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A DESCRIPTION AND ECONOMIC ANALYSIS OF INVESTMENT ALTERNATIVES IN HOG PRODUCTION SYSTEMS IN MICHIGAN

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A DESCRIPTION AND ECONOMIC ANALYSIS OF INVESTMENT ALTERNATIVES IN HOG PRODUCTION SYSTEMS IN MICHIGAN

By

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ABSTRACT

A DESCRIPTION AND ECONOMIC ANALYSIS OF INVESTMENT ALTERNATIVES IN HOG PRODUCTION SYSTEMS IN MICHIGAN

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Hog production systems are a major capital investment. The purpose of this paper is to analyze investment in three significantly different systems known as the one-litter pasture production system, the two-litter pasture production system and the 51-day confinement system. These systems represent the extremes from labor intensity to capital intensity.

The investment analysis used is concerned with the cash flow perspective plus the net present value criterion. Required resources for land, labor and capital are defined for each system. Given these structural definitions for a given set of price-cost data, the confinement system is more favorable from both the cash flow and net present value criteria than is the one-litter system. The two-litter pasture production system does appear able to compete with the more intensively used confinement system.

These results suggest that the critical areas leading to profitable swine production (based on acquisition price for new assets) are: 1) housing the growing-finishing hogs in confined, insulated facilities, and 2) more intensive use of the sow.

ACKNOWLEDGMENTS

Completion of this paper would not have been possible were it not for the assistance given by others to whom I wish to express my thanks.

The Department of Agricultural Economics has been most cooperative in allowing the additional time needed to complete this project.

While a student I had been fortunate to know and make many lasting friends who I don't see often but remember often the times we've had. I am especially grateful to Per, a true and forgiving friend since our junior year.

The members of my thesis committee have been exceptionally patient and given generously of their time towards its completion. Dr. Gerry Schwab, as thesis director, has greatly improved my quality of thinking behind this thesis. The exactness and correctness are because of his overseeing my efforts. Dr. E. Dale Purkhiser, Extension Swine Specialist, made me understand and appreciate the technical aspects of swine production within each system. His time in assisting with this project as well as making real world applications are genuinely appreciated. Dr. Ralph Hepp, who 'will tell you what he thinks,' provided constant encouragement whenever he saw me with "keep writing." Dr. Glynn McBride, who assured me of academic eligibility to finish, always warmly welcomed me in his office with "Come in, sit down."

My parents and grandmother have been the source of my interest in farming and their interest in my education essential. The opportunity

to return to the farm as a career is also the opportunity to be where I have always felt at home.

Julie, my wife, was my motivation to complete this paper. Her positive support was required in order to finish.

Finally, remembering the account by my departed grandma of the sow whose litter of 19 paid the taxes on the farm one year, I have recounted often in the progress of this work.

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CHAPTER I

Introduction

A. Problem Setting and Needs

The persistent characteristic of United States agriculture is its tendency to "expand production to the point at which product prices fail to cover investments and expectations in producing farm products."[1] Such errors in investment are in no small part the result of imperfect knowledge about future events on which the production plans are based. The divergence of actual prices and expectations "are evidence of resources badly allocated, wrong investments having been made, certain enterprises over-expanded and others not given enough support. The result of all this is that there occurs a loss to the farmer and a waste of resources generally. Society is poorer because of these mistakes."[2]

Pork production, like other sectors of United States agriculture, has undergone changes in its input or resource requirements. The swine sector has experienced developments in nutrition that have eliminated the need for pasture. The pasture is being replaced by more capital intensive housing systems and rations balanced by assistance of

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[1]Glenn L. Johnson and C. Leroy Quance, The Overproduction Trap in U.S. Agriculture, 1972, p. 3.

[2]T. W. Schultz, "Theory of the Firm and Farm Management," Journal of Farm Economics, Vol. 21 (1939), p. 585.

computers. While adaption of confinement housing requires relatively less labor and land for similar levels of production, it is fixed to the firm, fixed to the enterprise, and requires higher levels of other resources as capital.

Unusually high prices for hogs, as occurred during 1975, could be expected to be followed by additional investments in hog facilities. Reasons for an expansion of resources committed to hog production confinement facilities are:

1) Expectation of profit;

2) Income tax and investment credit considerations;

3) Relatively low opportunity cost for cash grains as corn;

4) A desire by producers of labor intensive systems to improve labor productivity and efficiency;

5) An inflation hedge and expansion mechanism whereby producers have increased their net worth position and thus their ability to command more credit, i.e., the capacity to use financial leverage to expand their operations.

Should the potential to expand the hog "production plant" materialize and additional resources become committed to hog production, these committments occur in the face of great uncertainty. These uncertainties are of the following nature:

1) Prices for hogs (output);

2) Prices for inputs, and even their availability;

3) Institutional criteria in the form of legal and environmental regulations;

4) Advances in technology which render investments obsolete; and

5) Biological production difficulties.

By reducing the uncertainty surrounding investment decisions it follows that the probability of resource misallocation is also reduced.

Once committed, resources often tend to become fixed to production, making the production function non-reversible,[3] and thus, the adjustment to changing conditions is not without costs.

B. Statement of Objectives

With the background in mind, the purpose of this paper is to:

1) Define the characteristics of certain alternative swine production systems which should be considered when evaluating the systems;

2) Determine the production surface for each system, i.e., the levels and combinations of resources used for the individual systems;

3) Develop an investment analysis for different pork production systems of equivalent size (at which virtually all economies of scale have been achieved);

4) Provide a means to evaluate not only current levels of new investment required for a system, but to determine how much can be paid for a system;

5) Incorporate the non-cash factors of land rent for pasture production and the value of the manure produced by the system as both represent substantial opportunity costs;

6) Incorporate operating efficiencies for all systems that would normally be realized through excellent management of the enterprise.

For a particular producer the investment analysis presented may be inadequate. By considering the swine enterprise separately the analysis may not be applicable to producers who have other enterprises which

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[3]Clark Edwards, "Resource Fixity, Credit Availability and Agricultural Organization," (Ph.D. dissertation, Michigan State University, 1958), p. 89. "The nonreversible supply functions . . . do not have the same elasticity for product price increases as for decreases . . . when product prices decrease, both acquisition costs and salvage values are likely to decrease, with salvage values falling at a faster rate. This effect counteracts the tendency for prices to become variable downward and makes the supply function less elastic with respect to product price decreases than to increases."

require the same resources. Opportunity costs of resources will differ by farm situation. Thus a producer who has certain resources available for swine production may be forced to plan investments on a fixed asset approach or a sub-production function of those explained herein. By determining the input-output data for the production systems it will be possible to develop overall farm plans directly applicable to particular producers which will assist in their planning and farm (re)organization.

C. Method of Analysis

The analysis of various production systems having different technologies first requires a determination of production systems which are physically feasible within the geographic-climatic constraints. This task was accomplished through direct interviews with producers, recommendations by agricultural engineers and by extension specialists who have direct contact with producers.

For the defined systems it is then necessary to determine the input requirements for an expected level of production in order to specify points on the production function. Data for this is generally secured from research projects conducted by various experiment stations. While experimental data which compares systems could be expected to have similar management within the experiment, very good management is assumed necessary and available at the commercial producer level.

The capital costs associated with alternative investments can also be estimated. Producers who are currently making investments in a given structure are one source of capital cost data. Contact with manufacturers of hog facilities and equipment provides the other major

source of investment costs. Capital budgeting techniques can then determine if that amount of debt can be repaid.

Investment and operating costs vary considerably between individuals and are rapidly outdated, but the technical coefficients associated with each system remain stable over time. It is expected that the nature or method of production remains relatively stable over time and may be re-evaluated under changing market conditions and costs.

Prerequisite to analysis is the development of an enterprise budget which includes all cash and non-cash items involved in the system for a given level of production once full production has been achieved. This budget then provides a means to determine the amount of net income from the hog system that is available for debt servicing. As this amount is directly related to market changes in hog and corn prices, the analysis is made for various levels of each. The gross margin or net return over variable costs can be used to determine debt repayment capacity of the hog system from a cash flow perspective. Net present value investment analysis can then be used to determine the economic wisdom of the investment in alternative swine systems. These techniques and their application will be discussed in later chapters.

CHAPTER II

The Role of Hog Production in Michigan--
Past, Present, and Future

A. Introduction

Pork production, like other segments of United States agriculture, has been experiencing rapid changes. These changes are characterized by an increase in the number of hogs produced per farm, an accompanying decline in the number of hog farms, and a shift from pasture production systems in favor of confinement systems on many farms.

The adoption of confinement building systems represents a change in technology that may well permeate the other characteristics of the changing swine industry. While the months of March, April, May and September represent the traditional farrowing pattern, confinement housing and multiple farrowing patterns are in no small part responsible for sharply changing this pattern. "In 1974 approximately 60 percent of the pigs farrowed were farrowed during this four-month period."[4]

More recent developments in the grain markets have created further impetus of the trend toward confinement. As the prices of grain and protein feeds paid to farmers have increased and stabilized at substantially higher prices than those which prevailed in the early 1970s, so too, has the opportunity cost associated with using this same property for hog pasture. Geographically, hog production closely

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[4]Charles Lee Moore, "Decision Strategies for Managing the Swine Breeding Herd," (M.S. Thesis, University of Illinois, 1970), p. 1.

approximates the areas of corn production in the United States, making a hog pasture system competitive (as opposed to complementary) with corn production.

While the production practices have changed sharply, pork production continues to be one of the most profitable enterprises within agriculture. Traditionally the hog has been known in American agriculture to be the "mortgage lifter." For Michigan producers on the TELFARM accounting project this is readily supported by their summary of returns on investment for the ten year period 1969-1978, for which swine farms averaged the highest rate earned on investment of the various enterprises (see Table II-1).

In addition to being an enterprise having high return on investment, hogs also continue to be a major source of income to United States' farmers. In 1978 cash receipts from hog marketings accounted for nearly nine billion dollars, or approximately 7.8 percent of total receipts from farm marketings of crops, livestock and livestock products (see Table II-2).

While hogs are relatively less important as a source of income in Michigan than nationally, there exist certain factors creating an environment conducive to an expanded production of pork within the state. Only three other states slaughter more hogs than Michigan,[5] and yet, consistently Michigan's number of hogs marketed have been surpassed by all of the fourteen major states, thus indicating that the vertical capacity to process an expanded farm production within the state exists. This facet is further reflected in the market for hogs. "Average prices received by Michigan Telfarm swine record keepers average

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[5] Michigan Agricultural Statistics (June 1974), p. 37.

Table II-1. Rate Earned on Investment by Type of Farm

	Dairy	Saginaw Valley Cash Crop	Cash Grain	Cattle Feeding	Swine	Poultry	Potato	Tree Fruit
1969	6.1%	5.3%	1.5%	7.8%	16.3%	15.0%	9.4%	1.9%
1970	6.8	7.3	4.5	6.0	5.3	8.0	11.8	-6.9
1971	3.0	3.0	.4	6.0	4.6	3.0	4.4	1.5
1972	7.0	7.9	6.4	10.0	17.0	-8.0	17.0	4.5
1973	12.5	20.2	13.7	17.0	33.7	29.2	22.6	11.0
1974	6.3	19.4	10.5	.3	6.2	14.1	17.3	17.4
1975	3.0	10.4	7.4	10.4	15.0	5.5	11.2	- .5
1976	5.2	1.0	2.0	- .2	6.7	6.6	8.7	7.1
1977	3.4	4.7	2.1	3.8	5.2	12.7	5.6	18.6
1978	10.0	3.4	4.7	16.3	14.3	9.0	5.9	21.9
10 yr. avg.	6.3%	8.3%	5.2%	7.7%	13.1%	9.5%	11.4%	7.6%

Source: "Telfarm Michigan Farm Business Analysis Summary, All Types of Farms," Department of Agricultural Economics, Michigan State University.

Table II-2. Marketings and Cash Receipts from Hogs

Marketings	1978	1973	1967	1962
U.S. Total (1,000 hd)	59,860	82,317	85,528	81,660
Cash Receipts from Marketings ($1,000)				
Illinois	1,090,726	1,005,064	552,736	466,040
Indiana	662,894	664,145	325,145	315,547
Iowa	2,279,883	1,715,186	952,772	734,181
Missouri	570,911	563,701	282,966	222,722
Subtotal (4 states)	4,604,414	3,948,097	2,113,739	1,738,490
Georgia	197,692	179,856	67,242	54,375
Kansas	327,813	288,039	105,412	78,844
Kentucky	148,602	168,212	70.197	63,182
Minnesota	651,061	496,914	235,229	221,947
Nebraska	515,969	453,820	212,064	158,461
North Carolina	301,372	224,662	85,662	51,500
Ohio	270,236	264,396	164,335	150,768
South Dakota	276,001	270,486	135,271	111,173
Texas	137,301	142,266	47,658	41,175
Wisconsin	237,598	201,556	121,701	105,320
Subtotal (14 states)	7,668,059	6,638,304	3,358,390	2,775,235
U.S. Total	8,715,458	7,524,606	3,779,711	3,158,025
4 States as % of U.S. Total	52.8	52.5	55.9	55.0
14 States as % of U.S. Total	88.0	88.2	88.8	87.9
U.S. Total Cash Receipts from Livestock & Livestock Products	58,991.000	46,243,653	24,364,667	19,986,549
Total Hog Receipts/Total Livestock	14.8	16.3	15.5	15.8
Total Hog Receipts/Total Livestock & Crops	7.8	8.7	8.8	7.6
Michigan				
Cash Receipts from Hog Marketings ($1,000)	96,439	97,474	44,489	41,018
Cash Receipts from Livestock & Livestock Products ($1,000)	997,659	709,317	455,642	400,843
Hog Receipts/Livestock Receipts	9.7	13.7	9.8	10.2
Michigan Hog Receipts/U.S. Total Hog Receipts	1.11	1.30	1.18	1.30

Source: Agriculture Statistics, USDA, various issues.

approximately $1.50 above Illinois swine record keepers."[6] In addition to a positive price differential in favor of Michigan producers, improved crop production within the state has expanded more rapidly than have livestock numbers. Michigan is now a net "exporter" of corn which is available to support an expanded hog industry within the state.

B. Risk and Uncertainty Concerns Associated with Hog Production

While swine enterprises tend to provide one of the highest rates of return on investment relative to other agricultural enterprises within Michigan, this analysis may fail to fully depict reality. Rate earned on investment masks the age or degree of obsolescence of the assets on which the return is computed. Similarly, different durable assets used in the various enterprises will have differeing life spans, thus requiring different returns needed to facilitate replacement. Also, since real estate is one asset which generally appreciates in value, whereas buildings and equipment depreciate, the proportion of these assets used in the enterprise may lead to bias in an analysis of profitability based on return from different enterprises.

It is also of increasing importance to consider the role of rapidly and widely changing product and input prices associated with hog production. As is shown in Table II-3 the uncertainty associated with hog prices has generally become larger, but even the level of uncertainty is unpredictable. Feed, the largest single cash expense for hog production, has also tended to exhibit wider price fluctuations. The probability of either windfall gains or windfall losses occurring has dramatically increased.

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[6]"Michigan's Livestock Industry of 1985," Michigan State University Research Report 184 (January 1973), p. 16.

Table II-3. 12-Month Average Annual Price of Hogs and Corn and Their Annual Standard Deviations[1/]

	Barrows & Gilts		Corn	
Year	$\bar{p}$ [2/]	σ_p	$\bar{p}$ [3/]	σ_p
1979	43.20	5.93	2.36	.38
1978	48.68	1.63	2.04	.14
1977	41.87	2.68	1.92	.26
1976	44.64	6.18	2.38	.22
1975	46.37	9.02	2.57	.23
1974	37.11	4.17	2.89	.37
1973	41.12	5.93	1.83	.43
1972	27.71	2.34	1.12	.10
1971	19.38	1.54	1.23	.20
1970	23.52	4.08	1.22	.08
1969	24.53	2.74	1.09	.05
1968	20.22	.84	.96	.04

[1/] Standard deviation is a measure of the dispersion or range of observations around the mean or average. Therefore, greater standard deviations indicate a relatively wider range in monthly prices either above or below the average.

[2/] Source: Livestock, Meat, Wool Market News (Indianapolis Price), USDA, various issues.

[3/] Source: Agriculture Prices (Michigan Price), USDA, various issues.

