COMPARING MANAGEMENT SYSTEMS FOR BEEF CATTLE BACKGROUNDING: A MULTIDISCIPLINARY APPROACH

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Beef cattle production gradually has become more specialized with increasing separation of activities among geographic regions and farmers. The research literature commonly identifies two tiers of production — (1) cow-calf enterprises and (2) feedlot finishing [14, 19]. An intermediate tier — special feeding activities whose main functions are to assemble and grow out calves from a weaning weight to a weight and condition ready for feedlot finishing — has been operating for years. In recent years, as these activities have become more visible and distinct from the cow-calf or finishing enterprises, the name "backgrounding" has come into common usage among producers and market analysts [8].

This article is an overview of applied multidisciplinary research on systems of beef cattle backgrounding. The research is concerned with the process and consequences of selecting specific systems of backgrounding. In such research, the emphasis and approach commonly are very different in plant or animal sciences than in agricultural economics. Economists stress optimal use of productive resources through maximizing profits; plant scientists tend to concentrate on efficient production of high-value forages; animal scientists stress animal growth rates. Such diversity of interests has given rise to what sometimes seem to be conflicting results or "recommendations."

At the extreme, in Kentucky during the late 1960s and early 1970s, some economists were proclaiming that "backgrounding is not profitable." In contrast, in a region where beef production competes with tobacco as the major source of cash farm income, some animal scientists were advocating backgrounding as a very profitable farm production alternative, as a potential income substitute for tobacco. These different conclusions were reached by use of essentially the same research framework, viz., cost-returns enterprise budgeting. Yet the differences should have been expected, because the line items in the budgets were prepared for what in reality turned out to be very different backgrounding systems. The systems often were not well delineated and, in retrospect, only two or three systems had been considered. Accordingly, the multi-disciplinary research project was designed to evaluate costs and returns comparatively for several actual systems of backgrounding. The project was conducted (1974-76) partly in response to the aforementioned differences but, more importantly, in light of the continuing importance of backgrounding in Kentucky and similar midsouth producing regions. Two applied research objectives were emphasized: (1) identification of major backgrounding systems actually being used and (2) a systematic comparison of revenues, costs, and profits.

A cost-returns enterprise budget framework was used for the second objective because that approach is meaningful to all disciplines involved either directly on the project or by consultation about delineation of systems, estimates of parameters, and interpretation of results. In designing the methodology, the project leaders from agricultural economics and animal sciences as well as persons consulted in plant sciences favored this framework rather than, for example, a comprehensive simulation model, primarily because of its rather straightforward ties to each discipline's theory and empirical literature. The enterprise budget approach was believed to provide the best linkages between theory and previous results. All participants agreed that more sophisticated analytical techniques might be better applied in a follow-up study.

An overview of the study's methodology, analytical techniques, and certain results is presented in the following sections. The presentation illustrates both strengths and limitations of the multidisciplinary team efforts. Obviously, most of what the authors perceive as limitations or strengths are identified by

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hindsight. But these perceptions should prove useful to others who will embark on similar research efforts.

Delineation of Systems

In a three-tiered beef production industry, the intermediate tier (backgrounding) seems to be subject to the most variability in profits. Market prices for backgrounded animals are potentially more inelastic than prices at the feedlot level [3]. Purchase prices for feeder animals fluctuate widely because of varying and uncertain supplies from cow-calf producers [6, p. 5]. Production cost variations are caused by many factors, perhaps the most important of which is variation in feed prices and feeding efficiency. As a result of these risks and uncertainties, backgrounding producers are continually assessing their price and cost control methods. A primary means of management control is through the selection of a specific backgrounding system. The term "system," as used here, pertains to selection and implementation of the production strategy in the sense described by Blackie and Dent [2].

Nine alternative backgrounding systems are described in Table 1 on the basis of four major characteristics — (1) animal type, (2) days fed by dates, (3) average daily gain (ADG), and (4) feed classes available. These systems are real, being the major systems actually used by many Kentucky and other midsouth producers who background calves. The systems were identified on the basis of a special 1974 survey of Kentucky producers and subsequent consultations with extension specialists in the surveyed areas. Some systems used by relatively few producers are not included, and characteristics of the nine predominant systems are standardized slightly. The rate of gain (ADG) applicable to each system was selected on the basis of published research in animal sciences [8, 13, 20] and in consultation with beef cattle nutrition scientists. Although the ADG determines the precise feeding time (length of the period) for animals in each system, the starting and ending feeding dates shown conform closely to commonly used producer practices.

