ELASTICITY OF BREAKEVEN PRICES BETWEEN AGRICULTURAL ENTERPRISES

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ABSTRACT

The concept of breakeven price elasticity between agricultural enterprises is introduced. The technique is highly flexible and allows for sensitivity analysis of breakeven prices between enterprises. An application of the approach to corn and soybean production in East Texas indicates that for a fluctuation in the price of soybeans, a lower relative change in the corn price is required for corn production to maintain an equal level of returns above costs.

KEY WORDS: Breakeven prices, elasticity, decision tools

Agricultural producers encounter and must deal with a countless array of varied decisions. Participants in the market face a complex environment that creates a need for simple, practical decision aids. Given the situation of the agricultural production sector, survival of the farm or ranch may depend on implementing sound economic decisions based upon logical analysis of all relevant information. The resources of the agricultural production industry are often readily acceptable to a variety of different enterprises, thus giving producers several options. Breakeven prices thus play an important role in the decision-making process of choosing between enterprises. Beyond the static notion of breakeven prices, however, is the dynamic concept of breakeven price elasticity.

Given the significance of the selection of alternative agricultural enterprises on profits, the need arises for an easy, adequate tool of analyzing the relative importance of these enterprises to an individual farmer or rancher. The objective of this study is to develop a technique to facilitate the decision-making procedures necessary in the selection of production enterprises and to investigate the price sensitivity of the indicated crop mix. Theoretical development of the model is presented first. This is followed by calculations and analytical interpretations of an application to a specific example involving corn and soybean production in East Texas, which precedes summary and conclusions.

THEORETICAL DEVELOPMENT OF THE MODEL

Breakeven analysis involves direct application of the decision-making process, which is often regarded as being comprised of the following interrelated stages: 1) identification of the problem, 2) summarization and organization of relevant data, 3) conceptualization of alternative solutions, 4) analytical determination of an alternative plan to be executed, and 5) active implementation and evaluation of the decision (Bender et al.; Manicus and Kruger). The decision-making process is a logical, stepwise approach to the selection of competing alternatives in order to accomplish a particular goal (Pappas et al.). As such, the process implies an analysis of data and the information that data analysis yields in estimating the optimal activities to pursue. Decisionmaking is also fundamentally inseparable from at least three underlying factors: 1) data which serves as the nucleus of the decision, 2) the analysis of this data as a means by which they are interpreted, and 3) the decisionmaker's personal judgment (Downey and Trocke).

Intertwined in the decision-making process is the need for applicable analytical procedures which can assist in the process of deciding among alternative courses of action. The decision-making process in an agricultural production framework relies upon several analytical techniques including whole farm and partial budgeting (Kay; Luening). Systematic approaches in the development and analysis of farm and ranch enterprise budgets and whole farm budgets can assist in the study and comparison of alternative enterprise mixes (Krenz). Nested within enterprise budgeting techniques is the concept of breakeven analysis which can assist managerial decisionmaking (Kay). Thus, to accomplish the production management decision-making procedure, breakeven analysis as complemented by breakeven price elasticities can be utilized to provide information in the evaluation of agricultural enterprises. Breakeven price analysis has been developed and discussed (Kay; Tucker; Harris), as well as extended and applied (Casey; Collins et al.; Lacewell et al.). The concept of breakeven price elasticities adds a dimension of sensitivity analysis.

Typically, the goal of the agricultural producer is to select the enterprise mix that will maximize the individual's net returns. Of the economic variables (yield being considered a noneconomic variable) which affect net returns, prices of the outputs are probably the most volatile. A practical yet simple model for analysis of this equivalency may be obtained through breakeven comparisons.

To simplify the presentation of the model developed within the context of this study, an example of corn versus soybeans in East Texas is used. Note however that the mathematical research methods derived herein are readily adaptable to other enterprises. Net returns of the crops are estimated as follows:

(1) $NR_c = P_c * Q_c - C_c$

(2) $NR_s = P_s * Q_s - C_s$

Where:

NR_c = net returns of corn per acre, dollars
P_c = price of corn, dollars/bushel
Q_c = quantity of corn per acre (yield), bushels
C_c = production cost of corn per acre, dollars
NR_s = net returns of soybeans per acre, dollars
P_s = price per bushel of soybeans, dollars/bushel
Q_s = quantity of soybeans per acre (yield), bushels
C_s = production cost of soybeans per acre, dollars

An important attribute of this analysis is the great amount of flexibility it possesses. By using variable or total costs, a breakeven equation for either may be estimated. Therefore, one could use breakeven price elasticity above variable costs to analyze the sensitivity of breakeven prices for a producer considering short run enterprises (fixed costs constant). This is because fixed costs would be equal for the enterprises in question. To study the sensitivity of breakeven prices to new production enterprise alternatives where fixed costs have not been incurred, breakeven price elasticity above total costs may be used. As always, the relevant factor is to consider additional costs resulting from the course of action in question. Also, as long as logical consistency is retained, the varied units of the different elements do not alter the model's adaptive characteristics. Thus, stocker cattle may be compared to peanuts if cattle are put on a per acre basis.