The commodity futures market represents a tactical (as opposed to strategical) method by which producers may reduce the uncertainty of net income caused by widely fluctuating hog and corn (and protein) prices. There is, however, evidence which suggests that this is not a widely used marketing practice of producers. A survey of production units marketing in excess of four thousand head annually indicated that while size of operation is strongly and directly related to volume contracted, only approximately one-seventh of the slaughter hogs from these units were sold under contract. Also, self-sufficiency in grain production declined with size of operation with no unit marketing over fifteen thousand head per year being self-sufficient, and of those marketing between four thousand and five thousand head, only 24 percent were self-sufficient in grain production. And yet, less than half of the operators did any hedging for the previous two year period for <u>either</u> hogs or corn.[7]

Investment decisions in hog production systems are susceptible to uncertainty. The time lag from the decision to pursue a particular production system until the initial cash receipts are generated, and especially all subsequent production and marketings over the life of the investement are likely beyond the scope of the future's market with respect to time. Since the "success or failure of operations at early dates affects the firm's ability to finance later operations,"[8] the impact of changes in net worth through either favorable or unfavorable

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[7]"A 1974 Survey of Large-Scale Hog Production in the U.S.," Special Report 165 (University of Missouri-Columbia, August, 1974), p. 12.

[8]A. G. Hart, "Anticipations, Uncertainty and Dynamic Planning," <u>Studies in Business Administration</u>, (1940), Vol. XI, No. 1, p. 68.

price relations may become critical as the firm may experience effective credit rationing.

Not only are price levels subject to (statistical) variance, but so also is the enterprise's production yield. That is, the pigs produced per sow per year are influenced by reproduction efficiency, disease, nutritional disorders and management in general. As income is the product of price and yield, with a variance attached to each, investment planning is further complicated by an inability to statistically deal with such a situation.

Within this volatile framework of the product and input markets rests a point of contemporary concern: Among all livestock in the United States, the hog sector is the largest consumer of corn grain, as well as being a primary user of high protain feeds (see Table II-4). Amidst a heightened awareness and concern of an expanding world population and its pressure on available grain supplies as well as the production of grain itself, the future of hog production takes on another dimension of uncertainty.[9] As the investment involves planning over a number of years there may be changes in the conversion and use of grains as feed to produce pork for human consumption. Therefore, greater pressure may be exerted to curb the conversion of grains to feed and make them directly into food for humans.

C. Summary

There currently exist a number of factors which enable Michigan to expand its production of hogs. Comparative advantage in pasture

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[9]George Borgstrom, The Hungry Planet (1967), p. XIII, "If the world's population continues to expand at the present rate . . . within 120 years the present production of food stuffs will have to be increased eightfold."

Table II-4. Consumption of Feed by Livestock Groups

	1976[1] Consumption of Harvested Feed (1,000 tons)			1972 Consumption of Harvested Feed (1,000 tons)		
	Corn	High Protein	Total	Corn	High Protein	Total
Hogs	38,200	6,093	50,236	32,035	4,660	42,032
Milk Cows	15,137	7,092	26,914	14,392	1,631	25,740
Cattle on Feed	20,187	1,119	34,190	31,870	1,592	55,695
Other Beef Cattle	6,178	732	12,845	6,520	689	13,529
Hens & Pullets	9,096	2,629	17,585	8,692	2,358	17,587
Broilers	7,880	3,639	12,948	6,843	2,870	10,829
Turkeys	1,840	1,459	4,025	1,694	1,528	4,312
All Livestock	99,651	21,720	177,758	105,912	18,286	185,610

Source: Feed Situation, USDA, various issues.

[1] Preliminary

production, availability of grain for feed, excess processing facilities and a favorable market price relative to other hog production areas are among the factors that can assist an expansion in Michigan hog production. However, there also exist volatile grain and hog prices which can bring both windfall losses and windfall profits. Length of time needed to start-up an operation and become fully operational may eclipse the period of profitability which existed when the investment occurred. Also, there is concern in the long run regarding production problems in confinement facilities as influenced by biological and institutional constraints in addition to consumer acceptance and demand for the pork products.

CHAPTER III

Hog Production Systems: Economic and Managerial Concerns

A. The Production Surface

Alternative input combinations capable of producing a particular product can be described by a production surface which defines the various input combinations that will result in similar levels of production. An analysis of this production surface indicates that selection (and level) of an optimal production technique or system will be based upon the quantity of available resources and their relative costs to the enterprise.

A traditional example of this production surface, that is extremely applicable to hog production, is the substitution of capital for labor. Illustrated graphically this phenomenon indicates the various combinations of labor and capital required in order to achieve a given level of production, e.g., number or cwt of hogs annually. The loci of these points when plotted relative to capital and labor is termed an isoquant (see Figure III-1).

More of at least one resource must be available to the enterprise in order to achieve a higher level of production. The resulting higher levels of physical production are illustrated by isoquants shifting out from the origin (see Figure III-2).

Given these input-output relationships it is then possible to determine production levels and input combinations by equating the

Figure III-1 An isoquant map showing the combinations of labor and capital that may be used to produce 300 cwt of pork annually.

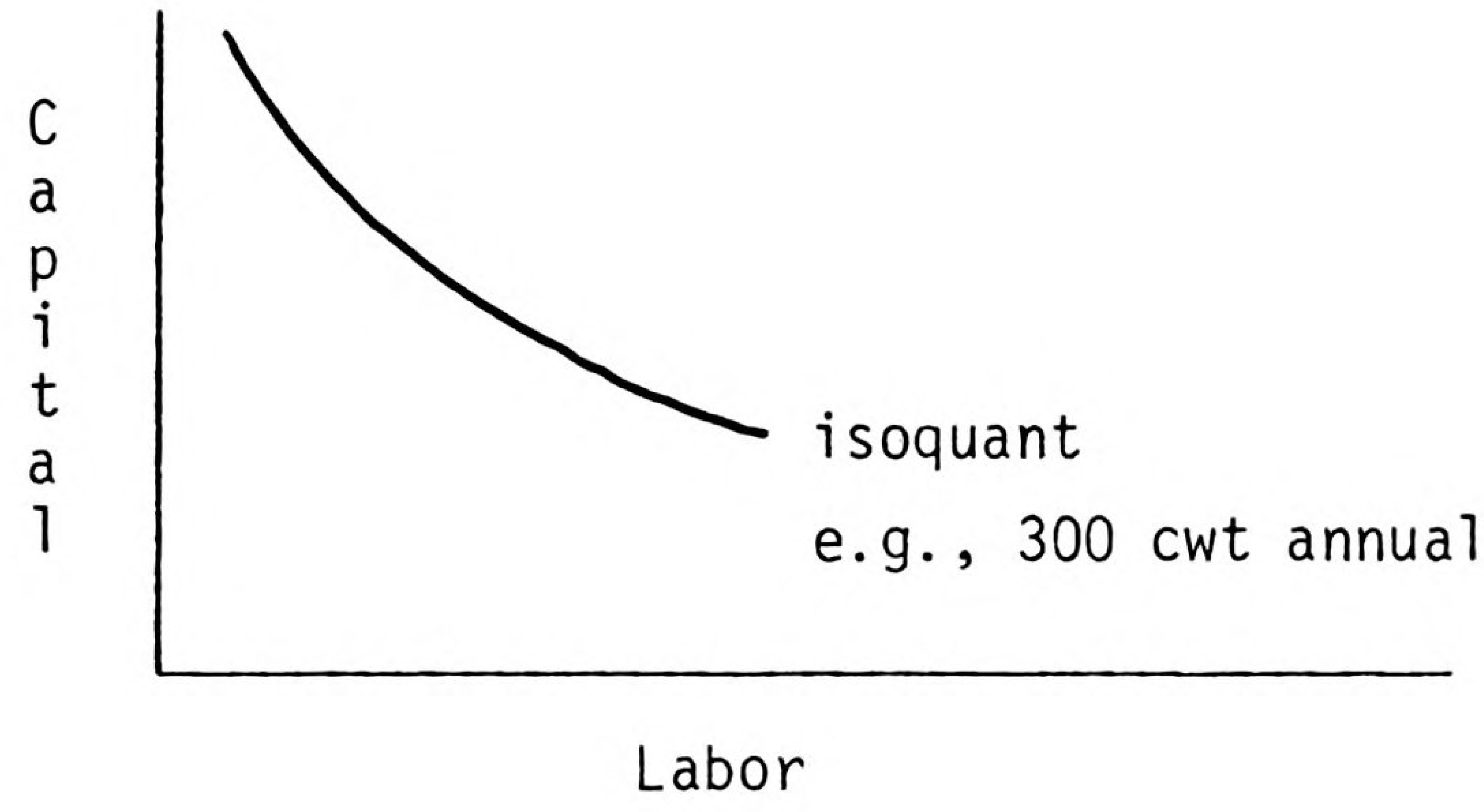
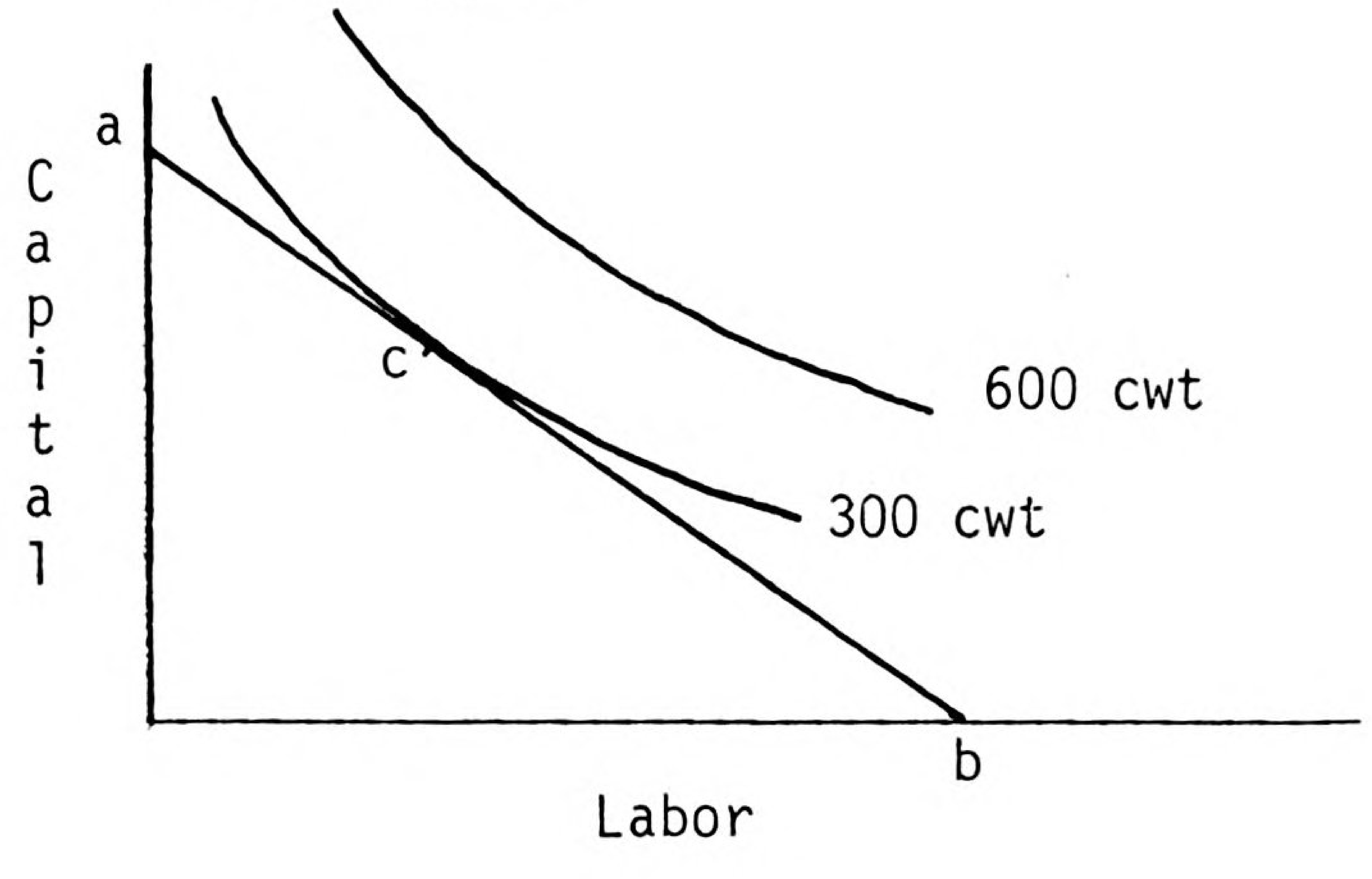


Figure III-2 An isoquant map showing the combinations of labor and capital needed to achieve an annual production of either 300 cwt or 600 cwt of pork. For a constraining budget which allows maximum of "a" units of capital or "b" hours of labor, 300 cwt would be produced at "c". As the budget is increased, the budget line moves outward. The intersection of successive budget line and isoquants forms an expansion path, which is the highest level of production that can be achieved with the given budget.



marginal rate of technical substitution; i.e., the slope of the isoquant, with the inverse input price ratio, the slope of the budget constraint. This budget constraint indicates the maximum amount of resources that can be controlled with available monetary resources. The equating of these two ratios is indicated by the tangency between the budget constraint and the isoquant. The expansion path, which depicts the loci of such tangency points, is determined and finally the high profit point can be determined. The theoretical high profit point with unlimited resource is where the ratio of MVP_{x_i}/P_{x_i} is equal to one for all 'i' inputs. This analysis is, however, a static analysis. Over the life of the investment both technical and economic relations may not resemble those on which the planning was based. Recognizing the problem that the investment spans an uncertain future which will likely be different from the past requires a paradoxical rational: "The possibility of the solution of the problem depends on the future being like the past."[10]

B. Economic Analysis of the Adjustment Process

As price levels and relationships change, so too, will the optimum level of production and resource requirements. Adjustments to changing price relationships may be effected by either changes in size or through substitution of inputs. Substitution will maintain the desired equality of the value derived from separate resources. This results in adjusting factor proportions until the marginal product of a dollar's worth of each input is the same.[11]

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[10] Frank H. Knight, Risk, Uncertainty and Profit (1971), p. 313.

[11] C. E. Ferguson and S. Charles Maurice, Economic Analysis (1974), p. 181.

This equality is expressed as:

$$\frac{P_y \cdot MPP_{x_1y}}{P_{x_1}} = \frac{P_y \cdot MPP_{x_2y}}{P_{x_2}} = \cdot \cdot \cdot = \frac{P_y \cdot MPP_{x_iy}}{P_{x_i}}$$

where P_y is the price of each unit produced,

P_{x_i} is the price of each unit of resource i,

MPP_{x_iy} is the additional physical product produced by the last unit of resource i employed in the production of y

Maintaining this equality is necessary to assure that the enterprise is employing the most efficient combination of resources, i.e., that the enterprise is on the line of least cost combinations. Changes in scale or amount of production, however, may also be necessary for the enterprise to be at the optimal level of production. The high profit point is realized when:

$$\frac{P_y \cdot MPP_{x_1y}}{P_{x_1}} = \frac{P_y \cdot MPP_{x_2y}}{P_{x_2}} = \cdot \cdot \cdot = \frac{P_y \cdot MPP_{x_iy}}{P_{x_i}} = 1$$

At the high profit point 1) resources are combined in proper proportion, and 2) resources have been added to the level at which the last unit of input will generate no more revenue than its cost to the enterprise.

Once resources have been committed to a production technique, adjustments to product price declines are not necessarily the same as for increases in product prices. Such responses follow a contraction path which differs from the expansion path due to the tendency of

resources to become fixed to the enterprise.[12] Such resource fixity requires that the level of production be based upon an analysis of the fixed and variable cost to the enterprise. Fixed costs are past costs which continue to be incurred regardless of the level of production. Variable costs are avoidable costs which expand in relation to production and would not be incurred were production to cease.

These costs are illustrated in Figure III-3, where product prices and costs are plotted against level of production. In this figure, AFC is the average fixed cost; i.e., that cost which "goes on independently of output."[13] divided by the quantity produced. AVC is the average variable costs; i.e., the summation of inputs which must be expanded with higher production levels times their respective prices, divided by the quantity produced. ATC is the average total costs where ATC = AFC + AVC. MC is the marginal cost which is the addition to total cost attributable to the addition of one unit of output, and P_y is the product price. When P_y is constant, marginal revenue or the change in total revenue due to last unit of output is equal to P_y.

Given a product price, P_y, point "a" respresnts the optimum level of production. Since P_y = MR, when P_y is constant, at output level "a", MR = MC which is the high profit point. The optimal level of production is where the change in total revenue due to the last unit of output is equal to the change in total cost due to the last unit of output. For price levels greater than P_y the enterprise will realize a profit. For price levels less than P_y, but greater than P_y', the enterprise will minimize its losses by producing at the level when MR = MC.

