Using Breakeven Methods to Assess Financial Feasibility in Food Processing Firms: A Case Study in Pecan Shelling

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Linear and nonlinear cash breakeven analyses are applied to a pecan shelling firm to assess the feasibility of acquiring a long-term loan for operating capital. The linear analysis is used to find effects of varying volume under average price conditions. The nonlinear breakeven is developed and applied to capture the effects of changing margins due to aggregate production changes. Combination analyses are used to examine effects of changes in market share and aggregate production.

Two principal concerns in the financial management of any business are level and variability of profit. Adequate profitability is essential to reward owners and pay creditors. However, even with adequate average profits, occurrences of profits lower than the average can cause cash flow problems in servicing debt commitments and paying fixed cash costs. Macroeconomic factors are primary sources of profit variability for businesses in most industries. Recessions associated with business cycles cause declines in sales and profits. Inflation, which has been important in recent years, also can cause reductions in profits if input prices increase at a faster rate than output prices. Besides these general economic factors, food processing firms also are subject to variability in cost, price, and volume of output which arise from variability in the supply of unprocessed commodities caused by the biological nature of agricultural production. The resulting variability in sales is particularly a problem for new or expanding firms. Such firms often have high fixed cash requirements for servicing loans used to finance operating and fixed capital combined with limited knowledge of their ability to achieve the new planned sales volume.

Breakeven analysis is a classic technique to analyze the interaction among

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fixed costs, total costs, sales, and profit for varying volume of sales. Breakeven analyses are commonly presented in managerial accounting and financial management texts. However, few case studies exist that demonstrate its application to agribusiness and particularly illustrate special problems which can arise in an actual analysis. The limited case studies available in the agricultural economics literature generally concern farm applications—Menkhaus and Adams[1] and Musser, Tew, and Clifton[2] are examples. Farr and Musser's[3] study of livestock auction barns is a recent exception. These studies all follow the conventional linear analysis in which price of output is assumed constant as volume of sales vary. The linear assumption generally is appropriate for assessments of short-run profitability or financial feasibility when prices can be assumed constant, or for long-term assessments when expected prices can be used. However, for food processing firms, variations in volume of sales arising from fluctuations in agricultural production are associated with changes in prices of output and raw commodities. To analyze the combined price and volume effect for this situation, nonlinear breakeven techniques can be beneficial.

This paper presents a case study using both linear and nonlinear breakeven techniques to consider the financial feasibility of a long-term loan for a pecan shelling firm in Georgia. The techniques are used to assess liquidity problems arising from variability of net cash flow due to market share (volume changes with no concomitant price changes) and aggregate production changes (volume changes with concomitant price changes). Considerable attention is devoted to development of data necessary for the analyses, which were quite limited for some of the relevant variables and relationships. As a preliminary to the analyses, an overview of the pecan industry and the case firm is presented, and the general linear breakeven framework is reviewed and adapted for applying to the case firm problem. The linear adaptation is used as the basis for developing and applying the nonlinear model.

AN OVERVIEW OF THE PECAN INDUSTRY AND THE CASE FIRM

Pecans are produced in the Southern United States with producing areas ranging from Arizona to the Atlantic Ocean. Georgia has the largest production with Texas usually second; other major producing states include Oklahoma, Louisiana, and Alabama.[4] Production in the United States and Georgia for years immediately proceeding the case study are shown in Table I.[4,5] The problem of variability of raw commodity supply faced by firms in food processing industries is especially true for pecan shellers. Pecan production characteristically occurs in an alternating pattern; high yields in one year frequently are followed by low yields the next, and visa versa. It is not uncommon for yields in Georgia to decrease by 40% from one year to the next. Total US production follows a similar pattern. Cash flow variability associated with these fluctuations in pecan production is therefore a crucial problem in financial management of a firm in the pecan industry.

