMENT OF A SYSTEM OF DISCOUNTS AND PREMIUMS

The procedure for establishing a schedule of discounts and premiums begins with a description of the physical relationship between protein and oil content of soybeans and crude oil and meal obtained through the crushing process. These relationships are converted to value differences through use of varying prices for oil and 44 percent protein meal. One set of discounts is developed to reflect differences in oil value, while another accounts for differences in the value of meal. The two discounts are summed to obtain the total discount or premium to be assessed to a particular delivery of beans.

All discounts are to be applied to No. 1 grade soybeans with 13 percent moisture content. Soybeans that do not meet these specifications will be subject to the additional discounts currently applied in grain pricing.

Oil Value of Soybeans

The number of pounds of oil extracted in a crush is determined uniquely by the oil content of inputs. A bushel of soybeans with 18 percent oil content contains 10.8 pounds of oil. However, not all of this is recovered in the milling process; an amount equivalent to 1.2 percent of the non-oil dry matter remains in the material that is produced into meal, and 1.15 percent of total dry matter is lost in the crushing process.[1] Consequently, only 10.31 pounds of crude oil are obtained from beans with an oil content of 18 percent.

Calculations have been made over a wide range of oil contents to identify the relation between oil content and pounds of recoverable oil. Linear regression has been used to express the relationship in a form that is conducive to the establishment of a discount scheme. The estimated equation is as follows:

$$O_i = -.62 + 60.72\, X_i \qquad R^2 = 1.0 \qquad (1)$$

where

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[1] These numbers apply to the solvent extraction milling process. Over ninety percent of all soybeans in the U.S. are processed by this method.

O_i = number of pounds of oil obtained from a bushel of soybeans having X_i percent oil content

X_i = oil content of soybean, expressed as a decimal.

The oil value equation is computed by multiplying each side of Equation 1 by the price of crude oil. A set of oil discounts and premiums is produced by selecting an oil standard and subtracting its oil value from that of any soybeans under consideration. A standard of 18 percent has been chosen for illustrative purposes. In this case, any oil discount or premium may be calculated by inserting appropriate values for the price of oil and oil content into the following equation:

$$D_i^o = P_o\,[60.72\,(X_i - .18)] \qquad (2)$$

where P_o = price of crude oil in cents per pound.

Meal Value of Soybeans

The amount of meal obtained from a bushel of soybeans is determined by the amount of dry matter remaining after the oil extraction process; therefore, it depends upon oil content of the beans. The protein content of meal varies positively with that of the soybeans from which it is produced. Thus, meal value is influenced by both oil and protein content of processed beans.

Soybeans containing 18 percent oil and 13 percent moisture will yield 40.8 pounds of non-oil dry matter. In addition, .49 pounds of oil will remain after extraction. This material will produce 46.92 pounds of 12 percent moisture soybean meal. Calculations of this type have been made over a wide range of oil contents to allow for estimation of a relationship between pounds of meal produced and oil content. These observations led to the following equation:

$$Y_i = 59.34 - 69.0\,X_i \qquad R^2 = 1.0 \qquad (3)$$

where

Y_i = pounds of soybean meal produced from soybeans containing X_i percent oil

X_i = oil content of soybeans, expressed as a decimal.

The derivation of the protein content of meal is a simple matter, once the oil and protein content of processed soybeans is known. A bushel of beans containing an oil content of 18 percent and 35 percent protein will yield 21 pounds of protein that will be contained within 46.92 pounds of meal. Such meal would consist of 44.46 percent protein and 55.54 percent fiber, hull and moisture. By repeating this exercise for numerous values of oil and protein content, enough observations have been generated to estimate the following relationship.

$$Z_{ij} = -.1343 + .6712\,X_i + 1.3203\,X_j$$

$$R^2 = .99 \qquad (4)$$

where

Z_{ij} = pounds of protein content (expressed as a decimal) per pound of soybean meal

X_i = oil content of soybeans, expressed as a decimal

X_j = protein content of soybeans, expressed as a decimal.