Sales Revenues

Expected sales revenues were estimated on the basis of monthly time series data (1961-1975) for steers and heifers (Table 2). The data were fitted by simple linear regression models, and resultant parameter estimates were used

TABLE 1. CHARACTERISTICS OF TYPICAL BEEF CATTLE BACKGROUNDING SYSTEMS

	System								
	Feedlot, Drylot [a]			Combination			Pasture		
Characteristic	1	2a	2b	3	4a	4b	5	6	7
Animal type	Steer	Steer	Heifer	Steer	Steer	Steer	Heifer	Steer	Steer
Days (period)[b]	212	182	182	365	240	240	190	180	365
	(Oct. 1 May 1)					(Dec. 1 July 31)	(Apr. 1 Oct.16)	(Apr. 1 Oct. 1)	
Average daily gain (ADG), lb[c]	1.65	1.65	1.65	1.10	1.65	1.65	0.80	1.10	0.80
Feed classes available[d]	Grains and silages (hays for system 1)			Seasonal[d]--Combination grains, pastures and hays			Pastures only, except hays in winter for system 7		

[a]Feedlots are fully automated with silo unloaders, feed augers, etc., whereas drylots rely upon manual labor.

[b]Systems 2a, 2b, 3, and 7 have no fixed starting or selling dates. Starting and selling dates for systems 1, 4a, 4b, 5, and 6 are shown in parentheses.

[c]The ADGs for each system were predetermined. See the narrative for details.

[d]Protein supplements and minerals are available for all systems. System 3 feeding periods are divided into four seasonal segments. Systems 4a and 4b are divided into two 120-day segments. Minimum feed cost mixes are described in detail for each system by Rutledge et al. [15].

to extrapolate 1976 and 1977 monthly prices for animals when purchased and when sold.

Monthly data were compiled from secondary sources [17, 18] for feeder steer calves, feeder heifer calves, and for "backgrounded" feeder steers and heifers — four classes of animals. Monthly price was regressed on a proxy for time (1=1961, 2=1962, ..., 15=1975) for each of the four classes. In total, there were 48 regression equations — four classes of animals for each of the 12 months. Each coefficient was positive and statistically significant (.05 level). No significant serial correlation was present (Durbin-Watson statistics were compiled). R^2 values, though fairly low, were not improved upon by using curvilinear models; neither polynomials nor log models gave higher R^2 values.

Fitting curvilinear models, the team believed, should have taken account of price premiums for heavy cattle during 1974-75. In retrospect, however, it seems that the last two years of a 15-year time series simply do not provide enough information. This deficiency was confounded by the lack of a complete time series for estimating monthly prices of different fleshing grades within the four classes. Because fleshy cattle commanded premium prices during the forecast years (1976-77), the linear extrapolation approach should have worked to bias the forecasts of price margins in favor of the pasture systems. That sort of result is not apparent in the numbers shown in Table 2.

Expected purchase prices for feeder calves (steers or heifers entering each backgrounding system) were calculated for each month in 1976 by extrapolating the linear regression coefficients, i.e., multiplying 16 by the slope coefficient and adding the intercept estimate. A similar procedure (multiply by 16 or 17, depending on the system) was followed to calculate expected sales prices for backgrounded animals. Projected price margins (Table 2) are the differences between the expected purchase and sales prices, the appropriate monthly series being determined by the number of days in the system. For example, for system 1 the projected 1976 October purchase price was $43.28 per cwt, the projected 1977 May sales price was $39.68, and the difference of −$3.60 was estimated to be the expected price margin. For systems not constrained to fixed purchase and sales months (2a, 2b, 3 and 7), the most favorable margin was selected. For example, the +2.46 margin for system 2b implies that producers who adopt this system are able to capitalize on its open time period and select the

TABLE 2. SUMMARY OF EXPECTED SALES REVENUE, COSTS AND NET REVENUE ABOVE COSTS.