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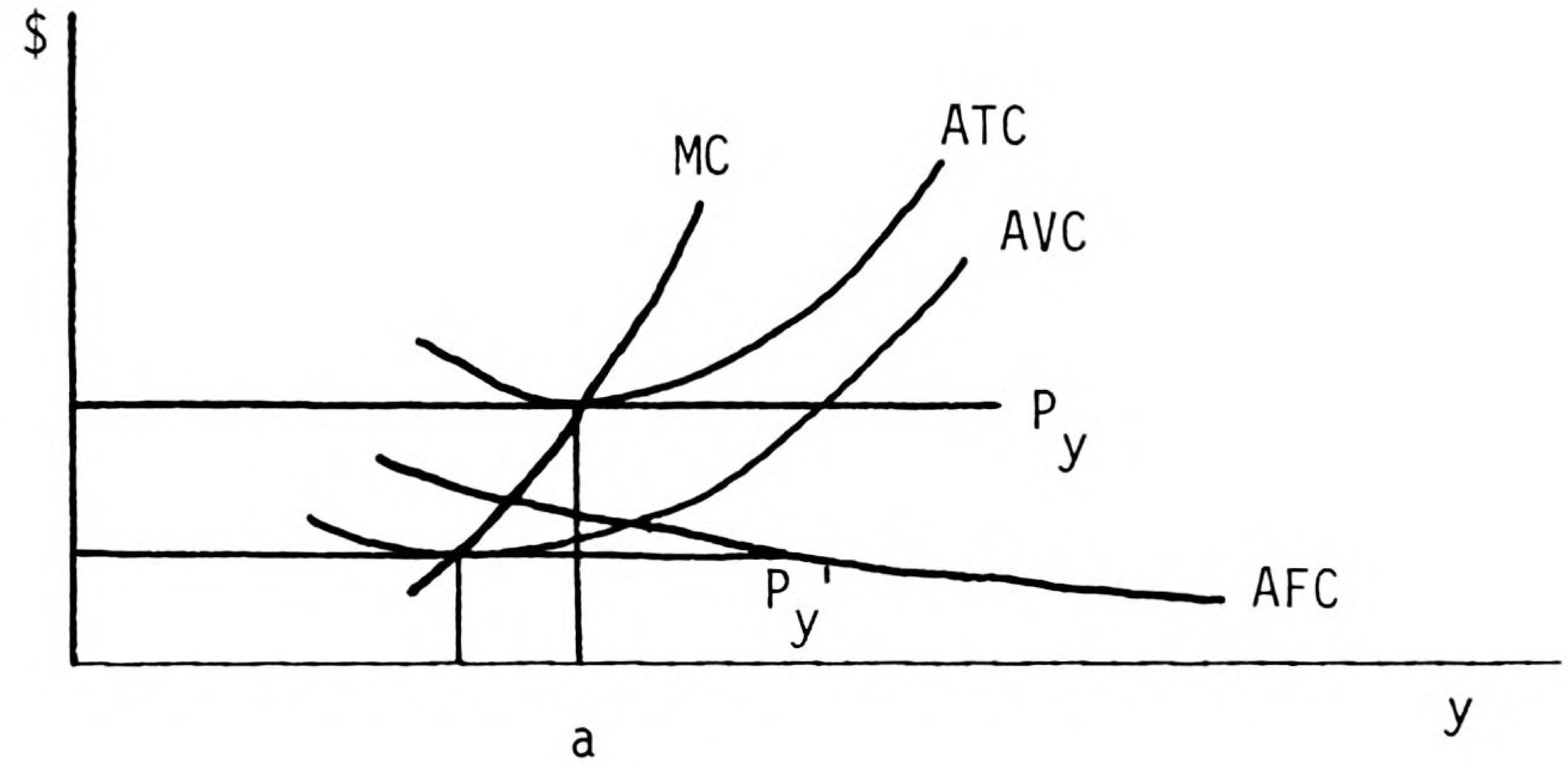
[12] The Overproduction Trap in U.S. Agriculture, p. 191.

[13] Paul A. Samuelson, Economics: An Introductory Analysis (1967), p. 370.

Figure III-3   Average costs of production plotted against level of output "y".



This follows since all variable costs are recovered and a portion of the fixed costs are met also. When product prices fall below P_y' the enterprise would cease production as the costs avoided (variable costs) exceed the returns from production.

C. Investment Analysis

An investment requires a current expenditure of a certain sum of capital and a subsequent future committment of other resources. The meaning of investment analysis is to evaluate over time the returns generated by an investment relative to its costs.

Discounting future returns as well as costs is fundamental to the analysis. The investment decision involves presently held capital, anticipated future earnings, and anticipated future operating costs.[14] By discounting, all future revenues and costs are expressed in terms of today's monetary value.

When all expenditures, both capital and operating, and returns are brought to an equivalent basis the analytical decision-making criteria

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[14]Max D. Richards and Paul S. Greenlaw, Management Decision Making (1972), p. 370.

leading to a decision may be of essentially three types. A ratio of the present value of earnings to the present value of costs gives a Profitability Index or Benefit/Cost ratio. This index must be greater than unity in order for the investment to merit consideration. When alternative investments are possible the decision rule would be to select that investment where the index is the greatest, provided that the different level of capital costs and the production technique between the alternative investments is inconsequential.

The second decision rule would be to invest in the production system where the difference in present value of earnings over the present value of expenditures is greatest. Like the Profitability index analysis, this too, requires establishing expected prices for hogs, feed and capital cost.

Both decision rules are based on the assumption that the investment is made in order to either maximize the present value of net returns or total profit. Investor-managers may have other goals such as personal preference of production technique, capital risk limitations, minimum cash flow requirements, or the lack of profit maximization as the goal. Therefore, the rule they would apply in reaching a decision is to maximize a weighted set of multiple goals that forms some measure of utility or satisfaction.

The problem faced by individual producers who have varying and generally increasing capital cost is of viability of the investment. Evaluation of potential investments in hog production systems requires a determination of the cost of variable resources, production volume relative to facility size, and expected prices for corn and hogs. This investment data combined with financial arrangements will

determine the debt carrying capacity for that system. In the economic analysis non-cash costs or benefits which result from the investment are also included in the analysis. This analysis is not prescriptive; it does not decide what the manager should do. The analysis is a prerequisite before the decision is made.

D. Economic Considerations of the Investment

1. Management: Critical to the viability of an investment in a swine enterprise is the managerial capacity. Management is unique in its impact on profitability. While not being an input into the production function, management is a controller of the inputs. Management selects the production technique, selects the timing, combination, and level of inputs and thereby exerts its influence on technical efficiencies. The quality of management is considered when determining the external credit rationing of the firm and may thus be an inherent constraint. It is management which determines the goals of the firm and whether that goal is profit maximization. When considering the effect of various price levels the strategy of the manager might be: 1) select an investment which has the maximum profitability under the most favorable conditions of all alternatives, 2) select the investment with the greatest minimum expected profit under the most adverse conditions, or 3) select the alternative which when subjected to the most unfavorable market conditions will have the minimum possible loss.[15] Another alternative is to select that strategy which yields the highest expected value given the probabilities of the various sets of events and their associated reward or net return.

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[15]Max D. Richards and Paul S. Greenlaw, pp. 48-50.

2. Discounting Returns: Discounting returns is a means to recognize the time pattern of returns and the risk associated with the dynamic nature of the investment. Knowledge and foresight of the future are not perfect. Production plans are therefore based on "anticipated prices and yields, and on probability distributions concerning the anticipated prices and yields."[16] These discounted returns due to risk may be manifested in the form of: internal cash rationing, internal credit rationing, or credit reserve. Internal cash rationing and internal credit rationing result in a reduction in production due to risk and uncertainty of the future returns from production as more resources are used in favor of household consumption. While both are self imposed constraints on production, the essential difference is that the former applies to owned resources and the latter to borrowed funds.[17] Credit reserves are funds available to the firm, but which are not actually borrowed. Each represent a form of insurance used by the firm to account for the influence of risk and all result in a reduction of the level of production. Under such effective credit rationing the firm is "not allowed to purchase the use of as much capital as is necessary to permit him to add resources up to the point where marginal costs equals marginal revenue . . . the farm is kept below its best combination of resources."[18]

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[16]Glenn L. Johnson, "Needed Developments in Economic Theory as Applied to Farm Management," Journal of Farm Economics (Vol. XXXII), p. 1151.

[17]Lawrence A. Bradford and Glenn L. Johnson, Farm Management Analysis (1953), p. 396.

[18]T. W. Schultz, "Capital Rationing, Uncertainty, and Farm Tenancy Reform," The Journal of Political Economy (June 1940), p. 313.

Both acquisition and control of funds are directly related to the management control function. "Management involves far more than production techniques, methods, and prices. In order to do a good job of using credit, then, a farmer needs to know how much income is personally worth to him, how much the security derived from discounting prospective returns is personally worth to him, how much the various consumption items . . . which he might buy are worth to him, and how much the ability to adjust to change is worth to him."[19]

As borrowed funds provide the vehicle by which the firm increases in size, there is a consequential increase in the risk of losing the business. Increasing the scale of the enterprise leads to premiums on costs as more is borrowed against the firm's net worth. "The problems and difficulties of running a business successfully change with the scale of the business . . . an entrepreneur's successful running of a business at one scale gives less and less of an indication of his competence to operate successfully at another scale the greater is the change contemplated."[20] Increasing the firm size via specialized resources which are fixed not only to the enterprise but also to the firm are further compounded by the risk of actually lowering net worth when the credit needs are greatest. The value of assets is expected to reflect their income potential. When returns to the swine system are unfavorably reduced so too is the firm's asset base and net worth. The reduction in net worth or equity can occur precisely when credit requirements increase.

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[19] Ibid., p. 401.

[20] R. H. Tuck, "A Reconsideration of the Theory of Agricultural Credit," Journal of Agricultural Economics (June 1956), p. 25.

3. Cash Flow and Debt Service: Once cash expenses have been deducted the remaining balance of revenues is an inexact and upward biased indicator of the funds available for debt servicing. Interest on debt, family consumption, Social Security, Federal and State income taxes "constitute a significant cash withdrawal with prior claim"[21] over debt repayment. Failure to recognize these obligations causes the upward bias in cash flow availability and is further compounded in each production period. Determining this figure is further complicated by the technical aspects of the method of accounting, business structure as relates to tax rates, and the direct action of management in year-end purchasing and selling as pursuant to an income tax management strategy. For the individual firm having other enterprises the combination may result in substantial changes in the tax rate that would exist were the swine enterprise the firm's sole enterprise.

4. Timing of Investment: Just as management is essential to the financial survival of the enterprise, so too is the point in time of the investment. Historically there have been indications of a prevailing 'hog cycle'. Such a cycle evidences a cobweb model whereby prices and quantities are considered to be "linked recursively in a causal chain."[22] High price levels encourage larger production. The resulting increase in supplies results in reduced prices, which in turn signals the need for less production, and so forth. This analysis is a consideration of the macro-economic system. To the individual firm

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[21]John R. Brake, "Firm Growth Models Often Neglect Important Cash Withdrawals," Journal of Farm Economics (August 1968), p. 769.

[22]William G. Tomek and Kenneth L. Robinson, Agricultural Product Prices (1972), p. 176.

the point in time at which investment is made and when actual marketings begin is critical. At a time when the profit potential (based on current prices) is acceptable, investment is committed. The prices in effect at the time when initial marketings begin may have declined and result in windfall losses where profits were anticipated, possibly making the returns inadequate to meet the financial obligations of the firm.

5. Seasonal Prices: While the production surface indicates pertinent input relationships, a capital budgeting analysis of investment alternatives enables the inclusion of additional factors. Such additional factors include: The effect of annually recurring price fluctuations which complicate the transition from isoproduct to isorevenue values when systems under consideration have marketings which are neither uniform nor of the same seasonal pattern. By virtue of their disparity in marketing time as reflected in disimilar prices, so too is the investment success affected by seasonal prices of feedstuffs which represents over half of the production costs.[23] This suggests that inputs and outputs of different points in time should be considered as different resources and products.[24]

The receipts from marketings of barrows and gilts constitute the primary source of revenue from farrow-to-finish operations. A system which markets hogs when the price is generally below or above yearly

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[23]Business Analysis Summary for Swine Farms, 1973, Michigan State University Agricultural Economics Report No. 272 (August 1974), p. 2.

[24]T. W. Schultz, "Theory of the Firm and Farm Management Research," Journal of Farm Economics (1939), p. 580.

average price experiences profound changes in its net income level when compared to a marketing pattern which is uniform over time. A one or two litter system which markets the bulk of its production over a small period of time are examples of production systems which are vulnerable to seasonal depression of prices for barrows and gilts.

In evaluating various production systems it is, therefore, important to include the seasonal price components involved in the marketing of hogs. Table III-1 presents price seasonalities for market hogs, sows and corn. For the twelve years of monthly prices from January, 1964, until December, 1975, there have been two months in which the prices for barrows and gilts have been (statistically) significantly different from the yearly average; April, ($p < .20$) and July ($p < .05$). The remaining months exhibit less consistency as well as less severity in their seasonal prices.

The market prices paid for sows, like the market for barrows and gilts, also exhibits seasonal price patterns. As sows are generally disposed of in entire groups at a time, i.e., continuous farrowing systems liquidate an entire group in order to maintain desired breed crosses and one littler systems market all sows after weaning their first and only litter, the seasonal price pattern will affect the income level. The impact of seasonal prices on sows is amplified in after-tax analysis as the receipts from sow marketings provide vehicle for capital gains income.

Just as net income is affected by seasonal components in the products which it markets, so too, is it affected by the seasonal prices associated with a primary input--corn. As hog operations increase

Table III-1. Index of Seasonality for Market Hogs, Sows, and Corn Prices

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Index of prices for barrow and gilts, U.S. No. 2 and 3 (200-220 lbs.); Indianapolis												
Index[1]	99.0	101.4	96.1	92.4	99.2	104.1	109.2	108.1	101.2	97.7	94.1	96.9
t statistic[2]	.16	.23	.82	1.46	.09	.47	2.48	.81	.18	.26	.90	.57
Index of prices for sows, U.S. No. 1, 2, and 3 (330-400 lbs.); Indianapolis												
Index	95.6	103.0	101.0	97.2	97.5	100.3	106.7	110.0	105.6	101.9	92.7	88.4
t statistic	.16	.38	.18	.53	.26	.03	1.16	.90	.77	.21	.67	1.80
Index of prices for corn, Michigan farm												
Index	100.8	99.0	99.0	97.8	100.5	103.5	103.7	106.1	102.2	96.3	92.7	98.6
t statistic	.15	.19	.14	.25	.07	.51	.66	.62	.34	.42	.81	.25

[1]For Method of Computation of Seasonal Indexes see Ag. Econ. Recport No. 118, "Seasonality in Michigan Agricultural Prices," by Richard G. Heifner and Robert P. Ferguson.

[2]t = (Seasonal Index - 100.0)/std. dev. This is the test for seasonal indexes significantly different from 100.0 (d.f. = 10).

their volume they become less self-sufficient in grain production.[25] Purchases of corn are also influenced by the seasonal prices. Similarly, operations which produce a portion of their feed requirements have an opportunity cost associated with feeding their corn rather than selling it. While the selling price may be less than for purchased corn due to transportation differential, the two will be closely and directly related.

In applying seasonal prices in an analysis of various production techniques the data, in part, are not statistically significant. While not always meeting statistical requirements it is appropriate and consistent to apply each monthly index since economic significance, as opposed to statistical significance, is of critical importance.

E. Physical Considerations

Similar considerations are necessary with respect to the non-homogeneity of inputs into the breeding herd. Variations between sows and gilts in their reproductive performance, i.e., conception rate and number of pigs raised, affect their relation to total physical output.

As facilities vary, the feed requirements are varied as is the waste management system. Storage and handling methods of swine waste have a substantial effect upon manure value when the opportunity cost of the chemical plant food nutrients which it replaces is considered.[26]

1. Reproduction and Dam Performance: The sow is profoundly fundamental to pork production. It is with the sow that substantial changes

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[25]"A Survey of Large Scale Hog Production in the U.S.," p. 12.

[26]"Swine Handbook, Housing and Equipment," Midwest Plan Service - 8 (1974), p. 33.

in the level of net income are possible. "The number of pigs reared per litter, and the frequency with which the sow farrows has . . . an important influence on pig production costs."[27] The economic significance of relevant factors which are capable of human control is readily defined: The impact on net income to the farrow-to-finish operation of a $.10 increase in the price per bushel of corn or a $.53/cwt decline in market prices for hogs is offset entirely by improving conception rate by 6.4 percent, or increasing pigs weaned per litter by .45, or increasing the number of farrowings per sow per year by .14.[28] As the genetic potential of the hog herd is changed in only four generations, an improvement in feed efficiency of .21 pounds of feed per pound of gain is possible through selective breeding and has a positive effect upon net income.[29]

Research on the pigs born per litter shows that for successive gestations of females the litter size generally increases at a decreasing rate and eventually declines. Table III-2 summarizes various studies on pigs born per litter versus litter order for the dam confirming the law of diminishing returns in reproductive performance.