As with other tree nuts, most pecans are marketed to the consumer in shelled form or further processed forms such as candy. Shelling generally is done shortly after harvest to minimize the volume in refrigerated storage. Shelling is therefore a crucial function in the marketing process. Shelling firms acquire the inshell

Table I. Total Pecan Production in the United States and Georgia 1967–1976.[a]

Year	1000 Pound Inshell	
	United States	Georgia
1967	231,900	55,000
1968	192,400	42,000
1969	225,100	88,000
1970	154,600	54,000
1971	247,200	90,000
1972	183,100	48,000
1973	275,700	100,000
1974	137,100	58,000
1975	246,800	75,000
1976	103,100	52,000

[a]Sources: *Agricultural Statistics* and *Georgia Agricultural Facts*.

pecans from the producers at harvest, shell the pecans, and store them until they are packaged for direct consumer use or acquired by firms higher in the marketing channel. Because of the seasonal harvest, working capital requirements to finance seasonal inventories and accounts receivable as pecans are sold are quite high for such firms. Vertical integration back to commodity production and forward to further processing and/or wholesaling and retailing may reduce working capital requirements, but integrated firms do not account for all pecan marketing. Pecan shelling is quite competitive as compared to many other food processing industries. None of the shelling firms in Georgia appeared to have market share enough to affect prices of raw or shelled pecans, and none were publicly held corporations at the time of this study. Entry of new firms, which is the situation of the case firm, is feasible.

The firm of this case study is located in Southwest Georgia, the primary pecan producing area. The firm began operation in 1973 with a new shelling plant with a projected annual shelling capacity of 2–5 million pounds of inshell pecans. The firm is integrated into pecan production, growing 7–25% of the projected shelling capacity, depending on fluctuating annual output. As with many new firms, limited working capital from long-term sources has not been available; thus operations began at levels far below projected plant capacity. The purpose of this study was to assess the cash flow feasibility of a long-term loan for working capital which would enable the firm to acquire and store an inventory of pecans sufficient to approach the capacity of the existing facilities and finance sales on accounts receivable. The annual servicing requirements of the loan was $50,000.

ADAPTATION OF THE BREAKEVEN FRAMEWORK

Breakeven analysis more appropriately may be thought of in terms of a cost–volume–profit relationship. This relationship may be defined by

$$I = PQ - WQ - F, \qquad (1)$$

where I is net income, P is the price of output, W is the per unit variable cost of output, Q is the quantity of output, and F is the fixed cost. Breakeven is the condition in which $I = 0$. In this case Eq. (1) can be arranged in the standard contribution margin breakeven framework[6]:

$$Q = F/(P - W). \tag{2}$$

This form allows easy calculation of the physical quantity of sales needed in order to cover all costs. The use of this framework assumes P is constant and W is constant over the relevant range of output. The assumption of a constant W is justified for food processing firms by noting that the amount of total operating time necessary at a fixed output level per unit of time is an important decision variable for such firms.[7]

Two alterations of the standard framework were necessary for this study. First, a cash breakeven formulation was used to focus on the volume of sales for debt repayment feasibility. This alteration replaces fixed cost (F) in Eq. (2) with fixed cash commitments (FC); FC includes the cash components of F plus the $50,000 debt servicing requirement. The second adjustment in the analysis reflects raw material costs (inshell pecans in this case) in the total revenue relationship, rather than in the total variable cost relationship. That is, the price of output (P) in Eq. (2) is replaced with per-unit gross shelling margin (m) defined as

$$m = P_s - P_i, \tag{3}$$

where P_s is the price of shelled pecans per unit of shelled pecans and P_i is the price of inshell pecans per unit of shelled pecans. This adaptation reflects the gross margin as the value of processing added by the firm. This allows the analysis to focus on the joint effects of fluctuations in aggregate production of pecans on the price of inshell and the price of shelled pecans. Using the gross margin concept greatly simplifies the nonlinear analysis compared to separately relating shelled and inshell prices to production. With these two alterations, the basic breakeven relationship used in this study is

$$Q = \mathrm{FC}/(m - w), \tag{4}$$

where w is variable cost per unit of output excluding raw material (inshell pecan) cost.

The breakeven analysis in this study focuses on the impact of variations in sales on the ability to meet fixed cash commitments. Two conceptually separate analyses of variation in sales are presented. The first analysis, which is a conventional linear breakeven analysis, considers the consequences of failure to achieve the projected market share due to procurement, processing, or marketing difficulties. This linear analysis uses a constant per unit gross margin which implicitly assumes that aggregate production and price are constant as the firm's volume varies. Because the purpose of the loan was to allow expansion of output, the linear analysis was helpful in exploring consequences of not achieving projected volume requirements. This conventional analysis focused on average values of m, which does not account for short-run variations in m as aggregate production of the unprocessed commodity varies. The second analysis considers the short-run consequences of varying aggregate pecan production under the assumption that the firm achieves its projected market share. A nonlinear breakeven technique allows per unit gross margin to vary as aggregate production changes.