Revenue or cost item	System: Feedlot, drylot 1	2a	2b	Combination 3	4a	4b	Pasture 5	6	7
EXPECTED NET SALES REVENUE									
Price margin [a] ($ per cwt.)	-3.60	-1.18	2.46	-4.07	-.96	-.96	-3.47	-6.17	-4.07
Expected net sales revenue[b] ($ per head)	125	112	119	141	155	155	34	48	99
BUILDING, EQUIPMENT [c]									
Investment ($ per head)	243	266	284	108	277	290	46	47	101
Annual overhead cost ($ per head)	26	27	29	11	30	30	5	5	11
OPERATING COSTS									
Feed									
Dollars per 100 pounds gain	14.26	18.50	19.75	15.27	13.04	13.77	18.82	14.39	17.62
Dollars per head	49.92	55.49	59.24	61.07	52.17	55.09	28.23	28.78	52.86
Other operating costs ($ per head)	25.40	23.64	20.99	27.01	25.40	22.86	19.64	22.52	29.50
NET REVENUE ($ per head)									
Above operating costs	49	33	39	52	78	77	-14	-4	17
Above "all" costs	23	6	10	41	48	47	-19	-9	6

[a]The expected difference between the purchase price for the animals and the selling price.

[b]Difference between the total purchase cost and the total selling revenue.

[c]Budgeted for a 50-animal enterprise. See discussion for rationale.

most favorable purchase in relation to sales month. Finally, the "expected net sales revenue" is calculated by subtracting expected animal purchase costs (projected purchase price times purchase weights) from the expected gross sales revenues (projected sales prices times the sales weight).

These projections were made in early 1976, prior to availability of any 1976 data. As the research team was not satisfied with using only this approach, alternative projections were considered which also were based on relatively simple historical averages, historical averages adjusted for general inflation and general outlook information. None of these alternatives was judged, at that time, as acceptable. Monthly price extrapolations thus were tentative — in recognition of the definite need of a more comprehensive study of market prices.

Costs and Net Revenue

Building and equipment requirements were budgeted for 50-animal units. Data were obtained from farm management and equipment handbooks [1, 10, 11] and from interviews with selected building supply and equipment companies. Previous studies [1, 5, 9] and consultations with agricultural engineers indicated it is plausible to assume that no scale economies are obtainable for larger herd sizes. Specific building and equipment requirements vary considerably among systems. Systems 5 and 6, for example, require no winter housing or feed storage facilities. Hence, investment outlays are considerably less than for feedlot-drylot systems which require hay and silage storage facilities. The annual overhead cost for buildings and equipment includes depreciation, interest on investment, insurance, property taxes, and equipment housing. These items were budgeted by standard procedures for time allocation and discounting [1, 10].

Feed costs are a summary of the optimal types and amounts of feeds selected by means of a linear programming model for each system [15]. Feeds available (activities) and feed price data were based on previous research and other published reports [7, 8, 13]. A total of 82 activities were defined — 19 concentrates, 8 silages, 39 dry roughages (hays), 13 pasture combinations, and 3 mineral sources. Nutrient requirements (RHS values) and nutrients supplied by each feed activity (A_{ij}s) were based on previous backgrounding nutrient studies and NRC data [13, 20].

Availability of the types of feeds varied considerably among the nine systems. System 4b, for example, was designed to rely heavily on silages and hays, whereas, systems 5 and 6 (pasture systems) were designed to rely heavily on relatively abundant green forages during April to November. Accurately specifying nutrient contents and amounts of green forages is a problem which deserves more study. The specifications were made jointly by forage specialists and animal scientists, but admittedly this procedure is no better than their general knowledge of past studies, their experiences with forage growing and feed trials, and their "best judgment."

Base feed price levels were specified for 1974-75, obviously a period when grain prices had just risen sharply in comparison with prices for other feeds. However, parametric programming results, with prices of hays and certain forage silages being increased up to 40 percent showed essentially the same feed activities entering optimal solutions. With these solutions, feed costs per 100 pounds of animal gain increased by as much as $6 for the feedlot-drylot systems (1-3) and up to $4 for the combination systems (4-6). However, there was no reason to believe these prices should be accepted instead of the base 1974-75 levels.