Since observable prices exist for 44 percent and 49 percent meal only, it is necessary to infer values for meal with protein content that differ from 44 percent. Following the federal discount penalty for protein-deficient meal, the value of a pound of meal that contains Z percent protein will be $(Z/44) \cdot (P_{44})$ where P_{44} is the price of 44 percent protein meal in cents per pound.

The meal value of a bushel of soybeans may now be expressed as:

$$M_{ij} = \frac{P_{44}}{.44}\,[(59.34 - 69.0\,X_i)(-.13 + .67\,X_i + 1.3203\,X_j)]$$

or

$$M_{ij} = \frac{P_{44}}{.44}\,[(-7.71 + 48.73\,X_i + 78.33\,X_j - 46.23\,X_i^2 - 91.08\,X_iX_j)] \qquad (5)$$

To establish a set of meal discounts it is necessary to select a standard value for the protein content of soybeans. This standard should be set at a level allowing processors to produce either 44 percent or 49 percent meal. Soybeans yielding 46 percent meal, hulls included, have the lowest protein content of beans that would produce 49 percent meal with hulls removed. Given an oil standard of 18 percent, the appropriate protein standard is found through Equation 4 to be 35.86 percent. A set of meal discounts and premiums may then be generated by subtracting meal value of a bushel of standard soybeans from that of any lot purchased. This may be expressed as:

$$D_{ij}^{m} = \frac{P_{44}}{.44} \Big\{ 48.73\,(X_i - .18) + 78.33\,(X_j - .3586) - 46.23\,(X_i^2 - .18^2) - 91.08\,[X_i X_j - (.18)(.3586)] \Big\} \qquad (6)$$

where

D_{ij}^{m} = meal discount in cents per bushel for soybeans containing i percent oil and j percent protein

X_i = oil content of soybeans, expressed as a decimal

X_j = protein content of soybeans, expressed as a decimal.

TOTAL DISCOUNTS

A set of oil discounts may be summarized in tabular form with levels of oil content and various oil prices listed in as detailed a fashion as seems desirable. A separate table of meal discounts is required for different prices of 44 percent protein meal. Total discount (or premium) is simply the sum of oil and meal discounts (premiums).

Table 1 illustrates a few total discounts that would be assessed to soybeans of differing quality when the price of oil is 25 cents per pound and the price of meal is seven cents per pound. The range of values of oil and protein content encompasses those that might have been purchased in North Carolina during recent years.

TABLE 1. PER BUSHEL DISCOUNTS AND PREMIUMS* FOR ALTERNATIVE LEVELS OF OIL AND PROTEIN CONTENT WHEN THE PRICE OF SOYBEAN OIL IS 25 CENTS PER POUND AND THE PRICE OF 44 PERCENT SOYBEAN MEAL IS $140 PER TON

Protein Content (Percent)	Type of Discount	Oil Content (Percent)					
		15	17	19	21	23	25
	Oil	-45.54	-15.18	+15.18	+45.54	+75.90	+106.26
28	Meal	-83.25	-78.46	-76.26	-74.65	73.63	- 73.20
	Total	-126.79	-93.64	-61.08	-29.11	+ 2.27	+ 33.06
	Oil	-45.54	-15.18	+15.18	+45.54	+75.90	+106.26
30	Meal	-60.67	-58.46	-56.84	-55.81	+55.37	- 55.52
	Total	-106.21	-73.64	-41.66	-10.27	+20.53	+ 50.74
	Oil	-45.54	-15.18	+15.18	+45.54	+75.90	+106.26
32	Meal	-40.09	-38.46	-37.42	-36.97	-37.11	- 37.83
	Total	-85.63	-53.64	-22.24	+ 8.57	+38.79	+ 68.43
	Oil	-45.54	-15.18	+15.18	+45.54	+75.90	+106.26
34	Meal	-19.51	-18.46	-18.00	-18.13	-18.85	- 20.15
	Total	-65.05	-33.64	- 2.82	+27.41	+57.05	+ 86.11
	Oil	-45.54	-15.18	+15.18	+45.54	+75.90	+106.26
36	Meal	+ 1.07	+ 1.54	+ 1.42	+ .71	- 0.58	- 2.47
	Total	-44.47	-13.64	+16.60	+46.25	+75.32	+103.79
	Oil	-45.54	-15.18	+15.18	+45.54	+75.90	+106.26
38	Meal	+21.65	+21.54	+20.84	+19.56	+17.68	+ 15.21
	Total	-23.89	+ 6.36	+36.02	+65.10	+93.58	+121.47

*Relative to the standard soybean containing 18 percent oil and 35.86 percent protein.