LINEAR BREAKEVEN

An initial step in analyzing the cash breakeven point was to develop cost relationships for the firm. This requirement necessitates separation of costs into variable, fixed cash, and fixed noncash costs. The results of this procedure are presented in Table II. These data represent management projections for 1979 based on historical experience of the firm, given adequate operating capital. These total costs represent an output level of 851,400 pounds of shelled pecans (1.935 million pounds inshell). The classification of costs follow standard procedures, although some arbitrary decisions were necessary in some classifications. Semivariable costs, such as telephone and utilities, have a fixed component that does not vary with production. The fixed components of these costs were based on cost levels occurring in 1977 when production was close to zero. The cost of inshell pecans is not included in Table II because it is incorporated in the total gross margin.

Cost variables for the breakeven analysis were developed from data in Table II. Total variable cost, excluding the cost of inshell pecans, is \$317,029 for sales of 851,400 pounds of shelled pecans (0.8514 million pounds). Thus, the variable cost per million pounds of shelled pecans (average variable cost per million pounds) is

$$w = \frac{\$317,029}{0.8514} = \$372,362. \qquad (5)$$

The total variable cost relationship in million pounds of shelled pecans is therefore

$$w = \$372,362 \times (\text{million lb. shelled pecans}). \qquad (6)$$

The total fixed cash commitment (FC) is \$255,978, which includes \$205,978 of fixed cash costs (Table II) plus \$50,000 of loan payment requirements. The total cash outlay equation was developed by adding the total variable cost relationship to the fixed cash commitment:

$$\begin{aligned} TC &= FC + wQ \\ &= \$255,978 + \$372,362Q. \end{aligned} \qquad (7)$$

A total gross margin relationship was developed in a manner similar to that of total variable cost. Management projections for 1979 were 0.8514 million pounds of shelled pecans at \$2.20 per pound for a total revenue of \$1,873,080. The inshell pecans necessary for the 0.8514 million pounds of shelled pecans were projected to cost \$1,257,750 (1,935,000 lb. × \$0.65 per lb., implying a 44% shelling yield). Total projected gross margin on the shelled pecans is therefore \$615,330. Dividing this total margin by 0.8514 yields the margin relationship on a million pounds basis:

$$\begin{aligned} mQ &= \$615,330/0.8514 \times (\text{million lbs. shelled pecans}) \\ &= 722,727 \times (\text{million lbs. shelled pecans}). \end{aligned} \qquad (8)$$

Table II. Separation of Projected Total Cost by Cash Fixed Cost, Noncash Fixed Cost, and Variable Cost for an Output Level of 851,500 Pounds of Shelled Pecans for Case Firm in SW Georgia, 1979.[a]

Cost Item	Cash Fixed Costs	Noncash Fixed Costs	Variable Costs
Plant Insurance	$10,224		
Plant Salaries	39,000		
Plant Wages			$101,794
Plant Fuel			8745
Plant M&R Buildings	600		
Plant M&R Equipment			6600
Plant Payroll Taxes	3718		9703
Plant Sanitation			2840
Contract Labor			1155
Auto and Labor			1373
General Supplies			1485
Cold Storage			10,560
Plan Deprec.		$52,896	
Plant Utilities	1500		6330
Boxes and Bags			30,342
Plant Advalorem Tax			2200
Freight			47,820
Brokerage			39,814
Travel			2640
Advertising			2100
Samples			950
Lost and Damaged Merch.			335
Other Selling Exp.			1515
Education and Promotion			200
Cash Discounts			1990
NYTCO Services			8030
Salaries Adm.	56,844		
Office Exp.			1325
Telephone	1000		2900
Utilities	4200		
Taxes & Licenses	810		
Employee Benefits	1620		
Auto Expense			2400
Prof. Fees	3310		
Equip. Rental	3600		
Adm. Payroll Taxes	600		
Misc.			1200
Insurance	1500		
Interest	72,917		15,705
Dues and Subscript	400		
Bad Debts			4977
TOTAL	$205,978	$52,896	$317,029

[a]Source: Management Projections for Case Firm.

