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Firm Investment Model*

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Specialization and Flexibility Considerations in a Polyperiod Firm Investment Model*

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Objectives

Investment analysis in farm planning remains a troublesome area due to problems of risk and uncertainty and the nature of the firm growth process. While risk and uncertainty in agriculture include a number of aspects, this paper considers only uncertainties associated with product price changes. The farm firm growth process includes interrelated timing aspects of, 1) initial resource mix and levels, 2) annual or short-run maximizing plans, 3) investment strategy and, 4) goals and restrictions of the firm.

In analyzing investment strategy, conventional analysis is not able to consider the dynamics associated with the growth process. Static linear programming with inclusion of investment activities has similar difficulties. Polyperiod linear programming has been employed in this research to incorporate the growth process into investment analysis.

This paper summarizes research which evaluates optimal investment strategy resulting from product price changes in an agricultural firm growth framework. Emphasis is placed on the alternatives of flexible and specialized investments. Flexible investments, while less technically efficient compared to specialized investments, are hypothetically of greater economic efficiency when wide product price changes are considered. (3, ch. 9)

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Model

The model is a 20-year model with discounted net returns as the objective function. The polyperiod linear programming model may be denoted as:

Maximize $Z = C^1X$

Subject to:

$$A\,X \leq B$$
$$X \geq 0$$

A is the matrix of input-output coefficients partitioned into submatrices for each time period. Rows and columns of each submatrix overlap other submatrices in a block triangular fashion. Each subvector of B represents resources of the firm available for that time period. The C vector is partitioned into subvectors of discounted net returns by time periods. The solution or X vector is a series of subvectors of activity levels by time period.

Problem and Restrictions

The area of study is in eastern Nebraska, an area of the Great Plains with a moderate degree of economically alternative crop and livestock enterprises. The basic farm resource situation is 320 acres at full equity of $300 per acre. The initial capital level is $10,000 with 2,080 hours of operator labor available per year. No livestock facilities are assumed to be present initially. Fixed and living expenses initially total $15,000 per year with fixed costs increasing in relation to land ownership.

It is assumed that the operator is restricted to either $50,000 of short-term borrowing or 50 percent of the operator's equity whichever is smaller. An eight percent cost of capital is employed. Four thousand hours of labor are assumed available for hiring at two dollars per hour.

Activities

Corn, corn silage, soybeans, alfalfa and pasture compete yearly as crop alternatives. Land purchase is included an an activity with the capital requirements at $300 per acre. One-third down payment is required with a fifteen year mortgage available at eight percent.

Four investment alternatives exist for construction of cattle feedlots. These specialized facilities vary in terms of capital and labor requirements, feeding efficiency, and also by the type of feeding activities employed in each facility. Financing of two-thirds of the cost is available. Varying term facilities are included so as to allow response to short-term cattle price changes is so determined as optimal. The four facilities are:

1) A $60 per head capital investment lasting 10 years.
2) A $40 per head capital investment lasting 10 years.
3) A $20 per head capital investment lasting 5 years.
4) A $100 per head capital investment lasting 20 years.

Investment levels are in terms of capacity at a point in time. Cattle feeding activities employed each unit of capacity to finish two head per year.

Two specialized swine facility investments are considered. The first is a conventional farrowing house requiring a $267 capital requirement per sow lasting 10 years (Farrowing Facility A). The second is an environmentally regulated confinement facility requiring $448 per sow lasting 10 years (Farrowing Facility B). Each sow-unit of capacity is assumed to produce two litters per year.

A dual purpose or flexible livestock facility investment activity is also considered each year. This investment has associated cattle and hog activities which after investment is made can be rapidly adjusted if directed by price changes. This investment activity is of ten years duration with a capital requirement of $48 per head of cattle or $240 per sow.

The entire matrix is 481 rows by 657 columns; hence detailed discussion of all features is not appropriate here.

Prices

The basic hog and cattle prices employed in the three 20-year models are demonstrated in Figure 1. Three basic price models are evaluated here, a constant hog and cattle price model and two cyclical hog and cattle price models. The average prices shown in Figure 1 form the livestock prices for the constant price model (Model 1). The cyclical prices form the livestock prices of the two cyclical-priced models. A 10-year cattle price cycle is assumed and is based on 1959-68 data. Yearling and calf prices follow the fat cattle cyclical movements but are not shown. A 5-year hog price cycle based on 1964-68 prices is imposed on the cattle prices. The first cyclical-priced model (Model 2) assumes a price pattern commencing with year one, that is, initially high cattle prices and low hog prices. The second cyclical-price model (Model 3) begins at year five of Figure 1, that is, initially low cattle prices and low hog prices at a point on the hog price cycle one year prior to the starting point of the first cyclical-price model.