A study based upon the production of 156 pedigree brood sows of the large white breed, each farrowing exactly ten litters revealed that gilt litters averaged 9.5 pigs per litter born and 7.84 reared, while their next five successive litters averaged 11.5 pigs born and 8.82 reared.[30]

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[27] A. W. Menzies-Kitshin, M.A., "Fertility, Mortality, and Growth Rate in Pigs," Journal of Agricultural Science (Vol. 27), p. 612.

[28] "A Multiple Regression Model for Net Income Estimates from 100-Sow Production Units," Journal of Animal Science (January 1974), p. 6.

[29] Ibid., p. 6.

[30] T. M. Olbrycht, "The Statistical Basis of Selection in Animal Husbandry," Journal of Agricultural Science (Vol. 33), pp. 28-43.

Table III-2. Pigs Born Per Litter Influenced by Litter Order

Litter Order	Lush & Mollin	Kernkamp	Menzies-Kitchin	Olbrycht	Carmichael & Rich
I	7.92	8.4	8.6	9.5	7.2
II	8.49	9.2	9.8	10.72	7.9
III	9.49	9.2	10.1	11.38	8.4
IV	9.49	9.7	10.5	11.80	8.6
V	9.88	9.7	10.5	11.90	9.3
VI	9.93	9.3	10.9	11.72	8.6
VII	9.58	8.0	11.4	11.28	8.4
VIII	9.76	8.3	11.2	11.17	8.2
IX	9.42	---	10.4	10.78	7.1
X	9.04	---	10.4	10.10	10.6

Source: See Bibliography for separate author references.

Omtvedt, et al. (1966) produced similar results in the production of sows as contrasted to gilts. In this study gilts farrowed an average of 10.1 pigs per litter, weaning 8.3; sows farrowed 11.2 pigs per litter, weaning 8.4 pigs per litter.[31] These results are based upon the production records of 691 litters and five lines of breeding. While the sows not only farrowed more pigs per litter than gilts, they also had higher mortality rates for their litters than the gilts. The mortality rate in general illustrates the marked tendency for all pigs in very small litters as well as a high percentage of the pigs in very large litters to be lost. These findings are also indicated by Pomeroy (1960), Sharpe (1966), and Fahmy and Bernard (1971).

[31] I. T. Omtvedt, J. A. Whatley, Jr. and R. L. William, "Some Production Factors Associated with Weaning Records in Swine," Journal of Animal Science (1966), p. 373.

Omtvedt's study indicated that while sows have a higher mortality in their litter than do gilts the average weight of the pig at birth is also heavier among sow litters than gilt litters. There is much conclusive evidence to support a strong positive relation between the pig birth weight and the subsequent survival rate, including research by Vestal (1936), Weaver and Bogart (1943), Sovljanski (1965), and Sharpe (1966). While there appears to be an obvious inconsistency in data, Omtvedt established statistically significant correlations to explain the rationale of this phenomenon: The weight of the litter at birth and the birth weight of the pig is significantly ($p < .01$) different for the age of the dam with correlations of -0.10 and 0.10 for sows and gilts respectively. Also significant is the correlation of the litter birth weight and survival rate, $r = -0.12$ ($p < .05$), and the correlation of litter birth weight to litter size, $r = 0.82$ ($p < .01$). Other findings have found that while percent survival increases with increases in birth weight that the percent of pigs which weigh less than two pounds at birth generally increase with increases in litter size.

Complementary work has been done for the comparison/contrast of sows and gilts with respect to the weaning performance. Vestal observed that two-year-old sows weaned 1.62 more pigs than yearlings, and 0.21 more pigs than did three-year-old sows. A report from Kurmark (near Berlin) based on 11 years of swine production records of more than 24,000 litters concluded that "the 'young sows' (about one-third of the total) farrowed 1.09 less pigs per litter than 'old sows' and raised 0.69 less pigs to four weeks of age" (unweighted average).[32]

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[32] H. C. H. Kernkamp, "Birth and Death Statistics on Pigs of Preweaning Age," Journal of American Veterinary Medicine (Vol. 146), pp. 337-339.

Based on the assumption that most preweaning deaths occur within the first three weeks postpartum, and subsequently verified by Kernkamp (1965), Lush and Mollin compared weaning performance in their experiment with other prior research on weaning studies, one of which involved weaning at three weeks of age (see Table III-3). Figure III-4 illustrates the expected weaning performance from successive litters.

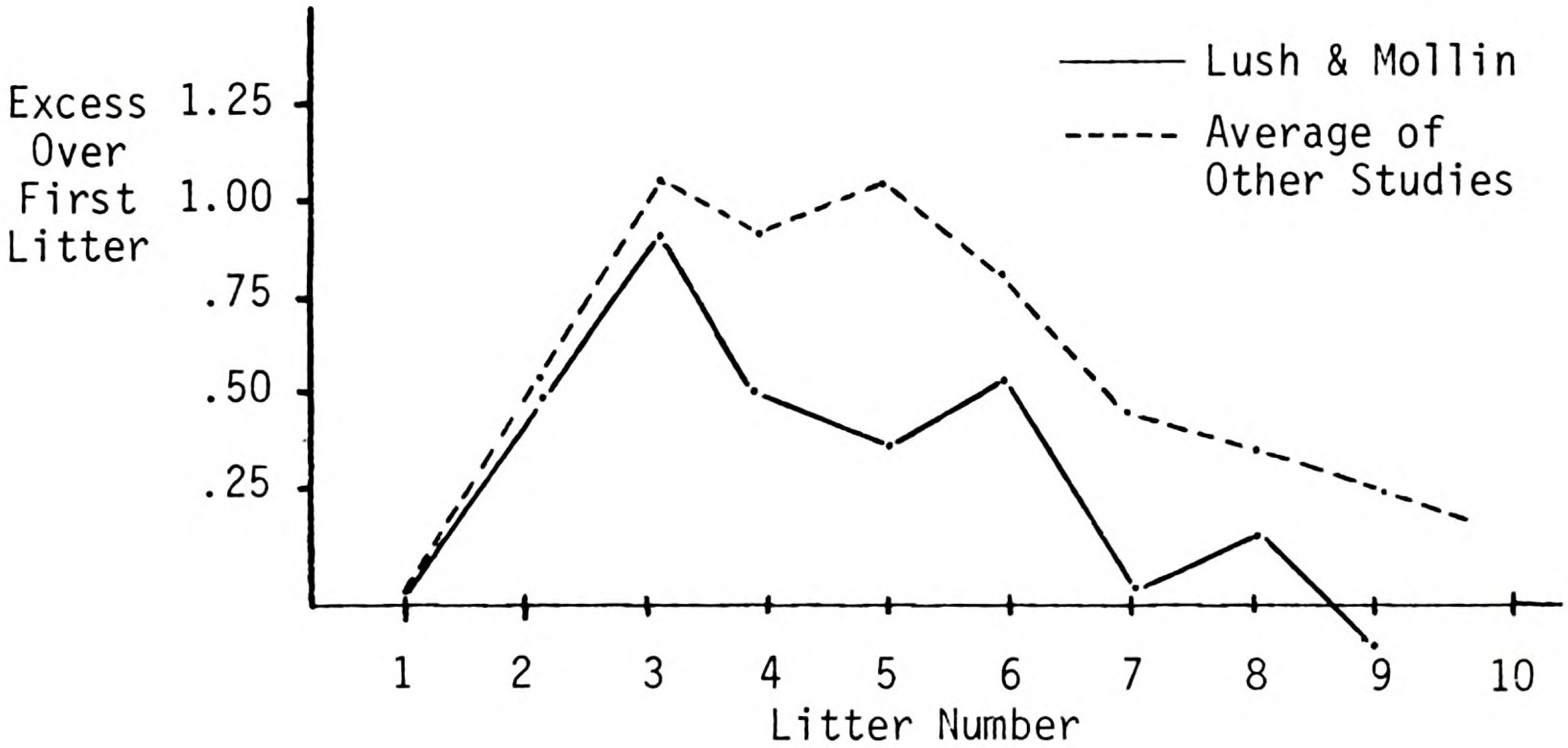
Table III-3. Excess Over First Litter
(number pigs weaned)

Litter Order	Lush & Mollin	Average of Other Studies
I	.00	.00
II	.46	.68
III	.92	1.11
IV	.60	.96
V	.40	1.04
VI	.61	.81
VII	.00	.50
VIII	.11	.42
IX	-.12	.40

Source: See Bibliography for author listing.

Farrowing performance of sows when contrasted to that of gilts bears crucial importance on evaluation of hog production systems when gilts provide the primary source of reproduction as opposed to primarily sow herds in other systems. For the one-litter system of production (farrowing) where the breeding stock is gilts as opposed to sows, a lower number of progeny per litter can be expected than for more intensive farrowing schedules utilizing primarily sows where gilts comprise only replacements after herd culling.

Figure III-4. Excess Over First Litter
for Successive Litters



Source: See Bibliography for author listing.

Not only is reproduction measured by the size of the litter but also by the extent to which available breeding stock is effectively used. "Such things as low conception rate, hot weather . . . boars that don't work in confinement . . . and problems of working gilts into a tight breeding schedule are among the 'non-disease related' problems that plague producers."[33]

While it is assumed that sows and gilts are capable of conceiving anytime during the year "it appears as though reproductive efficiency is much lower during late summer and early fall than during other times of the year."[34] Such a seasonal infertility phenomenon indicates the need for substantial increases in the breeding herd during late summer and early fall in order to have a number of farrowings commensurate with

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[33]"Southwest Minnesota Swine Health Clinic," (December 1976), p. 19.

[34]Ibid., p. 56.

those resulting from breeding during the rest of the year. Table III-4 gives the multiplication factor for each month which when multiplied by the number of desired farrowings will indicate the number of females needed for the month when breeding occurs.

Table III-4. Number of Females Required for Each Bred Female Desired

Breeding Month	Multiplication Factor	Implied Conception Rate
January	1.25	80%
February	1.28	78
March	1.35	74
April	1.43	70
May	1.52	66
June	1.64	61
July	1.69	59
August	1.82	55
September	1.52	66
October	1.35	74
November	1.30	77
December	1.25	80

Source: "Southwest Minnesota Swine Health Clinic," December 1976, unpublished presentation.

2. <u>Environmental Influence on Pig Performance</u>: The justification for greater building costs must be based upon greater expected (net) returns. Confinement pork production is intended to allow the pig to more nearly express its optimum genetic ability to perform. It is

important to know that different types of confinement support different levels of performance . . . sophistication of design and greater attempts at environment control are not synonymous with improved performance.[35]

As the environment for the hog becomes more controlled the expenses associated with labor requirements and feed requirements are reduced. Since feed accounts for approximately two-thirds of the total production costs of swine,[36] added savings due to feed efficiency are critical. That enclosed building structures can generally be expected to improve feed efficiency, i.e., reduce pounds of feed per pound of gain, as compared to open front type buildings has been demonstrated by Jensen, et al. (1969), Kaldec, et al. (1966), Cramer, et al. (1968), Hinkle, et al. (1971), McFate (1968), and Jones, et al. (1969).

Research further indicates that controlled environment units result in greater feed efficiency, but simultaneously reduce the rate of gain; Kaldec, et al. (1966), Cramer (1968) and Jones, et al. (1969). Although these research conclusions have been subject to question, it is an important aspect in considering various growing-finishing facilities.

The potential to maintain the level of feed efficiency from environmentally controlled facilities may be no greater than for facilities which make sacrifices in environmental control and less initial investment. Marketing of hogs before their economic optimum is achieved (as defined by the marginal value of additional gains in weight relative to the marginal cost of additional gains) may be necessary in order to increase returns to fixed assets.

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[35] "Nebraska Swine Report," University of Nebraska Publication E.C. 73-219 (January 1973), p. 20.

[36] "Business Analysis Summary for Swine Farms, 1974," Michigan State University Agricultural Economics Report No. 286 (August 1975), p. 2.

Within the literature on pig performance in various housings there is a lack of uniform levels of either feed efficiency or rate of gain. This can be attributed basically to two factors: 1) progression in feed technology which has resulted in less "deadwood" in present rations, and 2) improvements in the hog itself.

As applied to commercial hog production in Michigan, estimated feed requirements for hogs from 40 pounds to market weight yield approximately .256 pound of gain per pound of feed fed.[37] For hogs raised in pasture, feed requirements are expected to be approximately 12 percent greater and the marketing date will lag from 15 to 30 days behind the marketing time of hogs raised in environmentally regulated or the modified open front facilities.

3. Waste Management: An integral part of any swine housing system is its necessary provision for disposal of waste (see Table III-5 for manure production amount). For hogs farrowed and raised in pasture there is essentially no handling of waste as it is returned directly to the land. When hogs are housed on solid concrete, most manure removal is solid form. Slotted floors and partially slotted floors associated with environmentally controlled and modified open front buildings respectively are generally used in conjunction with either anaerobic liquid storage or lagoon storage.

The method of waste storage and handling involves not only different labor and initial capital requirements but also influences the total value of the waste when it is eventually returned to the land with respect to the net available crop nutrients (see Table III-6). While the

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[37]"Nutrition: Swine Feeds and Feeding," Michigan State University Extension Bulletin 537 (September 1975), p. 32.

Table III-5. Manure Production by Swine

Animal	Average Weight	Manure Pounds/Day	Available Crop Nutrients, Pounds/Day		
			N	P_2O_5	K_2
	(pounds)				
Finishing Hog	130	8.5	.059	.0445	.0472
Nursery Pig	35	2.3	.016	.012	.012
Gestating Sow (limit fed)	275	3.9	.062	.048	.048
Sow and Litter	375	33	.23	.175	.18
Boar (limit fed)	350	11	.078	.060	.061

Source: Derived from Swine Handbook--Housing and Equipment, MWPS-8.

Table III-6. Manure Nutrient Losses in Storage and Handling

	% Losses		
I. System of Storage	N	P_2O_5	K_2O
Open lot	55	50	40
Manure pack (solid)	35	10	5
Anaerobic pit	25	5	5
Lagoon	80	80	20
	% Losses		
II. System of Application	N	P_2O_5	K_2O
Broadcast, w/o immediate cultivation (solid)	21	5	0
Broadcast, w/o immediate cultivation (liquid)	27	5	2
Knifing (liquid)	5	5	2
Irrigate (liquid)	25	20	20
	% Remaining		
III. Nutrients Remaining after Storage and Handling	N	P_2O_5	K_2O
Open lot	45	50	60
Manure Pack (Broadcast)	51	86	95
Anaerobic (Broadcast)	55	90	93
Anaerobic (Knifed)	71	90	93
Lagoon (Knifed)	19	19	78
Lagoon (Broadcast)	15	19	78
Lagoon (Irrigate)	15	16	64
Anaerobic (Irrigate)	56	76	76

Source: Derived from Swine Handbook - Housing and Equipment, MWPS-8.

waste involves a cost to the swine enterprise in its removal, its return to the land represents a savings to the farm's cropping enterprise equivalent to the cost of purchased commercial fertilizer that can be replaced, therefore, the swine enterprise is credited by an equivalent amount.

F. Summary

The alternative methods of hog production give rise to a production surface having greatly different capital, labor, and feed requirements. The acquisition of capital intensive facilities results in the least amount of flexibility to change with varying economic conditions.

The level of management and timing of investment are critical factors affecting the viability of the enterprise. Management requirements are different for the alternative swine production systems. Inherent differences in the systems include the marketing season, pattern of feed and labor demands during the year, ability of the animal to express its genetic potential as constrained by its environment, and waste handling and storage.

CHAPTER IV

The One-Litter Pasture System

One purpose of adding an enterprise to the farm is to increase the expected net income to the farm. Hog enterprises have the obvious potential to achieve this goal by increasing income more than costs. The economic feasibility of the hog enterprise is further enhanced through its ability to increase returns to labor. Labor required for a one-litter system is seasonal and normally complements the cropping operation. The hog enterprise may further improve the farm's income as it provides a market for the farm's corn which eliminates the marketing and/or transportation cost for the grain.

A. General Description

A one-litter pasture system conforms precisely to the premise that "hogs are designed to be raised outside and bred in cold weather."[38] The basis of this system is pasture and labor-intensive facilities. All hogs have access to grass or legume pastures and farrowing occurs in portable pasture facilities. As opposed to confinement farrowing systems, the pasture system substitutes land and labor for capital investment in depreciable permanent facilities. The nature of this production strategy is to invest in real estate whose historic effect over time has been to increase the equity or potential financial leverage.

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[38]G. R. Carlisle, Introductory comments to "New Concepts in Breeding Herd Management," Southwest Minnesota Swine Health Clinic (December 1976).

This system is further characterized as having the simplest waste management system and being the least energy dependent.

Disadvantages to this system include the high risk associated with disease control as there is a single annual production cycle. The unpredictability of weather presents another problem which is capable of severely reducing production levels and efficiency.