To determine the breakeven quantity of shelled pecans, total margin, Eq. (8), is set equal to total cash outlay, Eq. (7); the resulting equation is

$$mQ = FC + wQ,$$

$$Q = FC/(m - w) \qquad (9)$$

$$= \$255{,}978/(\$722{,}727 - \$372{,}362)$$

$$= 0.730604 \text{ million lb. shelled pecans.}$$

This analysis indicates that the quantity of sales necessary to break even under the assumed market conditions is 730,604 pounds of shelled pecans. Therefore, the quantity projection of 851,400 pounds is more than adequate to cover projected cash commitments. The breakeven amount is 85.8% of the projected sales quantity. This result indicates that the quantity of sales actually realized at this per-unit gross margin cannot be more than 14.2% below the projected amount and the firm still cover its cash commitments.

Figure 1 shows the graphical solution of Eq. (9). The breakeven point occurs where the total gross margin line intersects the total cash outlay line. The figure also allows a quick visual solution of changes in cash margins above (below) cash commitments due to changes in volume of sales, assuming constant per-unit gross margin and variable costs. The cash amounts below cash commitments indicate the amount of extra financing that must be available for the firm to meet cash needs at each volume.

NONLINEAR BREAKEVEN

The linear breakeven analysis was concerned with the ability to meet cash commitments associated with various sales volumes under the assumption of a constant margin. Another consideration involves fluctuation of volume and margin due to variation of aggregate production of raw commodities. To analyze the impact of fluctuating aggregate production, the relationship between per-unit margin and aggregate production must be established. By assuming that the firm maintains a constant market share of aggregate production, margin values can be associated with the level of procurement and processing of the firm. The market share used in this analysis was based on management's projection that a 2-million pound average of inshell pecans (approximately 880,000 lbs. shelled) can be procured and processed. With an average national production of approximately 197 million pounds inshell, the firm's approximate market share would be 1.015%.

Estimation of the relationship between margin and aggregate production was complicated because of the structure of the pecan shelling industry. Data for Southeastern shellers were not available because these firms are privately owned and data are confidential. The only available time-series data were quarterly margins for a Texas firm for 1972–1977 production years. Assuming that margins for the Texas firm represent margins for the case firm, margin data were regressed on national production and time. Time was included as a proxy for effects of

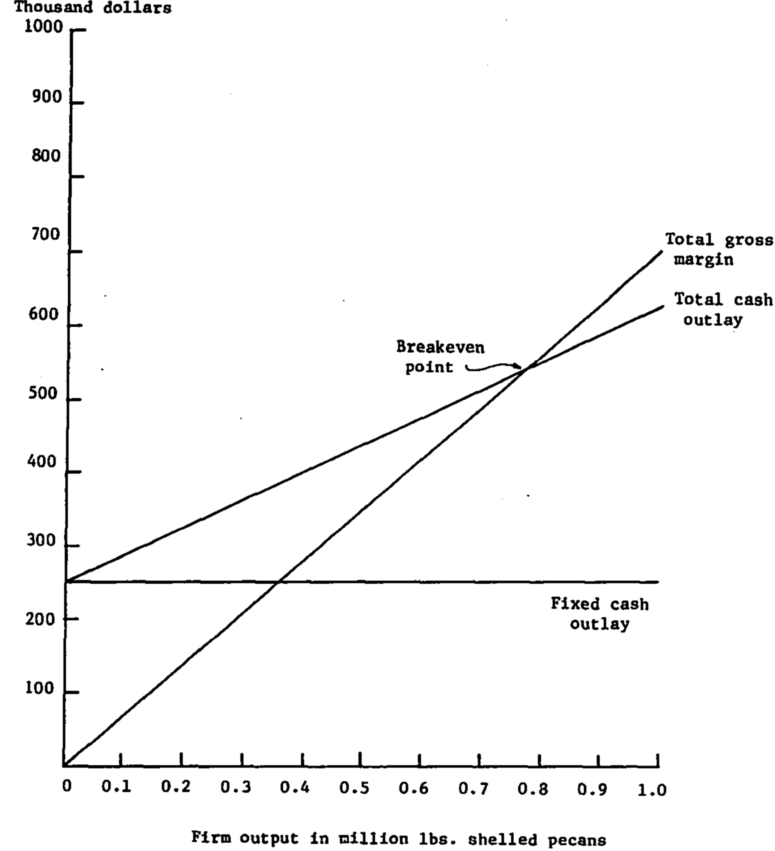

Figure 1. Linear Breakeven Chart for Management Projections, Case Firm, SW Georgia, 1979.