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In order to examine the breakeven prices for equivalent net returns between the two products, net returns of the two products are set equal:

(3) $NR_c = NR_s$

Substituting the net return equations for corn and soybeans (equations 1 and 2 respectively) into equation 3 and solving for the price of corn:

(4) $P_c = ((C_c - C_s)/Q_c) + (Q_s/Q_c)P_s$

This linear relation indicates the expected positive functional relationship between P_c and P_s (since both quantities are positive, the slope Q_s/Q_c is also positive). If net returns between the two enterprises are to remain equal, a rise in P_s would by necessity require an increase in P_c.

An additional dimension of flexibility of this analytical procedure is demonstrated in the ability to examine returns above variable costs, returns above total costs, or gross returns for the two enterprises. Notably, this affects the intercept of the breakeven price equation only. Hence, the equations of breakeven prices for returns above variable costs, returns above total costs, and gross returns are parallel.

Several theoretical concepts can be drawn from Equation 4. One underlying notion behind this equation is that of the breakeven responsiveness of one price to the other. This measurement of breakeven elasticity is especially important to producers, individuals in agribusiness and policy makers alike since it would provide information on the percentage change of output price among enterprises required for them to remain equally profitable. It would also provide an indication of which enterprises are most sensitive to price fluctuations thereby signaling that the manager should concentrate attention to those price levels. Breakeven price elasticity between enterprises therefore provides a measure of relative price risk associated with production mix decisions.

By definition, it will be stipulated that breakeven price elasticity is:

(5) $\varepsilon_{BP} = \% \Delta P_c / \% \Delta P_s$

Where:

ε_{BP} = breakeven price elasticity

$\% \Delta P_c$ = percent change in price of corn

$\% \Delta P_s$ = percent change in price of soybeans

This equation illustrates that breakeven price elasticity will provide the percentage change in the price of corn that must accompany a one percent change in the price of soybeans to maintain equal net returns between the two crops. The elasticity of breakeven prices is therefore a measure of the responsiveness of output prices (to other output prices) required to maintain equivalent profits between agricultural enterprises.

Actual calculation of Equation 5 can be tedious when viewed in its definitional form; consequently, further simplification reveals:

$\% \Delta P_c / \% \Delta P_s = (\Delta P_c/P_c) / (\Delta P_s/P_s)$

$= (\Delta P_c/P_c) * (P_s/\Delta P_s)$

$= (\Delta P_c/\Delta P_s) * (P_s/P_c)$

(6) $= (\partial P_c / \partial P_s) * (P_s / P_c)$

Where:

ΔP_c = change in the price of corn

ΔP_s = change in the price of soybeans

Note that $(\partial P_c/\partial P_s)$ is merely the slope of Equation 4 (given exogenous costs and quantities), which is the positive constant of Q_s/Q_c. Substituting this in Equation 6, the final computational equation is derived:

(7) $\varepsilon_{BP} = (Q_s / Q_c) * (P_s / P_c)$

Equation 7 indicates that the ratio of prices is a major factor affecting breakeven price elasticity. In addition, the ratio of quantities (yields) of the agricultural enterprises plays a predominant role as affected by such factors as variable weather conditions and alterations in technology. In order to demonstrate the application of this decision model, an actual example of corn and soybeans is given and the results are analyzed.

RESULTS AND ANALYSIS OF CORN AND SOYBEAN PRODUCTION

Application of this procedure requires data on the quantities yielded per acre for each crop and the relevant costs (variable, total, or none) on a per acre basis for each crop. Using Texas Crop Enterprise Budgets of the East Texas District (Texas Agricultural Extension Service), the case of dryland corn and soybean production for 1988 under typical management is investigated. Corn yield is 70 bu/ac (bushels per acre) and soybean yield is 25 bu/ac. Corn variable costs per acre are \$160.68 while total costs per acre are \$216.30. The variable costs for soybeans are \$122.36 per acre with total costs at \$165.56. The budget prices for corn and soybeans are \$2.86 per bushel (including deficiency payments) and \$6.15 per bushel, respectively. Corn possesses higher returns above variable costs than soybeans (\$39.52/ac compared to \$31.39/ac), but soybeans performed more favorably over total costs than corn. Returns above total costs are -\$16.10 per acre for corn and \$13.81 per acre for soybeans.