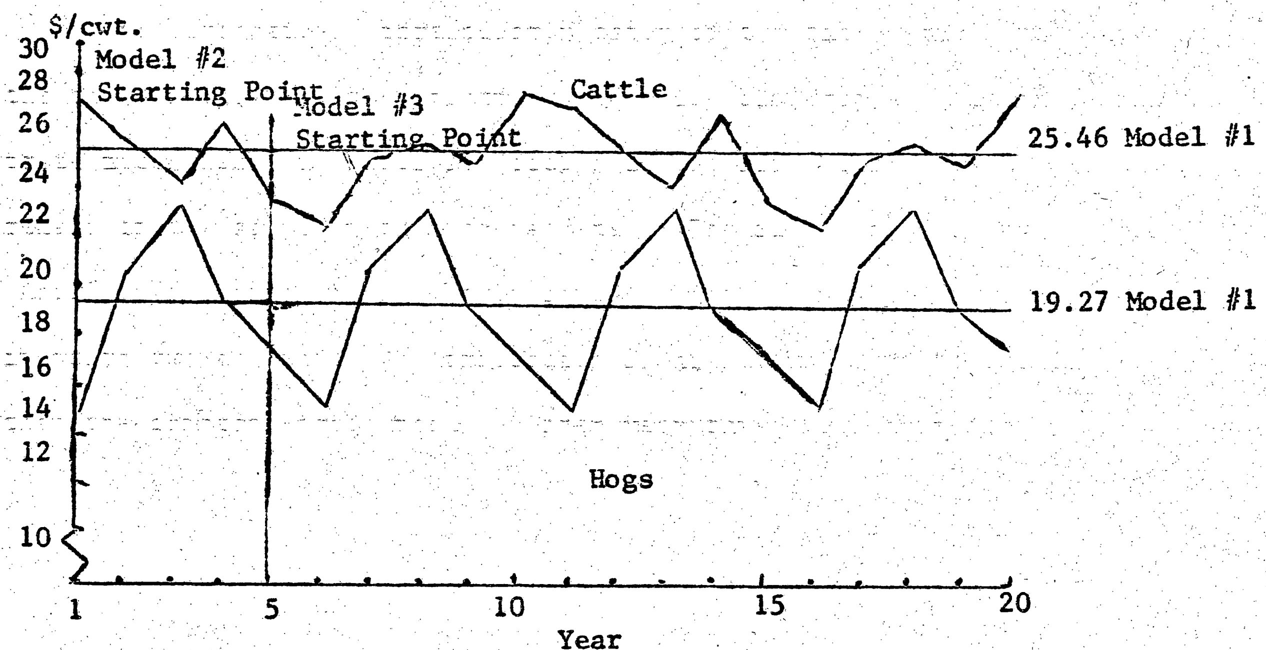

Figure 1. Hog and Cattle Price Assumptions for the Cyclical-Price and Constant-Price Models.

Results

Table 1 shows the investment and organizational results in the growth model for the 20 years. The constant-price model may be used as a base to view the general nature of growth of the firm.

The objective function of the constant-price model is $605,660 while the cyclical-price models are $600,879 and $600,881, respectively.

The general nature of the growth process is of high early hog investment and increasing land ownership. Both the constant-price and cyclical-price models follow this general growth pattern. No cattle investment activities occurred in the three models due to the greater capital generation from hog production. Similar forms of hog investments take place in the three models. In Model 1 investments for 26 sows in conventional facilities and 80 sows in the environmentally controlled unit are made in year one. Similar investments take place for Models 2 and 3 except for a one year's delay for the environmentally controlled investments. In the early years each model fully utilized its hog investments for capital generation. However, as cropland increased hog production declined with surplus hog capacity existing for many of the years of the life of the hog investments. All cropland was employed in corn production in each model.

Some differences, particularly early in the time period, occur between the three models due to adjustments to price differences. In the constant-price model heavy hog activity occurs in the first three years. Hogs remain in the solution through year ten. The first cyclical-price model (Model 2) has an initially lower level of hog and corn activity; however, in years two and three hog production is higher and corn production lower than the constant-price model. After year three similar patterns of organization emerge except that with the early higher hog investments of the