inflation and other secular trends on the margin. Regression results are

$$
\begin{aligned}
&\text{margin/million lbs. inshell pecans} \\
&= -66{,}699.60 + 800.80 \times (\text{million lbs. inshell national production}) \\
&\quad (-3.15) \qquad\quad (9.83) \\
&\quad + 10{,}991.20 \times (\text{time}), \\
&\qquad (5.38)
\end{aligned}
\tag{10}
$$

$$R^2 = 0.954, \qquad DW = 1.77.$$

The t-statistics for the parameters are given in parentheses. The value of these statistics indicate that parameter estimates on quantity, time, and the intercept are significantly different from zero at the 0.01, 0.01, and 0.05 levels, respectively. The R^2 value of 95.4% and the Durbin–Watson statistic of 1.77 indicate good statistical fit and no serial correlation, respectively.

The positive coefficient on time indicates that inflation and other secular trends have increased the margin in pecan shelling. The positive coefficient on the quantity variable indicates that margins vary directly with production. This direct variation implies that the price of shelled pecans is less responsive to production changes than inshell prices. This result is consistent with margin theory which assumes a positively sloped supply function for marketing services. With such a supply function the derived demand function for raw commodities will have a steeper slope than the demand for the final product. This condition implies that marketing margins increase with volume produced (quantity supplied).[8]

A nonlinear total margin equation for the case firm was developed from a transformation of the regression equation. The first step involved valuing the time component of the equation for the fourth quarter value in 1979, which is when most of the 1979 crop is harvested and processed. Combining the value for time with the intercept value yields:

$$\text{margin/million lbs. inshell pecans} = 164{,}115 + 800.80 \times (\text{million lbs. inshell national production}). \quad (11)$$

The per-unit margin function given by Eq. (11) was converted to a per-unit margin function based on the firm's production. Assuming that the firm maintains its 1.015% market share, the coefficient on the quantity variable on the right side of Eq. (11) was divided by 0.01015. This transformation yields the following per-unit margin function based on the firm's quantity procured and processed:

$$m_i = 164{,}115 + 78{,}879Q_i, \quad (12)$$

where m_i is the margin per million pounds of inshell pecans and Q_i is a million pounds of inshell pecans processed by the firm. Equation (12) is converted to the firms total margin equation by multiplying both sides by the total quantity (in million pounds inshell pecans) procured and processed by the firm. This step gives the quadratic total margin equation as follows:

$$m_iQ_i = 164{,}115Q_i + 78{,}879Q_i^2. \quad (13)$$

Admittedly, several unrealistic assumptions were necessary to develop Eq. (13). Regressing unit margin for the case firm or a similar firm in Southwest Georgia would have been preferable to the Texas firm if data were available. Nevertheless, comparing a prediction from (13) with some data from the firm helps validate the procedure in this analysis. Management of the case firm projected a margin of $615,330 for 1979 based on processing 1.935 million pounds inshell. If the processed quantity represents the planned market share of 1.015% of national production, then the national production would be 190.64 million pounds of inshell pecans in 1979. The prediction from Eq. (13) based on this level of production is $612,900. This estimate has less than a 1% error from management projections, which is a low prediction error and supports this analysis.

Equation (13) was used in finding the quantity of pecans necessary for the firm to breakeven, assuming that the firm maintains a constant 1.015% national market share. The total cash outlay, Eq. (7), developed in the previous section was utilized in the analysis by changing the units of Q from shelled to inshell. This change is accomplished by multiplying the coefficient on Q in Eq. (7) by the 44% shelling yield to give

$$\mathrm{TC} = 255{,}978 + 163{,}958Q_i. \tag{14}$$

The nonlinear breakeven point is determined by equating the quadratic margin, Eq. (13), to the total outlay, Eq. (14), and determining the positive root of the equation. Therefore, the breakeven equation is

$$78{,}879Q_i^2 + 157Q_i - 255{,}978 = 0. \tag{15a}$$

Solving for Q_i with the quadratic formula,

$$Q_i = \frac{-157 + [(157)^2 - 4(78{,}879)(-255{,}978)]^{1/2}}{2(78{,}879)}$$
$$= 1.8004 \text{ million pounds inshell.} \tag{15b}$$