Breakeven analysis is implemented with these data in order to assimilate the budgeting procedure across the two crops. Specifically, the sensitivity of the breakeven price of corn that maintains net returns equal to those of soybeans are studied under fluctuating soybean prices. Within the context of this decision framework, the appropriate data is substituted into Equation 4 and simplification is performed. For analysis of returns above variable costs the breakeven price of corn is given by:

$P_c = (160.68 - 122.36) / 70) + (25 / 70)P_s$

$P_c = 0.55 + 0.3571\ P_s$

Similarly, regarding consideration of total costs, the following is obtained:

$P_c = (216.30 - 167.56) / 70) + (25 / 70)P_s$

$P_c = 0.70 + 0.3571\ P_s$

The intercept of the total costs breakeven corn price equation is greater than that of variable costs as expected given that corn is more profitable than soybeans over variable costs and soybeans are more profitable than corn with respect to total costs. Additionally, by setting the price of soybeans at the budget price of \$6.15, the breakeven corn price of \$2.75 for variable costs and \$2.90 for total costs is calculated. While this unto itself may prove beneficial in the decision-making process, uncertainty of prices creates a fundamental concern in production planning. The agricultural manager is likely to also consider the responsiveness of the breakeven price of one enterprise as the price of the other enterprise changes. Study of breakeven price elasticities enables this sensitivity analysis to be performed. Solving Equation 7 with the data provided indicates:

$\varepsilon_{BP} = (25/70) * (P_s / P_c)$

$\varepsilon_{BP} = (0.3571) * (P_s / P_c)$

For the budget price of soybeans and the computed breakeven corn prices, the elasticity of breakeven prices is found to be 0.80 for returns above variable costs (0.3571 * 6.15/2.75 = 0.80) and 0.76 for returns above total costs (0.3571 * 6.15/2.90 = 0.76). This means that, at this breakeven price level, the price of corn must increase only 0.80% for every 1.00% the price of soybeans increases to remain equally profitable over variable costs. Likewise, a 0.76% increase in the price of corn is required to retain equal returns above total costs when the soybean price rises 1.00%. Alternately, however, soybeans can sustain a greater decrease in price relative to corn to retain equivalent returns. Thus, breakeven corn prices to soybean prices are inelastic at this level for the conditions analyzed indicating the relatively higher price risk associated with soybean production decisionmaking. With the uncertainty of prices, an individual farmer may prefer corn to soybean production under situations of increasing prices of the two crops but prefer soybean production when the crop prices are declining given the resulting breakeven price elasticity. It further denotes that economic decisions regarding production between the two substitutes are somewhat sensitive to price alterations. As the elasticity increases, farm managers should concentrate more heavily upon price levels in decisionmaking. Thus, if the breakeven corn price elasticity between soybeans exceeds the elasticity between corn and sorghum, farm managers might pay closer attention to soybean price as a more sensitive substitute for corn production.

More detailed breakeven analysis results are provided for returns above variable costs in Table 1. Breakeven corn prices and breakeven price elasticities are shown for selected soybean price levels. A one dollar increase in soybean price must be accompanied by about a $0.36 increase in corn price for breakeven status between production of the crops to be obtained with regards to returns above variable costs (Figure 1). Note that the slope of the breakeven equation of 0.36 is less than the budget ratio of corn price to soybean price at 0.47. This reinforces the potential advantage of corn production for a farmer in a breakeven situation between the two agricultural enterprises. It also indicates the need for careful evaluation of all relevant information in production management decisionmaking. Recall that under the conditions projected under static budget analysis, however, a farmer would not be operating in a breakeven situation between the two crops. The breakeven corn price elasticities increase over the entire range studied, more sharply at first and less so with increasing soybean prices. This is also depicted graphically in Figure 2, which displays the breakeven corn price elasticity increasing at a decreasing rate with respect to soybean prices.

Breakeven analysis of returns above total costs provide results similar to those found for variable costs as demonstrated in Table 2. The linear relationship between breakeven corn price and soybean price under total cost considerations is graphically presented in Figure 3. Breakeven price elasticity again increases at a decreasing rate. Higher breakeven corn price are required for total cost considerations, as depicted by the parallel lines between Figure 1 and Figure 3. Noticably, the only difference between variable and total cost breakeven analysis equations is the intercept. The characteristic inelastic breakeven corn price to soybean price is present for total cost analysis as it is for variable costs (Figure 4). The general structure of the breakeven price elasticity is similar for both variable and total costs (Figure 2 and Figure 4).