Not only is the one-litter pasture system characterized by its orientation toward pasture but also by its exclusive use of gilts, rather than sows, in the breeding herd. All pigs are raised and sold as market hogs except for a new group of gilts which are retained to continue the production cycle. This is an economically significant characteristic since gilts farrow and raise fewer pigs than do sows. Further, gilts generally will exhibit a lower conception rate than do sows, thus requiring a greater number of gilts to be retained from the market hogs in order to farrow an equivilant number of pigs relative to what sows would produce.

For the one-litter pasture system, the gilts farrow during the latter part of spring, generally in May and June. Farrowing is done in pasture using portable shelters such as a steel quonset or "A" frame to protect the sow and litter. In order to maintain the pasture, it is recommended that the farrowing intensity be no more than four litters per acre.

Until pigs become approximately three weeks of age they take no feed in addition to the sow's milk.[39] After three weeks of age, creep feed, and later a starter ration, is made available to the young pigs by creep

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[39]Olbrycht, p. 28.

feeders. The pigs are left on the sow until they are 5-8 weeks old at which time they are weaned. Approximately two weeks after weaning the sows are marketed. Receipts from this marketing are capital gains, and further coincide with a seasonally high sow market price.

After weaning, the growing pigs remain on pasture and as the finishing stage occurs are typically moved to a permanent type building--either a converted barn or an open front pole barn with a solid, bedded concrete floor.

For higher levels of production, gilts are bred in groups over a longer period of time. The level at which this multiple grouping occurs varies, but is suggested that production levels over 50 litters per year could be expected to follow the multiple group pattern.[40] This grouping results in savings as a smaller proportion of boars are necessary to achieve higher production levels. Groups of gilts reduce the peakedness in the labor requirements over the year.

For the lower level of production only one group of gilts is exposed to the boars for two estrous cycles. Expected conception rate would be 70-75 percent. When gilts are in two groups, after the first group of gilts is exposed to the boars another group is added. This procedure would be expected to increase the overall conception rate to 80-85 percent as the first group will have had two additional exposures during estrous.

Other economies from this multiphase farrowing are realized from more intensive use of the farrowing facilities. As the first farrowing occurs earlier in the year the need to provide housing for the first

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[40]"Economics of Size in Swine Production Under Different Production Methods and Phases," CARD Report 61, Iowa State University, (October 1975), p. 9.

group of pigs farrowed during their finishing stage may be virtually eliminated. Inherent efficiencies also accrue to this type of operation as the groups are smaller and more uniform than would be the case from only one group, thus being more conducive to improved pig performance.

Having two groups of hogs to market may well provide insurance against marketing pigs at seasonally depressed prices.[41] Since the months of October and November are consistently below average with respect to prices, breeding in groups results in dispersion of marketings protecting against marketing only at depressed prices.

B. Labor Requirements

While the cost of labor may represent a small proportion of the total cost in swine production, labor may be the most constraining resource on many family farm operations. The efficiency or productivity of labor is therefore critical when planning not only a production technique (line of least cost combination) but also in determining the optimal level (high profit point).

The distribution of labor is critical in establishing a monthly cash flow summary where labor is charged at a flat rate as well as in planning the size of the operation which is possible with the available monthly labor resource. With the one-litter system a relatively peaked distribution of labor occurs as opposed to a uniform distribution involved in a total confinement system. When considered in conjunction with the balance of the farm enterprises the peaked seasonal requirements of the one-litter system may result in achieving higher farm profits due to

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[41] C. O. Hardy, Risk and Risk Bearing (1929), p. 3.

seasonal labor surplus not being used by the crop enterprise. This opportunity exists despite the fact that the one-litter system is a less efficient user of labor than a confinement system.[42] One-litter systems require nearly 50 percent more labor than enclosed total slotted facilities for the same level of production.[43]

An estimated distribution of labor requirements for this system appears in Table IV-1. It is assumed that gilts are selected from market hogs when they have completed the finishing phase, i.e., 225 pounds. For the two lowest levels of production where gilts are all in one group a conception rate of 70 percent is applied.[44] For higher levels where gilts are in two groups, after breeding for April farrowing both groups are combined and exposed to the boars for June farrowing and conception is increased to 80-85 percent overall thereby reducing the number of gilts that need to be retained from marketings. Total labor requirements conform to those needed to include feeding, cleaning, and repairs.[45]

C. Feed Requirements

The changes and levels of feed necessary during the full production cycle has a significant impact on the monthly cash flow of the enterprise. A calendar of recommended feed requirements for breeding and

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[42] The Over Production Trap in U.S. Agriculture, pp. 185-188.

[43] "Planning Data for Hog Farms," Purdue University Publication EC-408 (January 1972), pp. 14-15.

[44] "Economics of Size in Swine Production Under Different Production Methods and Phases," p. 12.

[45] "Planning Data for Hog Farms," pp. 14-15.

Table IV-1. Monthly Hours Labor Required for One-Litter Pasture Production

# Gilts Kept	# Litters per Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total Hour
34	25	30	20	20	20	70	70	70	25	25	25	25	35	435
68	50	60	35	35	35	125	125	125	50	50	50	50	65	805
90	75	75	75	50	205	85	205	90	55	55	55	45	85	1080
300	250	230	230	150	630	260	630	290	190	190	190	150	270	3410
Monthly as % of Total		6.7	6.7	4.4	18.5	7.6	18.5	8.5	5.6	5.6	5.6	4.4	7.9	

Source: Iowa State University CARD Report 61.

Note: For production levels greater than 150 gilts, labor requirements increase in constant proportion to production levels.

Monthly labor requirements are a distribution of total labor necessary for each phase: gestation, farrowing, growing, and finishing--of the pasture production system.

gestation is based on removing gilts when they weigh 225 pounds and includes: 1) feed gilts 5 pounds of 13 percent protein ration daily until 2 weeks prior to breeding, 2) increase ration to 7 pounds per day 2 weeks before breeding, 3) reduce feed to 5 pounds per day during breeding and until 2 weeks prior to farrowing, 4) increase feed to 7 pounds per day 2 weeks prior to farrowing, and 5) provide lactating and weaned sows 11.6 pounds daily.[46]

Table IV-2 summarizes both the feed for the breeding herd and the market hogs. Feed efficiency factors for this system are: 1) overall feed conversion in this system is 4.72:1; 2) feed required per litter is 8245 pounds; and 3) based on the weighted average number of females in the herd the feed required is 8962 pounds per female.

D. Land Requirements

A one-litter pasture system is relatively land extensive. The effect of recent upward changes in the level of grain prices without offsetting increases in direct costs of production has been an increase in the opportunity costs associated with using land for hog pasture rather than grain production.

The impact of this change can be expected to be more acute in the major hog producing regions outside of Michigan than within the state. If corn production is the next best alternative for land use instead of hog pasture, the one hundred leading United States' counties (based on number of hogs marketed annually) have a statistically significant higher corn yield than the twenty leading counties in Michigan (based

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[46]*Ibid.*, p. 4.

Table IV-2. Total Feed Requirements (Breeding & Market Hogs) for One-Litter System, 250 Litters/Year

Month	Breeding & Gestation Corn	Breeding & Gestation Supp.	Nursery	Growing - Finishing Corn	Growing - Finishing Supp.	Total Corn	Total Supp.	Monthly Corn as % of Total Year	Seasonal Price Index of Corn
	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(%)	
Jan	44,271	9,718		131,432	28,786	175,703	38,504	10.9	1.008
Feb	43,986	9,656		50,691	11,124	94,677	20,780	5.8	.990
Mar	45,686	10,028		--	--	45,686	10,028	2.8	.990
Apr	58,078	12,749		--	--	58,078	12,749	3.6	.978
May	63,568	13,954	7,250	7,383	3,230	70,951	17,184	4.4	1.005
June	58,183	12,771		22,149	9,690	80,332	22,461	5.0	1.035
July	46,236	10,149	10,875	39,935	15,102	86,171	25,251	5.3	1.037
Aug	22,372	4,911		93,285	35,806	115,657	40,717	7.1	1.061
Sept	--	--		151,169	46,588	151,169	46,588	9.3	1.022
Oct	--	--		223,966	63,916	223,966	63,916	13.8	.963
Nov	22,483	4,935		246,210	64,118	268,693	69,053	16.6	.924
Dec	27,203	5,972		219,516	52,087	246,719	58,059	15.2	.986
TOTAL	432,066	94,843	18,125	1,185,736	330,447	1,617,802 (28,889 Bu.)	425,290	99.8	

on number of hogs marketed annually).[47] Therefore, Michigan has a comparative economic advantage in utilizing land for hog pasture than in the major hog producing regions in the United States.

Not only is this inequality statistically significant but also economically significant. As the yield increases, the breakeven grain price declines, thus increasing the returns over direct costs which increases net income per acre.[48] This higher net income will command either a higher land rent or a higher opportunity cost than land having a lesser yield. The land rent not only is reflected as a factor in economic analysis but also provides a basis for determining land value.

E. Derivation of Land Charge

To achieve satisfactory animal performance in a one-litter system requires the availability of uncontaminated pastures. This requirement plus the general nature of hogs to destroy pasture necessitates the operation to have three times as much land available as will be needed for raising hogs in each year. This allows two years of normal cropping before returning the land to hog pasture in the third year.

The land charge made to the proposed pasture system, both the one- and two-litter, reflects the reduction in net income by using the land for pasture rather than corn production. This charge is the net cash income from corn production, or gross income less variable expenses, plus seeding expenses for pasture. The charge is derived in Table IV-3.

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[47]See Appendix for Mann-Whitney U-test.

[48]As indicated by TelFarm returns as the yield increases the break-even price declines, thereby increasing the returns over direct costs which becomes land rent.

Table IV-3. Budget for Corn and Pasture Production

1. Selected Cash Cost for Corn Grain at 100 bushel/acre:

Seed		\$ 11.50/ac
Fert:	N	23.00
	P_2O_5	12.80
	K_2O	5.00
Lime		2.20
Herb.		10.00
Insect.		7.60
Fuel & Repairs		16.50
Hauling		5.00
Drying		13.00
Utilities		3.40
Misc.		1.70
Int. on above		3.92
Labor (5.6 hr.)		27.28
Total Variable Expenses		\$142.90

2. Gross Cash Income @ \$2.50/bu = \$250.00

Net Cash Income = \$250.00 - 142.90 = \$107.10[1]

3. Cash Cost for Pasture Seeding:

Seed	\$ 7.22/ac
Lime	2.20
Fuel & Repairs	12.00
Misc.	1.70
Interest	2.04
	\$ 23.94

4. Total Cash Cost/Acre for Hog Pasture:

\$107.10 + 23.94 = \$131.04

[1] \$107.10 is the "land rent" or returns to land. When capitalized at 8.75 percent represents a land value of \$1224/acre.

For both pasture systems it is assumed that there are four litters per acre during farrowing.

F. Distribution of Marketings

Seasonal prices for hogs have their most profound effect on the one-litter system. Since the age to market weight is generally greater for hogs raised on pasture or conventional housing than for those raised in a controlled environment implies that this system inherently has more risk: "The longer period gives more time for prices to change . . . ."[49] As most hogs reach market during the late fall and early winter in this system, a season when hog prices are normally below their yearly average, there is increased risk attributable to high concentration of marketings with respect to time.

Marketing of sows constitute a substantial protion of both hundredweight marketed as well as receipts. Like marketings of barrows and gilts, sow marketings are concentrated with respect to time. However, these marketings occur during seasonally high prices, and the receipts generated are capital gains income.

For the one-litter production systems described, the distribution of marketings appears in Table IV-4.

G. Summary

The seasonal characteristics of the one-litter system are its most identifying features. The requirements for labor vary greatly between

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[49]"New Procedures in Estimating Feed Substitution Rates and in Determining Economic Efficiency in Pork Production," Iowa Research Bulletin 409 (May 1954), p. 956.

Table IV-4. Marketings of Barrows and Gilts

Month	50 Litters/Year			250 Litters/Year	
	Number of Head	Percent of Total	Seasonal Price Index	Number of Head	Percent of Total
Jan	183	62.9	.990	304	20.9
Feb			1.014	512	35.2
.					
.					
.					
Nov			.941	238	16.3
Dec	108	37.1	.969	402	27.6
					100.0
Avg. weighted price index:	50 litters/year = .982			250 litters/year = .984	

Marketings of Sows and Boars

	Number[1] of Head	Percent of Total	Seasonal Price Index	Number of Head	Percent of Total
.					
.					
.					
Mar	5	6.8	1.010	11	3.5
Apr			.972		
May	18	24.7	.975	50	16.1
June			1.003	110	35.4
July	50	68.5	1.067		
Aug			1.100	140	45.0
					100.0
Avg. weighted price index:	50 litters/year = 1.040			250 litters/year = 1.042	

[1]Marketings of sows are those females retained from the previous year's pig crop. Therefore, the number of hogs produced by this system is barrows and gilts plus sows.

months. Due to seasonal marketing patterns selling price for sows and boars is normally greater than the average annual price by approximately 4 percent. Conversely, barrows and gilts normally sell below the average annual price. Corn, the largest direct cost, will cost less than if it were purchased at its average price for the year. This reflects a major portion of the corn required for the system being fed in the fall, a time of seasonally low prices for corn.

Although this system is reported to have relatively low total capital requirements, the intensity of use or lack thereof can increase the total facility and investment costs per hundredweight produced. This tradeoff of total investment between alternative hog production systems and to total costs relating to intensity of use and to increased feed costs will be discussed in Chapter VII.

CHAPTER V

The Two-Litter Pasture System

A. Introduction

The two-litter system has nearly the same distinguishing features of the one-litter system. As farrowing is still seasonal--but twice as frequent--so too are the demands for labor, feed, and marketings. As with the less intensive one-litter pasture system, the two-litter system has labor requirements which make it compatible with other cropping enterprises of the farm.

B. Building Facilities

In this system, as in the one-litter system, breeding and gestation facilities consist of pole buildings, converted barns, and adjoining lots. Sows are moved to pasture prior to farrowing. Each year's farrowing has new pasture which again follows a three-year rotation preceded by corn and small grain respectively. Use intensity is again four litters per acre. Nursery phase of production also is in the pasture but subsequent growing-finishing processes require adequate cold weather housing as would be provided by modified open front buildings.

As compared to the one-litter system, the two-litter system makes more intensive use of facilities available for breeding, gestation, and farrowing by using them twice annually--once in spring and again in autumn. This economy on facilities is to some extent offset by the

demands of fall-farrowed pigs for improved winter housing. The firm having a two-litter production system is in an intermediate position between one-litter and total confinement for capital asset requirements which are fixed, both to the firm and to the enterprise. This system as outlined remains independent of the need for supplemental or artificial sources of heat. This system is essentially a six-month cycle operation organized to complement cropping enterprises, utilizing seasonally slack labor during periods of least labor requirements for field work.

The self insurance on price risk inherent in two separate marketing seasons is offset somewhat in that pigs are still being marketed during seasonally weaker prices, especially the spring market for fall-farrowed pigs. The repeated use of breeding stock instead of a complete turnover each year results in a smaller portion of receipts qualifying as capital gains income. Like the one-litter system, this system too is vulnerable to the weather. In particular, adverse weather at farrowing time can reduce reproduction efficiency. At the other extreme warm weather when rebreeding sows for fall farrowing can result in low reproduction efficiency because of sow infertility or boar inactivity.

C. The Production Schedule and Efficiencies

For the two-litter pasture system the production calendar is: breed December 16-26 for farrowing April 10-20. These pigs are then weaned approximately May 20 and sows are rebred during May 24-30 to farrow again September 14-20. Fall weaning is approximately November 1. This weaning date for fall-farrowed pigs allows a five week minimum age of pigs when weaned and provides the proper cycling of sows for breeding

again in December. Boars for this system are ideally purchased 60 days prior to breeding--approximately October 15, used for winter and summer breeding and disposed of the first of June.

Sows for this system farrow an average of six times before being marketed. Replacement gilts are selected from the April farrowing and are added to the winter breeding herd to farrow their first litter in the next spring. Overall conception rate for winter breeding is 80 percent where one-third of the herd will be gilts. Rebreeding for fall farrowing in September occurs in May and conception rate is expected to be 67 percent (see Table III-4). The process of replacing sows with their offspring requires the annual turnover in boar stock. Boars are therefore sold annually after June breeding and their replacements are purchased during October to be first used during December. Sows which are culled from the herd are marketed at weaning time, typically October and June.

Gilts to be added to the breeding herd are selected from summer-farrowed pigs and combined with sows at weaning on November 1. Under this system overall conception is 75 percent. A winter breeding herd composed of 88 gilts and 100 sows would result in 150 litters in April, for a conception rate of 80 percent. Rebreeding these sows in May with an expected conception rate of 67 percent would yield 100 bred sows for September farrowing (see Table III-4). This system has 60 percent of its annual production in the spring and the balance of 40 percent in the fall. Non-bred sows or gilts are marketed when detected during gestation, generally in late March and September.