The algebraic solution indicates that the firm must acquire and process 1.8004 million pounds of inshell pecans (792,176 pounds shelled) in order to break even, if it achieves the national market share of 1.015%. This quantity implies a national production of approximately 177.38 million pounds of inshell pecans in 1979. This national production level is approximately 90% of the 1967–1976 national production average. This analysis supports the linear breakeven results by indicating that on average the firm can cover its cash commitments from current operating income. However, an aggregate production variation of about 10% below the average will cause the firm to be unable to meet its cash commitments, assuming that it cannot increase its market share.

The approximate probability of incurring cash flow problems arising from variations in aggregate production can be evaluated by comparing the nonlinear breakeven quantity of aggregate production with historical production figures. Historical data for the United States indicates aggregate production was below the breakeven level in three of 10 years between 1967 and 1976. Therefore, the firm should expect several years of cash operating losses during the life of the loan. For the loan to be feasible the firm must have liquidity reserves to overcome these short-term cash losses. These liquidity reserves may be from credit or earnings retained from years of high aggregate production. An increase in the market share of the firm without new fixed cash commitments is also a strategy to buffer the effects of aggregate production variations.

Figure 2 is a graph of the solution of Eq. (15). As before, the breakeven point occurs where the total margin line intersects the total cash outlay line. The figure allows a quick visual solution of changes in the net cash flow due to changes in aggregate production, assuming a constant market share. Note that in this figure the total margin line has an increasing slope. Thus, decreases in aggregate production have two negative effects on the firm: (a) the volume of the firm decreases if market share cannot be increased and (b) the per-unit margin decreases. These effects imply that each incremental decrease in aggregate production has a larger negative impact on the firm's ability to meet cash commitments.

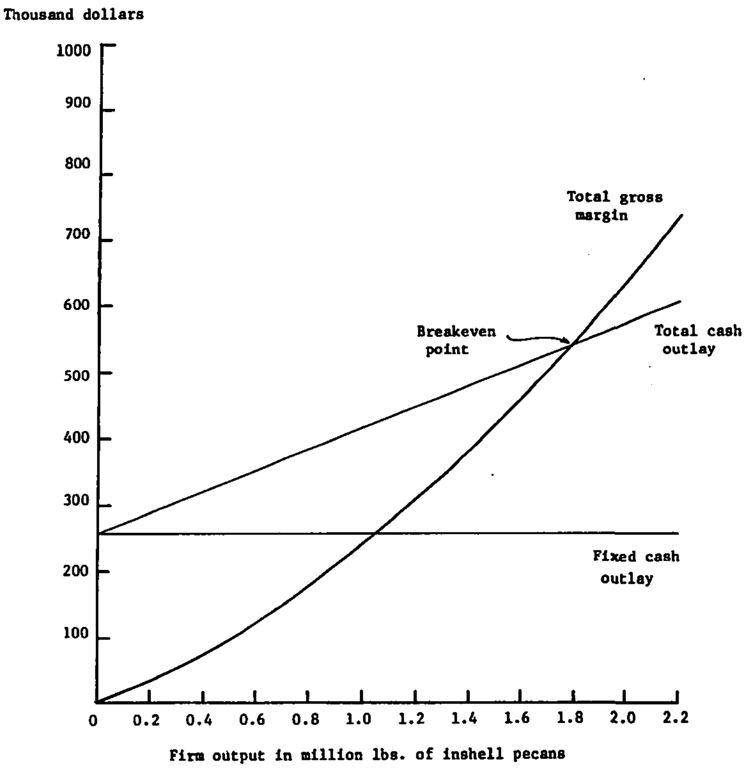

Figure 2. Nonlinear Breakeven Chart for Management Projections of Average Conditions, Case Firm, SW Georgia.