TABLE 1. BREAKEVEN CORN TO SOYBEAN PRICES AND BREAKEVEN CORN TO SOYBEAN PRICE ELASTICITIES FOR RETURNS ABOVE VARIABLE COSTS.

SOYBEAN PRICE	BREAKEVEN CORN PRICE	BREAKEVEN PRICE ELASTICITY
0.00	0.55	0.0000
0.50	0.73	0.2460
1.00	0.90	0.3948
1.50	1.08	0.4946
2.00	1.26	0.5661
2.50	1.44	0.6199
3.00	1.62	0.6618
3.50	1.80	0.6954
4.00	1.98	0.7230
4.50	2.15	0.7459
5.00	2.33	0.7654
5.50	2.51	0.7820
6.00	2.69	0.7965
6.50	2.87	0.8092
7.00	3.05	0.8204
7.50	3.23	0.8303
8.00	3.40	0.8392
8.50	3.58	0.8472
9.00	3.76	0.8545
9.50	3.94	0.8611
10.00	4.12	0.8671
10.50	4.30	0.8726
11.00	4.48	0.8777
11.50	4.65	0.8824
12.00	4.83	0.8867
12.50	5.01	0.8908

NOTE: Calculations are based on the following data from Texas Agricultural Extension Service.

	UNITS	SOYBEANS	CORN
YIELD	BU/AC	25.00	70.00
VARIABLE COSTS	$/AC	122.36	160.68

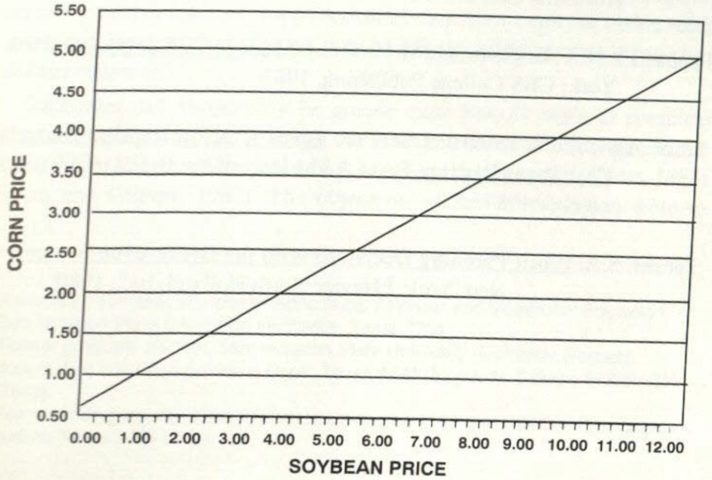

FIGURE 1. BREAKEVEN PRICE FOR CORN AND SOYBEANS RETURNS ABOVE VARIABLE COSTS

TABLE 2. BREAKEVEN CORN TO SOYBEAN PRICES AND BREAKEVEN CORN TO SOYBEAN PRICE ELASTICITIES FOR RETURNS ABOVE TOTAL COSTS.

SOYBEAN PRICE	BREAKEVEN CORN PRICE	BREAKEVEN PRICE ELASTICITY
0.00	0.70	0.0000
0.50	0.87	0.2041
1.00	1.05	0.3390
1.50	1.23	0.4348
2.00	1.41	0.5064
2.50	1.59	0.5618
3.00	1.77	0.6061
3.50	1.95	0.6422
4.00	2.12	0.6723
4.50	2.30	0.6977
5.00	2.48	0.7195
5.50	2.66	0.7383
6.00	2.84	0.7548
6.50	3.02	0.7693
7.00	3.20	0.7822
7.50	3.37	0.7937
8.00	3.55	0.8041
8.50	3.73	0.8134
9.00	3.91	0.8219
9.50	4.09	0.8297
10.00	4.27	0.8368
10.50	4.45	0.8434
11.00	4.62	0.8494
11.50	4.80	0.8550
12.00	4.98	0.8602
12.50	5.16	0.8651

NOTE: Calculations are based on the following data from Texas Agricultural Extension Service.