Table 1. Investments and Enterprise Organization in Models 1, 2 and 3.*

Year	Constant-Prices Model No. 1					Cyclical-Prices Model No. 2					Cyclical-Prices Model No. 3				
	Acres purchased	Build farrowing facility A (sows)	Build farrowing facility B (sows)	Hogs (head)	Corn (acres)	Acres purchased	Build farrowing facility A (sows)	Build farrowing facility B (sows)	Hogs (head)	Corn (acres)	Acres purchased	Build farrowing facility A (sows)	Build farrowing facility B (sows)	Hogs (head)	Corn (acres)
1	165	26.1	79.9	1643	484	126	27.0	0.0	419	446	126	25.5	0.0	396	446
2	97	0.0	0.0	1643	581	90	0.0	81.6	1683	535	90	0.0	83.7	1689	535
3	86	0.0	0.0	1643	667	117	0.0	0.0	1683	652	117	0.0	0.0	1689	652
4	89	0.0	0.0	1442	755	113	0.0	0.0	1428	766	113	0.0	0.0	1432	766
5	91	0.0	0.0	1238	846	72	0.0	0.0	1264	838	62	0.0	0.0	1293	828
6	0	0.0	0.0	1238	846	0	0.0	0.0	1264	838	0	0.0	0.0	1293	828
7	0	0.0	0.0	1238	846	0	0.0	0.0	1264	838	0	0.0	0.0	1293	828
8	0	0.0	0.0	1238	846	0	0.0	0.0	1264	838	0	0.0	0.0	1293	828
9	90	0.0	0.0	952	936	98	0.0	0.0	953	936	111	0.0	0.0	941	939
10	100	0.0	0.0	633	1037	113	0.0	0.0	595	1049	150	0.0	0.0	465	1089
11	198	0.0	0.0	0	1236	186	0.0	0.0	2	1235	146	0.0	0.0	2	1235
12	0	0.0	0.0	0	1236	0	0.0	0.0	0	1236	0	0.0	0.0	0	1236
13	0	0.0	0.0	0	1236	0	0.0	0.0	0	1236	0	0.0	0.0	0	1236
14	0	0.0	0.0	0	1236	0	0.0	0.0	0	1236	0	0.0	0.0	0	1236
15	0	0.0	0.0	0	1236	0	0.0	0.0	0	1236	0	0.0	0.0	0	1236
16	0	0.0	0.0	0	1236	0	0.0	0.0	0	1236	0	0.0	0.0	0	1236
17	0	0.0	0.0	0	1236	0	0.0	0.0	0	1236	0	0.0	0.0	0	1236
18	0	0.0	0.0	0	1236	0	0.0	0.0	0	1236	0	0.0	0.0	0	1236
19	0	0.0	0.0	0	1236	0	0.0	0.0	0	1236	0	0.0	0.0	0	1236
20	0	0.0	0.0	0	1236	0	0.0	0.0	0	1236	0	0.0	0.0	0	1236

* Rounding of activity levels may cause indications of less than full resource use in comparison between models.

cyclical-price model, greater hog production and lower crop production occurs through year 11. In year 12 and thereafter, identical organizations occur in both models.

The second cyclical-price model (Model 3) involves a solution nearly identical to the first cyclical-price model (Model 2). This would be expected since cattle production is not part of the optimal solution. Hence, the only meaningful difference between the two cyclical-price models is the one year difference in starting position in the hog price cycle. With Model 3 slightly greater hog production and slightly less crop activity occurs early in the period matching the peaks of the hog price cycle.

From the price assumptions used here a moderate response to the hog price cycle in terms of investments in hog facilities and level of the hog enterprise occurs in the cyclical-price models. However, no response to changing cattle prices is observed in terms of cattle facility investments because of lower relative prices of cattle compared to hogs. Also, no investment in flexible facilities occurs in response to changing price relationships of the cyclical-price models.

Conclusions

Given the resource base and the price assumptions of the problem, investment strategy is only moderately affected by the presence of cyclical livestock prices. Similar investments and timing of production occur in each model. The major difference is an early production response to increasing hog prices in the cyclical-price models. Optimal investments are in the form of specialized investments and neither flexible nor short-term specialized cattle investments emerge under cyclical livestock prices.

Given the similarity of investment strategies, a small (<1%) difference in the objective function occurs between the constant-price and cyclical-price models. The investment strategy under cyclical prices is able to adjust the timing of production levels to prices. This is at a slight loss in overall returns compared to static prices however, owing to differences in starting price assumptions.

The conclusions here are heavily dependent upon the initial resource levels, resource mix and restrictions of the model. Other price assumptions, such as greater amplitude in price cycles might yield quite different results.

An advantage of polyperiod programming in analyses of price uncertainties is full foreward knowledge and full period optimization. In such analyses, growth and timing considerations are fully incorporated. Solution cost, matrix size and difficulties of interpretation are definite disadvantages of such models. However, for research purposes in delineating resource levels, resource mixes and price assumptions under which given optimal growth and investment strategies hold, polyperiod programming possesses definite advantages.

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