COMBINED ANALYSIS

Although the firm is located in a major pecan producing area of the United States, the production level in the procurement area of the firm may vary enough from national production to affect the firm's ability to achieve its target national market share. Thus, effects of aggregate production and market share achievement need to be considered simultaneously. This can be accomplished by combining the analyses of the last two sections into one analysis. Focusing on the volume of output of the firm, the effect that aggregate production and market conditions have on breakeven volume can be assessed by varying the margin used in the linear analysis. Each aggregate production level considered has a per-unit margin associated with it based on the relationship established by Eq. (11). Figure 3 demonstrates three different aggregate production levels, hence, three different total margin lines. Aggregate production levels of 125, 175, and 225 million

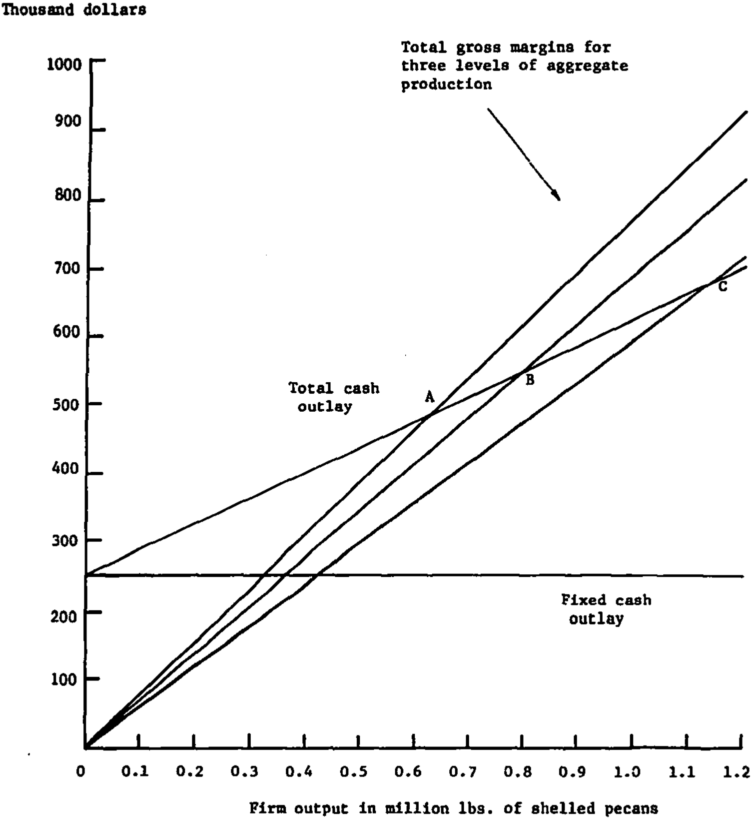

Figure 3. Linear Breakeven Chart for Three Aggregate Production Levels, Case Firm, SW Georgia, 1979. (Note: A, B, and C Are Breakeven Points Assuming Aggregate Production of 225, 175, and 125 Million Pounds of Inshell Pecans, Respectively.)

pounds of inshell pecans were considered. Transforming results of (11) to million pounds of shelled pecans gives per-unit margins of $600,489, $691,489, and $782,489, respectively. The fact that higher aggregate production implies higher per-unit margins allows the firm's breakeven quantity to decrease as aggregate production increases. The graph shows that the firm's breakeven volume is approximately 0.624 million pounds of shelled pecans when aggregate production is 225 million pounds of inshell pecans, a market share of only 0.63%. However, with aggregate production of 125 million pounds inshell, the firm is required to produce 1.1221 million pounds shelled in order to break even, a 2.04% market share. Therefore, unless local production is contrary to national production, which generally is not the case, breakeven in low production years is quite difficult to attain because a higher absolute breakeven quantity is required at the same time low production occurs.