	UNITS	SOYBEANS	CORN
YIELD	BU/AC	25.00	70.00
TOTAL COSTS	$/AC	167.56	216.30

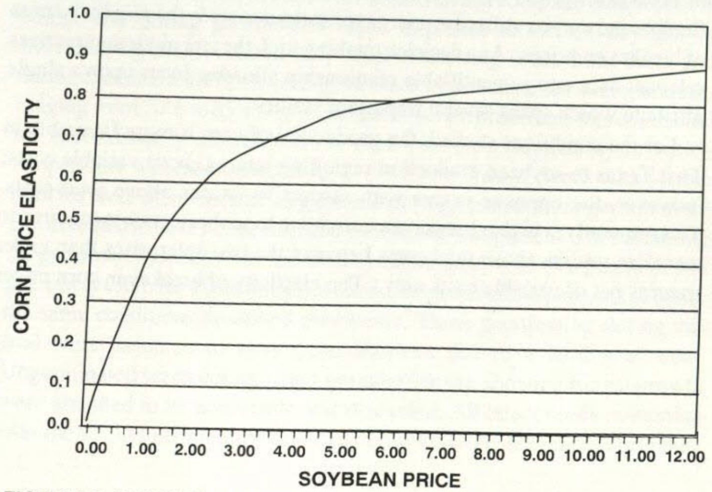

FIGURE 2. BREAKEVEN PRICE ELASTICITY FOR CORN AND SOYBEANS RETURNS ABOVE VARIABLE COSTS

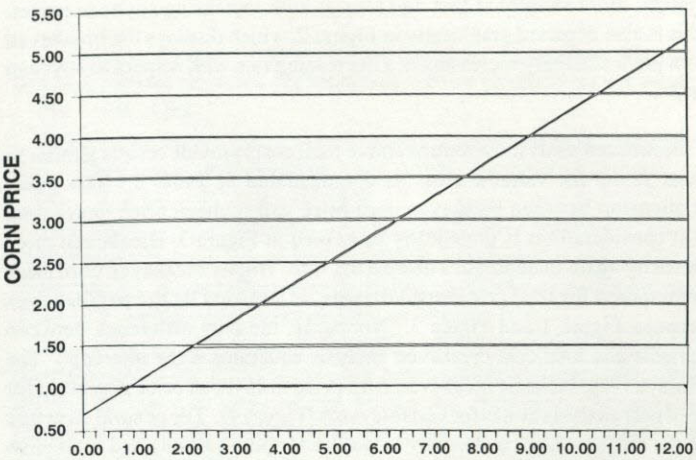

FIGURE 3. BREAKEVEN PRICE FOR CORN AND SOYBEANS RETURNS ABOVE TOTAL COSTS

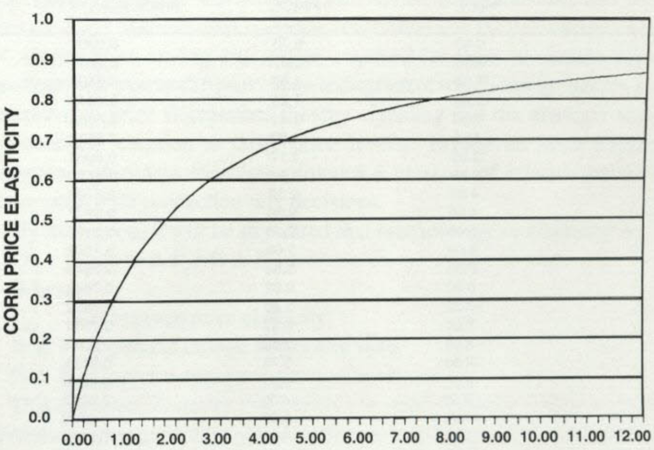

FIGURE 4. BREAKEVEN PRICE ELASTICITY FOR CORN AND SOYBEANS RETURNS ABOVE TOTAL COSTS

SUMMARY AND CONCLUSIONS

The concept of breakeven price elasticity allows for sensitivity analysis of breakeven prices between agricultural enterprises. The procedure is flexible and may be utilized in many applications to study the responsiveness of breakeven prices. As a decision-making tool, the technique summarizes relevant data into a quantifiable relationship allowing focus upon a single attribute which spans several important factors.

For the conditions studied, the production of corn is more favorable in East Texas to soybean production regarding returns above variable costs; however, the opposite is true with respect to returns above total costs. Consequently, a higher breakeven corn price to soybean price is required to equalize returns above total costs between the two enterprises than under returns net of variable costs only. The elasticity of breakeven corn prices is inelastic relative to soybean prices in terms of both returns above variable costs and returns above total costs for East Texas as based upon projections for 1988 derived from budget analysis (Texas Agricultural Extension Service). The breakeven corn price elasticity, under both variable and total cost analysis, demonstrates characteristics of increasing at a decreasing rate in relation to rising soybean prices. As soybean prices alter, less relative fluctuation in corn price is needed to keep corn production on an equal level of returns with soybean production.

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