The following standards are applied to the two-litter production system: (1) the ratio of boars to sows is 1:8, (2) 20 percent of boars

are sold after their first use or approximately January 1, the balance being sold after June breeding, (3) non-bred sows are sold two weeks prior to farrowing or the first of September and the fourth week in March (see Table V-1), (4) weaning efficiency of 8.25 pigs/litter, additional mortality of 6 percent prior to growing phase and 1.5 percent mortality during growing-finishing for a marketing average of 7.64 pigs/litter.[50]

D. Labor and Feed Requirements

For this system the labor requirements are represented in Table V-2. Feed requirements for the breeding herd are calculated as in the one-litter system. Table V-3 combines both breeding herd and market hog feed requirements. The feed efficiency factors for the two-litter system are: 1) the overall feed conversion is 3.67:1, 2) 6,982 pounds of feed are required for each litter, and 3) for the weighted average size of the sow herd, 11,048 pounds of feed required for each sow (or female) in the breeding herd.

E. Summary

The seasonal characteristics of the two-litter system are similar to those of the one-litter system. The most significant changes in this pasture system are its more intensive use of pasture land, facilities, and breeding animals. Greater initial capital is required to provide year-round growing-finishing facilities. The more intensive use of the sow herd results in lower fixed facility costs per hundredweight than with the one-litter pasture system. This budgetary analysis of alternative swine production systems will be presented in Chapter VII.

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[50] Planning Data for Hog Farms, p. 13.

Tavle V-1. Marketing Schedule for Two-Litter Production

Marketings of Barrows and Gilts
for 250 Litters Annually

Two-Litter Pasture Production

Month	Number of Head	Percent of Total Number Market Hogs	Seasonal Price Index
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.			
.			
Mar	458	24.0	96.1
Apr	306	16.0	92.4
.			
.			
.			
Sept	318	18.0	101.2
Oct	740	42.0	97.7
	Average weighted price - .971		

Marketings of Sows and Boars
for 250 Litters Annually

Month	Number of Head[1]	Percent of Total Number Market Hogs	Seasonal Price Index
Jan	5	3.4	95.6
.			
Mar	38	25.9	101.0
.			
.			
.			
June	20	13.8	100.3
.			
.			
Sept	50	34.5	105.6
.			
Nov	33	22.4	92.7
	Average weighted price = 1.004 1.0		

[1] November sale of sows would normally occur every third year for a complete turnover of breeding stock. To maintain consistency, a one-third (1/3) turnover in any given year is included here.

Table V-2. Labor Requirements for Two-Litter Pasture Production

	Number of Litters Annually	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Average Hrs. Per Sow Per Year
I.	100	51	48	40	333	118	41	41	47	288	25	44	44	11.9
II.	250	134	101	85	734	286	134	134	99	631	208	143	140	11.3
III.	750	453	360	290	2224	862	425	425	355	1951	647	463	445	11.8
Monthly as % of Total		4.3	4.0	3.4	28.0	9.9	3.4	3.4	3.9	24.2	8.0	3.7	3.7	

Source: Derived from CARD Report 61 for pasture gestation and farrowing, modified Open Front growing and finishing, total hours being distributed according to the production calendar outlined. Total hours for the three levels are: I = 1190 hrs., II = 2829 hrs., and III = 8900 hrs.

Table V-3. Feed Requirements for Two-Litter Pasture Production, 250 Litters/Year

	Breeding & Gestation		Nursery	Growing-Finishing		Total	Total	Monthly Corn as % of Total	Seasonal Index for Corn
	Corn lbs.	Supp lbs.		Corn lbs.	Supp lbs.	Corn lbs.	Supp lbs.		
Jan	26,108	6,055		76,496	25,499	102,604	31,554	7.5	1.008
Feb	23,582	5,468		87,572	17,407	111,154	22,875	8.1	.990
Mar	26,663	6,175		131,357	26,111	158,020	32,286	11.6	.990
Apr	37,628	12,472	12,375	43,786	8,704	81,414	21,176	6.0	.978
May	37,590	12,220		38,039	16,642	75,629	28,862	5.5	1.005
June	18,450	4,050		105,595	35,198	124,045	39,248	9.1	1.035
July	15,888	3,488		105,595	35,198	121,483	38,686	8.9	1.037
Aug	15,888	3,488		120,883	24,029	136,771	27,517	10.0	1.061
Sept	21,722	6,778		181,325	36,043	203,047	42,821	14.9	1.022
Oct	27,415	9,885	8,965	60,442	12,014	87,857	21,899	6.4	.963
Nov	25,818	6,058		27,557	12,056	53,375	18,114	3.9	.927
Dec	33,873	7,964		76,496	25,499	110,369	33,463	8.1	.986
	310,625	84,101	21,340	1,055,143	274,400	1,365,768	358,501		

CHAPTER VI

THE 51-DAY CONFINEMENT SYSTEM

A. Introduction

The rigid calendar of a 51-day multiple farrowing schedule is unique among the three hog production systems being described in this study. The one- and two-litter pasture systems can be scheduled to have the greatest labor requirements when cropping needs are seasonally low. These pasture production systems are often viewed as being supplementary and even complementary to crop production. However, hog production systems increasing in volume must become competitive with the cropping enterprises in challenging for use of resources. With the exception of breeding, all phases of the 51-day system are oriented toward confinement facilities as opposed to pasture. Scheduling the intensive use of these facilities is necessary to attain high production efficiency.

B. Description

An environmentally controlled production system is the most land intensive of the three systems being discussed. All pigs are farrowed in a slotted, totally enclosed insulated building which has controlled ventilation and heating, thereby eliminating the need for relatively large units of land. Breeding and gestation facilities may be pole-type, non-insulated buildings. The growing-finishing facilities are the same as in the two-litter system--modified open front.

This system maximizes the reproductive capability of the sows by minimizing the resting period between weaning and breeding. Three groups of sows are maintained and each farrow every 153 days; one group farrowing every 51 days. Pigs are left with the sow for an average of approximately 34 days before weaning. Sows are then rebred on the first estrous after weaning (4 to 7 days later) and would then be due to farrow in 114 days. This is a 153 day calendar for each sow. Pigs are weaned at about five weeks of age and moved into the nursery which holds only one farrowing group at a time. Pigs remain in the nursery until the next farrowing group is weaned at which time they are moved to the growing-finishing facility. The growing-finishing facilities must be of adequate size to house one group of hogs in each of the final two stages of development at all times. That is, one-time holding capacity for pigs in the growing-finishing must be available for approximately one-third of the total annual pig production.

Environmental control for farrowing enables this system to overcome the hazards of weather associated with the other two systems. It does require a uniform amount of labor during the year thereby eliminating this as an enterprise to complement crop production. Seasonal highs and lows of market prices do affect monthly cash flow but are averaged out in the year. As capital is substituted for labor, the productivity of labor is increased over the pasture systems.

Adapting the biological process of the pig to conform with desired production procedure of this system is not without difficulties. The need to produce at capacity requires breeding every 51 days. Breeding being attempted during the warmer months can suffer from declining conception rates. The scheme of a production calendar further dictates

the timing of marketing, possibly resulting in marketing prior to attaining optimal market weight. Energy demands for farrowing in this system are completely dependent upon artificial sources where price and availability of energy are uncertain. The specialized capital assets used in this system substantially increase the planning horizon involved prior to initial start-up. This aspect is contrasted to the pasture systems which rely largely on non-specialized structures often readily available to the firm.

In confinement production, capital is substituted for labor causing a shift in the basic cost structure of the enterprise. A substantially greater proportion of the total cost becomes fixed to the farm and to the enterprise. The requirements imposed by interest and principle payments indicate that this enterprise has a unique adjustment to varying economic conditions. These characteristics include: 1) when operating at capacity during profitable time periods there can be virtually no increase in the production level for the next period, 2) for production periods where the system is operating unprofitably due to market conditions, production level will remain unchanged (provided variable costs are being covered) whereas pasture systems would have the flexibility to contract production, and subsequently 3) the lower level of variable costs for a confinement operation indicates that they could generate greater losses than is simultaneously possible with pasture production. Under such conditions production would be discontinued in pasture systems but confinement production would continue and make partial coverage of fixed costs while still operating at a loss.

C. Labor Requirements

The ability of this system to provide the proper environment for the hog eliminates the need to plan production in anticipation of the seasons. This results in a uniform production level and uniform demand for labor. As with the two-litter system the demand for labor increases in direct proportion to the number of sows in the herd, implying that there are no economies of scale associated with the labor factor. A summary of the labor requirements for this 51-day farrowing system is presented in Table VI-1.

Table VI-1. Labor Requirements for 51-Day Farrowing System

No. Sows[1]	Hours Required for:			Total Hours	Approx. Hrs./Mo.	Hours/ Sow
	Gestation[2]	Farrowing	Growing-Finishing			
50	257	819	294	1,370	114	27.4
126	607	1,999	972	3,578	298	28.4
378	1,845	5,803	3,326	10,974	914	29.0

[1]Number of sows is the number of females gestating or nursing pigs. Adjustments to this number are made during the resting period (weaning-to-breeding) through a gilt selection pool averaging approximately 45 percent of the breeding to maintain the constant desired number in production.

[2]Gestation hours remain the same whether environmentally controlled or open front facilities are used.

D. Feed Requirements

Feed requirements for confinement production are not completely uniform from month to month. Maintaining uniform production levels does require increased feed demand during the winter months. Feed requirements for a 126 sow confinement unit are illustrated in Table VI-2. For

Table VI-2. Feed Requirements for 51-Day Farrowing System, 126 Sows

	Breeding & Gestation		Nursery	Growing-Finishing		Total	Total
	Corn lbs.	Supp lbs.	Creep lbs.	Corn lbs.	Supp lbs.	Corn lbs.	Supp lbs.
Jan	23,932	6,379	2,129	116,563	30,204	140,495	36,583
Feb	21,616	5,761	2,129	116,563	30,204	138,179	35,965
Mar	23,932	6,379	2,129	116,563	30,204	140,495	36,583
Apr	23,160	6,173	2,129	107,271	27,797	130,431	33,970
May	23,932	6,379	2,129	107,271	27,797	131,203	34,176
June	23,160	6,173	2,129	107,271	27,797	130,431	33,970
July	23,932	6,379	2,129	107,271	27,797	131,203	34,176
Aug	23,932	6,379	2,129	107,271	27,797	131,203	34,176
Sept	23,160	6,173	2,129	116,563	30,204	139,723	36,377
Oct	23,932	6,379	2,129	116,563	30,204	140,495	36,583
Nov	23,160	6,173	2,129	116,563	30,204	139,723	36,377
Dec	23,932	6,379	2,129	116,563	30,204	140,495	36,583
	281,780	75,106	25,548	1,352,296	350,413	1,634,076	425,519

larger production units feed requirements expand in constant proportions. For the 51-day multiple farrowing system requires: 1) a feed conversion of 3.74:1, 2) 6,937 pounds of feed for each litter farrowed, and 3) 14,363 pounds of feed on the average for each female in the breeding herd.

This system assumes a litter of pigs each 153 days from each sow in the unit with a weaning average of 8.5 pigs/litters. Mortality in the nursery phase is 3.5 percent and 1.5 percent in the subsequent phases or growing-finishing. This is a 19.27 pigs/sow/year production level. Marketing of hogs is uniform during the year. In order for sows to average six litters prior to marketing requires a 40 percent average annual turnover of sows, which includes culling of nonbreeders.

E. Summary

The non-existence of seasonal patterns identifies this system. Uniformity of labor, feed, and marketings, improve the cash flow planning for this enterprise on a monthly basis. The advantage of maximum intensity of the breeding herd coupled with specialized facilities is that reproduction and feed efficiency should be improved relative to the pasture based system. Conversely, this system has the highest capital requirements and highest fixed cost/hundredweight.

CHAPTER VII

Analysis of Three Hog Production Systems

A. Introduction

Hog production systems are a major capital investment involving returns and costs over a future period of time. Because both product price and input costs are subject to substantial change during the life time of the investment, windfall losses as well as windfall profits may occur. The ability to operate profitably is further affected by the institutional environment and the possibility of constraints or technical modifications being imposed upon the operation. Of concern also is the fact that a hog production system is based on a biological process that is never fully predictable.

While such an investment is shrouded in uncertainty, an investment analysis of various production systems and levels of swine production can assist in planning such investments. Such an analysis is based on historic, current, and expected future price levels and serves as a guide in planning resource commitments.

B. Budgets for Three Alternative Hog Production Systems

As part of the planning procedure, input and output prices are used as directives. In planning a given production system the concern for resource requirements is critical as their relative prices indicate their worth to the economy, and as such, reflect the process of rationing them.

By using these prices in conjunction with resource requirements and expectations on production-markting, enterprise budgets can be developed for each production system.

For the budgets developed, there are three categories of costs to the enterprise. Direct or operating expenses are those costs which would be avoided if there were no production. Indirect or fixed costs are those which would have to be paid regardless of the level of production. Finally, non-cash costs take into account those items pertinent to the economic analysis but not previously included in the cash flow categories. This category includes an enterprise credit to the swine enterprise due to the value of the manure wastes produced in the swine system which results in a reduction of cash expenses in the cropping enterprises for chemical fertilizer. Tables VII-1, VII-2, and VII-3 present the enterprise budgets in a monthly flow format for an assumed base price for corn and hogs. Definition and explanation of the coefficients used in these budgets is now presented.

1. Budget Coefficients: For these budgets the sole source of revenue is from the marketings of hogs, sows, and boars. Market hogs are assumed to weigh 225 pounds each, and there is no reduction for injured, overweight or runt pigs. Sows and boars for the one-litter system are assumed to weigh 350 pounds each and are sold on a market which is $8.00/cwt under the barrow and gilt market. Hogs are assumed to be $40/cwt, and sows and boars are $32/cwt. For the two-litter and 51-Day systems, sows and boars are sold at 450 pounds. Similarly, no discounts are taken for injuries, variations in weight, or death loss in the breeding stock sold. For both markets the seasonal index for

Table VII-1. Expected Operating Budget for One-Litter Pasture Production, 250 Litters/Year

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Receipts:												
Market Hogs[1]	27,579	45,619	--	--	--	--	--	--	--	--	--	--
Sows[2]	--	--	--	5,460	12,357	--	17,248	--	--	--	19,856	35,673
Boars[2]	--	--	1,244	--	--	--	--	--	--	--	--	--
Operating Expenses:												
Labor	1,122	1,122	732	3,074	1,269	3,074	1,415	927	927	927	732	1,318
Corn[3]	7,907	4,184	2,019	2,536	3,183	3,712	5,478	6,897	9,628	9,628	11,120	10,860
Concentrate	4,500	2,429	1,172	1,490	2,008	2,625	2,951	4,759	5,445	7,470	8,071	6,786
Creep feed	--	--	--	--	852	--	1,278	--	--	--	--	--
Breeding stock	--	--	--	--	--	--	--	--	--	--	3,300	--
Vet.[4]	--	--	220	--	330	648	624	--	--	--	--	600
Feed Additives[4]	160	83	18	23	54	683	1,374	189	388	280	296	351
Bedding	290	136	101	58	161	161	161	161	161	161	217	434
Repairs	307	307	307	307	307	307	307	307	307	307	307	307
Power & Fuel	255	136	74	80	122	192	138	109	138	202	406	355
Op. Interest	--	--	--	--	--	--	--	--	--	27	74	--
Monthly Op. Cash Flow	13,038	37,222	3,399	2,108	4,071	11,402	5,011	11,930	14,263	19,002	4,667	14,662
Net Cum. Cash Flow	13,038	50,260	46,861	44,753	48,824	37,422	42,433	30,503	16,240	2,762	7,429	7,233
Fixed Costs:												
Property taxes												3,384
Insurance												2,258
Amortize L-T[5]												28,120
Non-Cash:												
Land Charge[6]												8,204
Pasture Feed (included as decreased concentrate costs)							738	1,090	1,361			
Waste Value[7]												6,801
Net Economic Income												27,931

[1]Market hogs are barrows and gilts sold at 225 pounds each for $40/cwt in this budget example.

[2]Sows and boars are sold at 350 pounds each for $32/cwt ($8/cwt below barrows and gilts).

[3]Corn is charged at $2.50/bushel for this budget.

[4]See Appendix A.

[5]See Appendix B for asset requirements upon which amortization is computed. Amortization is at 12% interest for 10 years.

[6]Land charge or land rent is computed as per Table IV-3 and increased $50/acre for every $.50/bushel increase in corn price.

[7]Waste value is a budget credit.