TESTING SOYBEANS FOR OIL AND PROTEIN

For oil and protein to be included as discount factors in soybean pricing, there must be widespread acceptability of the notion that such a practice would improve pricing and marketing efficiency. The value of benefits accruing to all segments of the marketing system must exceed costs generated by changing present methods of trading. It is not clear whether utilization of oil and protein discounts would increase efficiency in production and distribution of soybeans and soy products.

Processors have the greatest incentive to adopt a pricing scheme that reflects quality differences among soybeans. They currently assume the risk of paying a price for an input that is greater than the value of products derived from it. The reduction in uncertainty gained by processors should be valuable to them. It remains to be determined if additional cost of purchasing new equipment and testing each delivery of soybeans would be surpassed by the benefits of more constant crushing margins.[2] Processors may acquire a satisfactory quality of soybeans by blending them in storage before the milling process begins. Alternatively, processors may reduce the risk of an unprofitable purchase of beans by sampling deliveries from various handlers to allow the formulation of expectations of soybean characteristics on a regional basis. Those processors who are least capable of adjusting to variation in quality of soybeans available for purchase would be the most likely candidates to benefit from a system of oil and protein discounts.

Handlers would be less enthusiastic about changing present marketing practices. Imposition of quality discounts and premiums would lead to additional operating cost without imposing additional revenues on the firm. It is possible that processors and exporters would provide an incentive for handlers to adopt the new standards by imposing discounts on the soybeans they purchase. Operating margins would have to adjust in the long run to allow handlers to earn a normal rate of return.

The costs and benefits to farmers of oil and protein pricing are extremely difficult to ascertain.

[2] Additional cost of estimating oil and protein content is expected to be approximately 20-25 cents per sample.

Since farmers can alter, within limits, the protein and oil content of soybeans through judicious selection of varieties and various cultural practices, the adoption and use of quality discounts and premiums would encourage producers to deliver a product that more accurately reflects market demand [1]. However, the uncertainty involved with forecasting future oil and meal prices, plus the marginal cost associated with changes in cultural practices, might prevent farmers from responding to the existence of protein and oil discounts. Alternatively, risk aversion on the part of producers could lead to a situation in which farmers plant a larger number of varieties in an attempt to reduce the proportion of a total crop that would be discounted heavily.

Prospective penalties or rewards arising from implementation of quality discounts can be sizeable indeed. Figures in Table 2 illustrate the extent to which market prices of a few deliveries of soybeans would have been adjusted had the system been in effect in 1974. Farmers who produced soybeans exhibiting high oil content would have benefited from the relatively high oil prices that prevailed at the time.

TABLE 2. MARKET PRICES PAID FOR SOYBEANS IN 1974 COMPARED TO DISCOUNTED PRICES WHEN THE PRICE OF OIL IS 25 CENTS PER POUND AND THE PRICE OF 44 PERCENT PROTEIN MEAL IS $140 PER TON

County of Observation	Oil Content	Protein Content	Market Price	Discounted Price
Duplin	.18	.38	$7.68	$7.87
Pitt	.19	.37	$7.68	$7.93
Harnett	.19	.37	$7.68	$7.93
Granville	.21	.34	$7.68	$7.94
Alamance	.19	.34	$7.68	$7.64
Randolf	.17	.37	$7.68	$7.63

Additional research is required to identify the most interesting economic implications arising from implementation of a system of discounts and premiums based on the quality characteristics of soybeans. Meanwhile, a few ramifications should become apparent as use of the new infrared optical equipment becomes more common in the industry.

REFERENCES

[1] Nichols, T. E., Jr., J. G. Clapp, Jr. and R. K. Perrin. "An Economic Analysis of Factors Affecting Oil and Protein Content of Soybeans," Economic Information Report No. 42, Department of Economics and Business, N. C. State University, September 1975.