Pasture prices (C_j values) were determined on the basis of a separate supplemental study conducted in consultation with forage specialists [15]. The lack of pasture rental market data or an opportunity cost pricing mechanism made it necessary to rely on cost-of-production coefficients. This problem, interestingly, did not disturbe the forage specialists. They were not reluctant to accept pasture values (on a dry weight basis) equal to long-term production costs. Even so, in Table 2 the pasture costs per 100 pounds of animal gain appear to be very high.

The popularity of pasture systems (5, 6, and 7), especially among small producers, could be due primarily to low investment outlays and resultant low annual overhead costs. Pasture systems, however, allow virtually no flexibility for alterations in the feeding period and for the date(s) animals must be purchased or sold. This situation leads to relatively large negative price margins which allow little opportunity for profits even if feed costs are estimated to be low, particularly for system 6.

Systems which appear to be potentially most profitable are the combination systems, especially 4a or 4b. But, as results in Table 2 represent unconstrained resource analyses, profit maximizing producers may face constraints which will dictate selection of some combination of the other systems.

Constrained Profit Maximization

The most profitable combination of systems depends on the relative net returns and the production-resource parameters for each farm situation. Previous modeling and programming have shown that resource situations vary widely among midsouth beef farms [4]. Hence, constrained profit maximization analyses are illustrative, limited to particular farm situations.

An abbreviated linear programming (LP) model containing seven activities, one for each backgrounding system with positive net revenue (C_j value), was applied to a case-study Kentucky farm. The 516-acre farm is farily typical of many farms in the midsouth area that produce burley tobacco and few if any other row crops, and thus concentrate the resources not allocated to tobacco on forage-livestock production. Resource requirements and their availability for the model were based on detailed records from the farm, from budgets prepared by Allen et al. [1], and from summarized records on about 70 other central Kentucky farms participating in the Kentucky bluegrass area farm business records analysis program. The resultant model had 20 resource restrictions — five land uses, four labor periods, four machinery classes, four livestock shed classes, hay storage space, silage storage space, and grain storage space. Resource requirements for tobacco and the nonbeef livestock activities were subtracted, thus leaving only RHS amounts which are customarily allocated to beef cattle systems. Details of the LP model are given by Moss [12].

Results of the LP analysis were consistent with expectations and with the systems which are most popular among the more innovative commercial producers. The optimal program consisted of 123 animals in system 3, 101 animals in system 1, and had total net returns from backgrounding of $14,249 annually. It is noteworthy that neither of these systems was shown to have a very favorable price margin (Table 2), but both are efficient users of feeds. System 3 also has relatively low overhead costs. Stock shed and hay storage space were the most restrictive resources, having respective shadow prices of $3.86 and $2.75 per square foot. Silage and hay producing land and bin storage space, though not restrictive, were nearly exhausted. Large surplus amounts of permanent labor and machine capacity reflect practices commonly followed by forage-beef producers. They seem to place a very high value on having ample permanent labor and machinery for their summer production and forage harvesting operations.

Concluding Remarks

The methods and quantitative techniques of this study, though regarded by economists as simple, provided a common basis for the multidisciplinary team efforts. At the outset of the study, the essential research approach and methodology were agreed upon by leaders from plant sciences, animal sciences, and agricultural economics. Consequently, even though certain empirical findings must be regarded as tentative, the study's systematic processes provide linkages among theories and research methods of the three disciplines. Future work, either analytically similar or more sophisticated, can begin and continue from a more positive perspective. Research problems common to each discipline can be related better to the needs of diverse applied specialists and to beef producers.

Results of the study demonstrate that investment requirements, sales revenues, and feed costs vary considerably among the currently popular systems of backgrounding. Hence, inferences about profits should be tied to particular specifications of the production-management systems. Meaningful applied research of the future should be directed, in part at least, toward a more precise specification of the variation in sales revenues and feed costs among the systems. This step can be followed by a more complete analysis of how profits (or other response variables) depend on the systems. Such research would be vaulable in refining parts of dynamic, stochastic simulation models of beef cattle production which now are still in the development and testing stages.

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