Table VII-2. Expected Operating Budget for Two-Litter Pasture Production, 250 Litters/Year

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Receipts:												
Market hogs[1]	--	--	39,612	25,530	--	--	--	--	28,963	65,068	--	--
Sows[2]	--	--	5,527	--	--	--	--	--	7,603	--	4,405	--
Boars[2]	688	--	--	--	--	2,889	--	--	--	--	--	--
Operating Expenses:												
Labor	654	493	415	3,582	1,396	654	654	483	3,079	1,015	698	683
Corn[3]	4,617	4,913	6,984	3,555	3,393	5,732	5,624	6,478	9,264	3,777	2,209	4,858
Concentrate	3,708	2,688	3,794	2,488	3,391	4,612	4,546	3,233	5,031	2,573	2,128	3,932
Creep feed	--	--	--	--	1,454	--	--	--	--	1,053	--	--
Breeding stock	--	--	--	--	--	--	--	--	--	7,500	--	--
Veterinary[4]	--	--	300	75	823	--	--	200	50	549	376	--
Feed Additives[4]	132	134	140	31	879	579	174	178	196	705	427	175
Bedding	72	72	54	180	216	108	108	108	120	120	54	72
Power & fuel[4]	122	120	160	376	83	145	148	156	288	311	78	126
Repairs	307	307	307	307	307	307	307	307	307	307	307	307
Operating Int.	89	178	--	--	--	--	27	140	--	--	--	--
Monthly Op. Cash Flow	9,013	8,905	32,985	14,936	11,942	9,248	11,588	11,283	18,231	47,158	1,872	10,153
Net Cum Cash Flow	9,013	17,918	15,067	30.003	18,061	8,813	2,775	14,058	4,173	51,331	49,459	39,306
Fixed Costs:												
Property taxes												3,815
Insurance												2,002
Amortize L-T[5]												32,634
Non-Cash:												
- Land Charge[6]												4,922
+ Waste Value[7]												6,995
Net Economic Income												2,928

[1]Market hogs are barrows and gilts sold at 225 pounds each for $40/cwt in this budget example.

[2]Sow and boars are sold at 450 pounds each for $32/cwt ($8/cwt below barrows and gilts).

[3]Corn is charged at $2.50/bushel for this budget.

[4]See Appendix A.

[5]See Appendix B for asset requirements upon which amortization is computed. Amortization is at 12% interest for 10 years.

[6]Land charge or land rent is computed as per Table IV-3 and increases $50/acre for every $.50/bushel increase in corn price.

[7]Waste value is a budget credit.

Table VII-3. Expected Operating Budget for 51 Day Farrowing System with 126 Sows

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Receipts:												
Market Hogs[1]	17,641	18,069	17,212	16,519	17,677	18,551	19,459	19,263	18,125	17,410	16,769	17,268
Sows[2]	550	593	582	559	562	722	615	634	608	587	534	636
Boars[2]	--	--	--	421	--	--	--	475	--	--	--	382
Operating Expenses:												
Labor	1,455	1,455	1,455	1,455	1,455	1,455	1,455	1,455	1,455	1,455	1,455	1,455
Corn[3]	6,322	6,107	6,209	5,695	5,887	6,027	6,074	6,215	6,375	6,040	5,782	6,184
Concentrate	4,298	4,226	4,298	3,991	4,016	3,991	4,016	4,016	4,274	4,298	4,274	4,298
Creep feed	250	250	250	250	250	250	250	250	250	250	250	250
Breeding stock	--	--	--	900	--	--	--	900	--	--	--	900
Veterinary[4]	197	197	197	197	197	197	197	197	197	197	197	197
Feed Additives[4]	373	374	373	374	373	374	373	374	373	374	373	373
Bedding	36	36	27	18	18	18	18	18	18	36	36	36
Repairs	307	307	307	307	307	307	307	307	307	307	307	307
Power & fuel	380	380	378	642	374	374	374	374	378	646	378	378
Monthly Op. Cash Flow	4,573	5,330	4,300	3,670	5,362	6,280	7,010	6,266	5,106	4,394	4,251	3,908
Net Cum. Cash Flow	4,573	9,903	14,203	17,873	23,235	29,515	36,525	42,791	47,897	52,291	56,542	60,450
Fixed Costs:												
Property taxes												5,639
Insurance												3,239
Amortize L-T[5]												52,116
Non-Cash:												
Land Charge												--
Waste Value[6]												9,853
Net Economic Income												9,309

[1] Market hogs are barrows and gilts sold at 225 pounds each for $40/cwt in this budget example.

[2] Sow and boars are sold at 450 pounds each for $32/cwt ($8/cwt below barrows and gilts).

[3] Corn is charged at $2.50/bushel for this budget.

[4] See Appendix A.

[5] See Appendix B for asset requirements upon which amortization is computed. Amortization is at 12% interest for 10 years.

[6] Waste value is a budget credit.

the appropriate month is applied. There is no differential adjustment for alternative marketing methods as that is a management function.

For corn, a net farm price of $2.50/bu is used in the initial plan. Concentrate is priced at $235 per ton, which is based on a soybean meal price of approximately $225 per ton. Creep feed is priced at $235 per ton. Boars are purchased at $300 each. Repair costs for all three systems are the average costs as reported in the Telfarm Summary[51] of swine farms with over 200 litters annually. Appendix A, Tables A-1 and A-2 present details on operating expense assumptions.

The estimated dollar investment required is presented in Appendix B, Tables B-1, B-2 and B-3. On a per litter basis, the investment cost excluding pasture land is $636, $737, and $982 for the one-litter, two-litter and 51-day confinement systems respectively.

For all three systems budgeted, the new investment in buildings, machinery, and improvements was greater than the net book value in the Telfarm Summary reports. By definition, the more intensive the system evaluated, the greater is the total dollar investment. If repair costs are calculated as a percentage of investment, the dollar repair cost on permanent specialized buildings and machinery would be proportionately greater than for the non-specific assets. In real-world hog operations, a larger capital investment is a substitute for repair and maintenance. While repairs on permanent and specific assets would be less frequent, they would be more expensive than for pasture systems. The Summary represents an actual farm record figure which exists on commercial operations.

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[51]"Business Analysis Summary for Swine Farms, 1978," Michigan State University Agricultural Economics Report, No. 363 (Septermber 1979), p. 22.

As breeding and gestations phases for the 51-Day system are conducted in a pole barn, bedding is required for all three systems. A charge of $1.20 per bale is used and is equivalent to approximately $60 per ton.

Property taxes for all systems are assumed to be 45 mills on one-half the acquisition costs of buildings, permanent equipment, and land required for the system. Property taxes are scheduled for payment at the end of the calender year. Insurance is usually a prepaid expense to the operation. As shown in the budgets, all fixed costs are assumed to be year-end expenditures. The insurance costs, computed at 1.03[52] percent of depreciable assets, is therefore compounded at 12 percent annual interest and charged at year end. The amortization of Long-Term debt is the equal annual payment needed to pay the accrued interest and principle when the investment is financed for ten years @ 12 percent annual interest and when 70 percent of the investment is financed with borrowed capital.

C. Method of Investment Analysis

Evaluating an investment in hog production requires a capital budgeting technique. Capital budgeting evaluation requires knowledge of: (1) The initial investment in a hog enterprise and the length of time over which the benefits are gained, (2) The cash flow items as well as non-cash items that have opportunity costs to the firm, (3) The finance cost of capital, and (4) The recognition of time value of money through the discounting procedure.

The analysis of the investment provides a means of comparing the investment alternatives. For all systems, the size or scale of the

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[52] Ibid.

operation under consideration is the minimum size for which most possible economies of scale have been achieved. Since all three investment projects are not of uniform size, and since there are substantial differences in the investment requirements, absolute values which would measure only the net present value, which is the absolute value of discounted returns minus discounted costs, is not used. Instead, an index which compares the present value of earnings to the prevent value of capital disbursements is used. Specifically the index is: Present Value Index[53] =

$$\frac{[\Sigma(\text{PV Net Income}) - \Sigma(\text{PV Interest on Long-Term Debt}) + \text{PV Salvage Value}]}{\text{PV Capital Expenditure}}$$

PV Net Income is the sum of the discounted net income as shown in the budget, excluding the amortization of the Long-Term debt. This subtle distinction between cash flow and investment analysis is because the amortization payment includes both interest, which is a business expense, and principle, which is not a tax-deductible expense. Hence, only the sum of the present value of interest on outstanding Long-term debt (which is the actual dollar cost of capital to the firm) is deducted from the net income budget figure. This total present value of the before-tax income of the enterprise is thus compared with the present value of the capital expenditures.

The Σ(PV of Interest on Long-Term Debt) is the discounted cost of borrowed capital for the system. For an initial equity of 30 percent in the system, when the balance is financed for ten years @ 12 percent annual interest on the outstanding principle, equal annual payments will result in a discounted present value of interest of $34.38/$100 capital expenditure (See Table VII-4).

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[53] Adolph E. Grunewald and Erwin Esser Nemmers, Basic Managerial Finance, (1970), p. 195.

Table VII-4. Financing Factors to Amortize $100 of Debt, for Ten Years @ 12 Percent Interest

Number of Years in the Future	Annual Payment	Interest Paid	Principle Paid	Outstanding Balance	Present Value Factor	Present Value of Interest	Present Value of Principle
1	$17.70	$12.00	$ 5.70	$94.30	.89286	10.71	5.09
2	17.70	11.32	6.38	87.92	.79719	9.02	5.09
3	17.70	10.55	7.15	80.77	.71178	7.51	5.09
4	17.70	9.69	8.01	72.76	.63552	6.16	5.09
5	17.70	8.73	8.97	63.79	.56743	4.95	5.09
6	17.70	7.66	10.04	53.75	.50663	3.88	5.09
7	17.70	6.45	11.25	42.50	.45235	2.92	5.09
8	17.70	5.10	12.60	29.90	.40388	2.06	5.09
9	17.70	3.60	14.10	15.80	.36061	1.30	5.09
10	17.70	1.90	15.80	.00	.32197	.61	5.09
						PV of Interest = 49.12[1]	
							PV of Principle = 50.90[2]

[1]With 30 percent initial equity financing, PV of Interest paid for every $100 invested is: .7 x $49.12 = $34.38.

[2]When $30 is spent initially as equity capital, then the PV of Principle Payments is: .7 x $50.90 + $30.00 = $65.63.

As principle payments are made over a period of ten years, the capital expenditure is also discounted to its present value. With 30 percent equity financing and ten equal annual payments, the present value of capital expenditures is $65.63/$100 investment when discounted @ 12 percent (See Table VII-4).

PV of Salvage Value for the systems is the discounted salvage value of the capital investment at the end of the projected useful lifetime (excluding livestock). Life of the investment for all systems is ten years and the discount rate is 12 percent. A salvage value of 20 percent of the initial capital investment is used, leaving 80 percent of the capital investment as a cost-in-use and obsolescence cost. As pasture land is charged to the pasture systems each year as an opportunity cost, the value of pasture acreage makes a positive contribution to the salvage value of pasture production systems. An inflation rate of 10 percent in land for ten years, discounted @ 12 percent is used.

Table VIII-5 summarizes the expenditure in the enterprise budget format with the unit of production being one hundredweight. A summary of the size and physical efficiency factors is presented in Table VII-6.

Two sets of Present Value indexes are presented in Table VII-7 for nine price combinations of hogs and corn. Table VII-7, Section A, is based on the above definitions of factors in the equation. Table VII-7, Section B, is calculated to reflect the effect of income tax and risk. Specifically, when a 20 percent tax rate and 10 percent reduction in receipts as risk protection are used, the index is defined as:

$$\frac{\left[\Sigma \text{PV (Net Income - 10\% cash receipts)} - \Sigma \text{PV Interest}\right] \times .8 + \text{PV Salvage Value}}{\text{PV Capital Expenditures}}$$

Table VII-5. Summary of Expenses for Hog Production Systems $/cwt

Operating Expenditures:	OLS[1]	TLS[2]	51-Day[3]
Labor	$ 3.81	$ 2.90	$ 3.13
Corn[4]	16.39	12.91	13.08
Conc.	11.39	8.86	8.97
Creep Feed	.49	.53	.54
Feed Add.	.89	.79	.80
Breeding	.76	1.58	.48
Veterinary	.55	.50	.42
Bedding	.50	.27	.06
Repair	.84	.77	.66
Power and Fuel	.51	.44	.91
Operating Interest	.02	.09	---
Total Operating Exp.	$36.15	$29.64	$29.05
Fixed Cash Expenditures:	**OLS**	**TLS**	**51-Day**
Property Taxes	.78	.80	1.01
Insurance	.52	.42	.58
Amortization of Long-Term Debt	6.44	6.86	9.35
Non-Cash Fixed Cost Land Charge	1.88	1.03	---
Total Fixed Exp.	9.62	9.11	10.94
TOTAL EXPENDITURES	$45.77	$38.75	$39.99

[1]One-Litter Pasture Production, 250 litters annually.

[2]Two-Litter Pasture Production, 250 litters annually.

[3]51-Day Confinement Production, 300 litters annually.

[4]Corn priced at $2.50/bushel.

Table VII-6. Summary Table of Production Assumptions

	One Litter	Two Litter	51-Day
Size: Number of Sows	230	158	120
Number of Litters/Year	250	250	300
Annual Percentage Conception Rate	83%	75%	70%
Pigs/Litter Weaned	7.6	8.25	8.5
Pigs/Litter Raised	7.02	7.64	8.1
Pigs/Sow/Year Farrowed	7.02	12.73	19.27
Feed Conversion Efficiency	4.72	3.67	3.74
Hours Labor/Litter	13.6	11.3	11.9
Cash Operating Non-Feed Expense/Sow/Year	$132.85	$197.43	$263.16
Investment in Buildings and Facilities/Sow	$513.73	$971.18	$2261.72
Hog:Corn Ratio Needed to Cover all Expenditures (Corn = $2.50/bu)	17.69:1	14.91:1	15.29:1

Table VII-8. Present Value Indexes for Investment Alternatives in Hog Production Systems

Hogs ($/cwt)	Corn ($/bu)	Section A: Indexes Without Considerations for Risk and Tax Requirements			Section B: Indexes With Consideration for Risk and Tax Requirements		
		OLS[1]	TLS[2]	51-Day[3]	OLS	TLS	51-Day
40	2.50	.01	1.46	1.38	(.60)	.56	.60
	3.00	(.94)	.79	.95	(1.36)	.02	.26
	3.50	(1.90)	.11	.53	(2.13)	(.52)	(.08)
45	2.50	1.20	2.55	2.20	.25	1.35	1.19
	3.00	.25	1.88	1.77	(.50)	.81	.85
	3.50	(.70)	1.21	1.35	(1.27)	.28	.51
50	2.50	2.38	3.63	3.02	1.10	2.13	1.78
	3.00	1.43	2.97	2.59	.35	1.60	1.44
	3.50	.49	2.31	2.17	(.41)	1.06	1.10

[1]OLS = One-Litter Pasture Production.

[2]TLS = Two-Litter Pasture Production.

[3]51-Day = Confinement Production System with farrowing every 51 days.

Since principle payments on Long-term Debt are made from after-tax income, a reduction in the income to the enterprise that reflects the effect of taxes more closely determines the repayment potential of the investment. To account for the risk inherent in the system a reduction of 10 percent of gross receipts is made in the second set of Indexes. This risk is due to the following:

1. Efficiency levels for conception rate and litter size are not always attained by the firm.
2. There are no provisions made for death loss within the breeding herd.
3. Not all market hogs are of proper weight and free of injury.
4. In the cost structure the only resource considered in sensitivity analysis is corn. All other input factors would remain more stable in price, and are individually relatively less critical in terms of total cost to the enterprise. Nor can many of these resources be considered as competing products for sale.
5. Since it is generally easier to project costs than returns, and since the life of the investment is largely beyond the period for which either costs or returns can be accurately predicted, the uncertainty of future profitability requires the discounting of future returns accordingly.
6. Uncertainty exists with respect to technical efficiency, price, and susceptibility to disease. This uncertainty has different implications to the different

systems. For the one-litter system where all hogs are essentially in the same phase of production at any one time vulnerability to disease affects the entire herd the same. Multiple farrowing systems, however, have hogs at various stages of production at any one time. This could be expected to reduce the initial impact of disease but disruption of the system's continuity would be comparable (operationally) to the one-litter system.

7. Returns from the investment expenditure lag behind the expenditure. Mechanical technological and managerial limitations lead to cash flow problems during the transition time prior to realizing full production.[54]

D. Discussion and Summary

Indexes used as comparative measures of profitability are of three cases. A present value index greater than unity indicates that the net present value of the returns generated by the enterprise exceed the net present value of the investment cost. When the index is less than 0 then the system is operating at a loss and is compounding losses by continuing production under the price relationship. For indexes between 0 and 1 profits exist but are inadequate to pay investment cost.