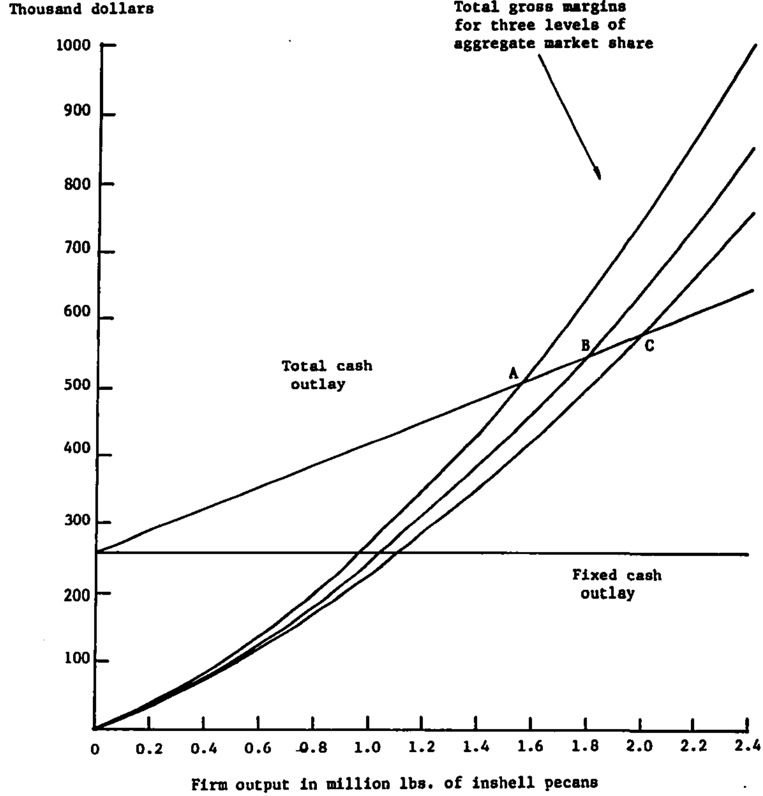

Figure 4. Nonlinear Breakeven Chart for Three Aggregate Market Share Levels, Case Firm, SW Georgia, 1979. (Note: A, B, and C Are Breakeven Points for 0.75, 1.00, and 1.25% of Aggregate Production, Respectively.)

Alternatively, the effects of achieving various market shares, while aggregate production varies, can be addressed by the nonlinear framework. This analysis requires reformulating Eq. (13) to reflect each market share analyzed. Figure 4 demonstrates three different market share targets. Market shares of 0.75, 1.00, and 1.25% of aggregate production are considered. Breakeven amounts were found by equating each transformed Eq. (13) with Eq. (14) and solving with the quadratic formula. The breakeven quantities in million pounds of inshell pecans processed by the firm are 1.5476, 1.7869, and 1.9977 for market shares of 0.75, 1.00, and 1.25%, respectively. Note that the firm's breakeven amount given a small market share is smaller than the breakeven amount given a large market share. These differences in breakeven amounts occur because margins increase as aggregate production increases, and aggregate production must increase as market share decreases to achieve the breakeven amount. Therefore, the firm with a smaller market share is less likely to achieve breakeven quantities, even though the firm's breakeven quantity is less. Comparing the breakeven aggregate production requirement for each market share with historical aggregate production data gives approximate probabilities of meeting cash flow requirements under each market share condition. Using the historical period 1967–1976, approximate breakeven would be achieved 50, 70, and 80% of the time for 0.75, 1.00, and 1.25% market shares, respectively.

SUMMARY

Breakeven analyses often are used to specify a firm's cost–volume–profit relationships in order to analyze profitability and/or financial feasibility. The conventional breakeven model assumes linear revenue and per-unit variable costs. These assumptions are not excessively restrictive for firms which face fairly constant input and output prices and operate in a relevant range of volume for the plant or for long-run analyses using expected values. However, for short-run analyses these assumptions have more severe limitations for firms, such as food processing firms, which face varying raw commodity and product prices, and, thus, whose profitability depends on the gross margin from processing as well as volume of products sold. This paper demonstrated how alternative breakeven techniques can be developed and used in assessing various sources of profitability or cash flow problems for such firms. The case of a pecan shelling firm was used to demonstrate the techniques.

A linear breakeven analysis was used to assess the volume needed to cover all cash commitments, given constant prices. Modifications from the standard linear model replaced revenue with processing margin and excluded raw commodity cost from per-unit variable cost. These modifications allowed easier development of a nonlinear model based on varying product and raw commodity prices in which a margin relationship exists. The nonlinear analysis incorporated impacts of both volume and gross margin changes caused by variations in aggregate production of the raw commodity, given a constant market share. Given a market share target, aggregate production needed for breakeven was compared to historical production data to obtain an estimate of the probability of achieving at least a breakeven volume. Extensions of both the linear and nonlinear methods were used to evaluate the combined effects of firm volume variations resulting from market share and aggregate production levels.

In conclusion, the techniques developed and demonstrated in this paper extend breakeven modeling to account for volume and margin effects due to changes in aggregate production of the raw commodity. The nonlinear model generally is applicable to firms depending on a processing margin which varies due to changes in aggregate production of the raw commodity, and which is fairly well behaved in relation to the aggregate production.

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