An index of "1" indicates that the swine enterprise is generating adequate income to meet all expenses, including paying for labor and corn at their designated price. The indexes therefore provide a basis to determine the potential of the hog enterprise to improve farm income

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[54] Donald D. Osburn and Kenneth C. Schneeberger, Modern Agriculture Management (1978), p. 209.

through marketing of grain through hogs. An index of "1" further implies that the investment does not generate income to provide for replacement at the end of its useful lifetime.

These indexes provide not only an absolute value for evaluating one alternative under given conditions but enable comparisons between the three. For any given market condition the one-litter system has the lowest income potential relative to the investment required in new facilities and equipment. The two-litter system, however, is very competitive with the confinement system. This implies that the two-litter and 51-Day systems have nearly equivalent potential (under the same market conditions) to repay the capital costs of the system. Also, as the present value indexes essentially express the dollars returned relative to the dollars invested, equivalent indexes have greater absolute values for larger initial investments. That is, for indexes greater than 1 total dollar "profits" are greater for higher capital investments but total dollar "losses" from the investment are also greater with equivalent indexes which are less than 1. While the present value indexes for the two-litter pasture system and the 51-Day confinement system are similar, because the initial investment required for the former is substantially less (See Appendix B) the magnitude of the "profits" or "losses" will be less for the two-litter than for the 51-Day system.

Table VII-9 illustrates the net income potential for each system for various hog and corn prices. Table VII-9, Section A, expresses the net income per hundredweight that could be expected after all costs have been paid. This Table further represents those price combinations and

Table VII-9. Net Income/Hundredweight for the Production Systems Under Various Market Conditions

		Section A			Section B		
		Net Income/cwt			Net Income/cwt Before Long-Term Debt Charge		
		OLS[1]	TLS[2]	51-Day[3]	OLS	TLS	51-Day
Hogs = $40/cwt, Corn =							
	$2.50/bu	(6.40)	.62	1.67	.04	7.48	11.02
	$3.00/bu	(10.44)	(2.41)	.95	(4.00)	4.45	10.29
	$3.50/bu	(14.49)	(5.45)	(3.56)	(8.05)	1.41	5.79
$45	$2.50/bu	(1.39)	5.52	6.70	5.05	12.38	16.05
	$3.00/bu	(5.39)	2.52	4.09	1.05	9.38	13.44
	$3.50/bu	(9.43)	(.50)	1.47	(2.99)	6.36	10.82
$50	$2.50/bu	3.60	10.40	11.74	10.04	17.26	21.09
	$3.00/bu	(.40)	7.42	9.12	6.04	14.28	18.47
	$3.50/bu	(4.39)	4.42	6.51	2.05	11.28	15.85

[1] OLS = One-Litter Pasture Production (4364.5 cwt annually)

[2] TLS = Two-Litter Pasture Production (4756.5 cwt annually)

[3] 51-Day = Confinement Production system farrow every 51 days (5575.5 cwt annually)

levels which would be required to bring about new investment in hog facilities and thus expand pork supplies at the macro level.

Table VII-9, Section B, expresses the net income per hundredweight that could be expected where all costs except Long-Term debt on buildings, facilities and breeding stock have been paid. This then represents the maximum amount available for debt servicing and thereby represents the debt carrying capacity for either of the production systems under various market conditions.

Periods of favorable (profitable) price relationships are a signal for expansion of overall pork supplies. Since the one-litter system is the only one which does not require specialized facilities this would be the system having the most flexibility where expansion of hog production might first occur. When facilities suitable for hog production already exist on the farm, then the one-litter pasture system without Long-Term debt obligations (except approximately $1.08/cwt for amortized cost of breeding stock) is more competitive with the two-litter and 51-Day systems which would need to incur substantial Long Term debt obligations to begin production (compare the OLS in Table VII-9, Section B, with the TLS and 51-Day in Table VII-9, Section A).

Table VII-5 is a summary of the budget costs in Table VII-1, VII-2, and VII-3. The figures in Table VII-5 are useful not only for comparison between the systems but also provide an economic basis to evaluate price relationships that would lead to a contraction of overall pork production. Based on acquisition price for buildings and equipment the one-litter system is the first to contract production. For this system to operate and be profitable requires hogs to sell for $44.21/cwt (when corn is $2.50/bu and a manure waste value of $1.56 is credited for

each cwt produced). Below this price losses are incurred but production will continue, at least in the short run, as long as the price remains above $36.15/cwt. For lower prices, the income generated by continuing production is less than the operating expenses and production would cease in order to minimize losses. Thus, investment in the one-litter system is economically competitive with the two-litter and 51-Day confinement systems when it utilizes existing facilities which do not increase the fixed expenditures needed to service Long-Term debt. Under these circumstances, all three systems have virtually the same total costs of production.

A substantial portion of fixed costs in pasture production systems is the land charge. This charge reflects the true economic cost of using land for hog pasture. Suitable pasture is assumed to be provided only by land which is cultivated and otherwise could be used for crop production. Because a cash crop could be produced there, the net income from that crop is foregone when used for hog pasture. This then, plus the cost of seeding for pasture, are the land charge which is a cost in pasture production of hogs.

Other criteria may be used in evaluating these production systems since maximizing profits is not always the goal of the producer. Where minimizing the capital or investment is essential, both pasture systems are less expensive to acquire than a comparable 51-Day system (See Table VII-5 and Appendix B). Both pasture systems, because of their seasonal labor requirements, can be complementary to the cropping enterprise as a means of increasing the returns to labor. As a result of this complementary aspect, pasture production allows the owner to be the operator of the swine enterprise.

APPENDICES

APPENDIX A

Budget Assumptions Used to Determine Expected Costs for Power and Fuel, Veterinary, and Feed Additives for All Production Systems

Table A-1: Resource Requirement Assumptions

I. Expected Power and Fuel Requirement for One-Litter Pature Production

A. Power and Fuel for feeding

10 KWH/ton for milling @ $.04/KWH = $.40/ton

Deliver feed @ 5 ton/hr. using 4 gal/hr.,

fuel @ $1.20/gal	=	$1.00/ton
feed handling costs	=	$1.40/ton

B. Manure Removal

Load and haul 1.5 load/hr. with 5/ton/load, using 5 gal/hr.,

fuel @ $1.20/gal = $.80/ton

C. Fuel during Farrowing

Loading & distributing shelters, feeders, watering, etc.,

200 gal. for 250 litters.

II. Expected Power and Fuel Requirements for Two-Litter Pasture Production

A. Power & Fuel for feeding

As above, Table B-1.

B. Fuel for Manure Removal

1) As above.

2) Liquid manure removal is at the rate of 15 ton/hr., using 5 gal/hr. of fuel, fuel @ $1.20 = $.40/ton

C. Fuel during Farrowing (Same as I.C.)

III. Expected Power and Fuel for 51-Day Confinement Production

A. Power for feeding

Milling and distributing feed using 14.7 KWH/ton, power @ $.04/KWH = $.588/ton

B. Fuel for manure removal (Same as II, B 2)

C. Power & fuel for Farrowing Barn

1) 25 gal L.P./day during Nov. 1 - Mar. 1
12.5 gal L.P./day during Sept. 15 - Nov. 1 & Mar. 1 - Apr. 15
L.P. @ $.56/gal.

2) Heat lamps used 35 days during each farrowing, 1-250 watt lamp/2 crates

Table A-2: Scheduled Veterinary and Feed Additives for All Production Systems

I. Veterinary

a. Vacs. sows for lepto before breeding & mma @ $2/hd

b. Vacs. sows before farrowing $2/hd[1]

c. Vacs. weaned pigs @ %.50/pig

d. Castrate weaned pigs @ $.33/boar pig

e. O.B. calls, every 50 litters @ $25/call

II. Feed Additives for Preventative (as opposed to corrective) Purposes

a. Nursery & Starter feed containing Banminth-Mecadox @ $20/ton of feed is approximately $1/pig

b. Growing-finishing feed contains 15 grams/ton of Tylan or 1.5# of Tylan 10/ton, Tylan 10 @ $1.12/pound

c. At breeding Furox 50 is fed for 3 weeks, costing $1/pound and used @ 3 pounds/ton

d. Before farrowing sows are wormed with Atgard at a charge of $.22/hd.

e. To all feed is added 1 pound of copper sulfate costing $.65/pound

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[1]In the Two-Litter and 51-Day systems sows are vaccinated only once for each litter.

APPENDIX B

Capital Requirements Based on Estimated 1980 Acquisition Prices for Each Production System

Table B-1: Assests Required for 250 Litters/Year One-Litter Pasture Production System

I. Buildings: 2 open front pole barns

each 80' x 64' w/40' concrete feeding floor

concrete @ $.55/ft^2, barn @ $4.80/ft^2

Barns	$ 49,152
Concrete	+ 9,152
	$ 58,304

II. Equipment:

20 - 60 Bu feeders @ $325	=	$ 6,500
10 - 250# Creep feeders @ $125	=	1,250
160 - 6' x 6' Quonsets @ $36	=	5,760
10 - 4-hold heated fountains @ $190	=	1,900
8 - 100 gal summer fountains @ $103	=	824
		$16,234

III. Fencing:

fence @ $5.20/rod

post @ $2.42/rod

labor @ $4.88/rod

$12.50/rod

10 - 100 rod fences (3 - 62.5 Ac fields)

+ 3 - 100 "temporary" fences = 1300 rods = $16,250

IV. Material Handling (% indicates swines' share of cost):

Feed mill 100%	=	$ 9,500
(Utility) tractor 50% x $1,800	=	900
Wagon 50% x $1,700	=	850
Manure spreader 100%	=	3,100
Tractor 15% x $14,000 (560 hrs annual, 84 hrs spreading)	=	21,000
Loader 50% x $9,600	=	4,800
TOTAL INVESTMENT (excluding stock)		$112,038

Table B-1 (Continued)

V. Breeding Stock:

300 gilts x $125/hd	=	$37,500
11 boars @ $300/hd	=	3,300
Total livestock		$40,800

VI. Building Site:

5 acre site @ $1,224/ac	=	$ 6,120

TOTAL INVESTMENT: $158,958

Table B-2: Asset Requirements for 250 Litters/Year Two-Litter Pasture Production System

I. Buildings: Open front pole barn, 64' x 64' w/40' concrete feeding floor

Barn @ $4.80/ft^2, concrete @ $.55/ft^2

Barn	=	$ 18,432
Concrete	=	3,661

Modified Open Front Growing-Finishing Barn,

240' x 30' w/30 pens,

Equipment	=	$ 15,200
Buildings	=	60,800
MOF Total	=	$ 76,000

II. Equipment:

8 - 60 Bu feeders @ $325	=	$ 2,600
6 - 250# Creep feeders @ $125	=	750
150 - 6' x 6' Quonsets @ $36	=	5,400
3 - 4-hole heated fountains @ $190	=	570
6 - 100 gal. summer fountains @ $103	=	618
Equipment Total	=	$ 9,938

III. Fencing: Fence @ $12.50/rod

3 - 37.5 Ac fields require minimum

750 rods x $12.50/rod = $ 9,375

IV. Material Handling (% indicates swines' share of cost):

Feed Mill	=	$ 9,500
Tractor 50% x $1,800	=	900
Wagon 30% x $1,700	=	850
Manure Spreader (solids)	=	3,100
Manure Spreader (liquid)	=	8,000
Tractor 20% x $14,000 (100 hr/yr)	=	2,800
Loader 50% x $96,000	=	4,800
		$29,950

V. 5 Ac. Building Site @ $1,224/Ac	=	$ 6,120
Total Investment (excluding stock)	=	$153,446

VI. Breeding Stock:

188 gilts @ $125	=	$ 23,500
25 boars @ $300	=	7,500
Total Livestock	=	$ 31,000
Building & Equipment	+	$184.476

Table B-3: Assets Required for 300 Litters/Year 51-Day Farrowing System

I.	Gestation Barn (90 head capacity)		
	Barn 40' x 80' @ $.480/ft^2	=	$15,360
	Concrete 10' Alley @ $.55/ft^2	=	2,200
	Feed Bin, Gates & Waterers	=	4,370
	Total Gestation		$21,930
II.	Farrowing Barn: 42 Crates w/2 rooms,		
	Nursery w/4 ft^2/pig, complete pit 4' deep,		
	140' x 40'	=	$126,000
III.	Modified Open Front Growing-Finishing Barn:		
	(800 pig capacity) 288' x 30' w/32 pens	=	$ 81,056
IV.	Material Handling (% indicates swines' share of cost):		
	Manure Spreader (solid)	=	$ 3,100
	Loader 50% x $9,600	=	4,800
	Manure Spreader (liquid)	=	8,000
	Tractor 35% x $14,000	=	4,900
	Mill	=	9,500
	Pneumatic feed delivery	=	6,000
	Total Material Handling	=	$ 36,300
V.	Building Site, 5 Ac @ $1,224	=	$ 6,120
VI.	Breeding Stock:		
	126 herd gilts @ $125	=	$ 15,750
	38 gilts for pool @ $125	=	4,750
	9 boars @ $300	=	2,700
			$ 23,200
	TOTAL INVESTMENT	=	$294,606

APPENDIX C

Appendix C

The Mann-Whitney U Test can be used as a statistical means of evaluating whether the corn yield in the 100 leading hog producing counties in the United States is equal to the corn yield of the 20 leading hog producing counties in Michigan. Proving that the Michigan yield is not equal to the United States' average is essential in order to assume that Michigan has a comparative advantage in pasture production of hogs. (Ignoring transportation basis.) When Michigan's yield is lower then it follows that the gross income per acre is lower and in turn the net income is lower. Net income determines the true land rent, or the cost per acre to use the land for hog pasture production. Results of this test verify the existence of this comparative advantage.

Statistical analysis requires the ordinal ranking of observations from both the United States and Michigan (See Table C-3). Summation of the ordinal rankings for each population of observations is then essential in the statistical analysis. If the two populations had equal averages, observations from both would be uniformally distributed. Instead, all 20 observations of Michigan yields are among the lower one-half of the United States' yields.

Mann-Whitney U test[1] for the hypothesis:

Ho: $u_1 = u_2$ where u_1 = avg. Mich. yield and u_2 = avg. U.S. yield

Ha: $u_1 < u_2$

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[1]Source: Statistical Analysis for Administrative Decisions, by Charles T. Clark and Lawrence L. Schkade, p. 390-393.

Appendix C (Continued)

$$U = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R,^2$$

$R, = 431,\ n, = 20,\ n_2 = 100$

$$U = 2000 + \frac{20 \cdot 21}{2} - 431 = 1779$$

$$u_v = \frac{n_1 n_2}{2} = 1000$$

$$\sigma v = \sqrt{\frac{n_1 n_2 (n_1 + n_2 + 1)}{12}}$$

$$= \sqrt{\frac{20 \cdot 100 \cdot 121}{12}} = \sqrt{\frac{242000}{12}}$$

$$= 142.01$$

$$Z = \frac{U - u_v}{\sigma v} = \frac{1779 - 1000}{142.01} = 5.48$$

For Z = 5.48, reject Ho at $\alpha = 3.3 \times 10^{-9}$

	20 Mich. Co.[3]		100 U.S. Counties[4]
u_1	= 77.273	u_2	= 94.699
std. dev.	= 7.450	std. dev.	= 11.877
$\hat{\sigma}^2$	= 55.499	$\hat{\sigma}^2$	= 141.053

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[2]See Table C-3.

[3]See Table C-1.

[4]See Table C-2.

Table C-1: Corn Yield in Michigan's 20 Leading Counties OF Hogs and Pigs Sold[1]

	County	Bu.	Ac.	Bu/Ac
1	Allegan	3,337,115	46,757	71.37
2	Barry	1,627,181	23,170	70.23
3	Berrien	1,756,604	22,907	76.68
4	Branch	3,380,541	44,707	75.62
5	Calhoun	3,160,430	42,604	74.18
6	Cass	2,685,753	37,514	71.59
7	Clinton	3,038,042	36,841	82.46
8	Gratiot	3,577,210	39,570	90.40
9	Hillsdale	3,373,724	43,617	77.35
10	Huron	3,548,865	44,477	79.79
11	Ingham	2,735,492	32,852	83.27
12	Ionia	3,250,705	42,008	77.38
13	Kalamazoo	1,869,070	27,963	66.84
14	Lenawee	7,069,410	77,037	91.77
15	Monroe	3,518,839	39,262	89.62
16	Ottawa	1,812,914	25,167	72.04
17	St. Joseph	2,709,619	39,451	68.68
18	Shiawassee	1,857,008	24,513	75.76
19	VanBuren	1,722,640	25,282	68.14
20	Washtenaw	3,058,604	37,167	82.29

[1]Source: Michigan's Agriculture, by K. T. Wright, Extension Bulletin 785, October 1974.

Table C-2: Corn Yield in the 100 Leading Counties in the United States for Hogs and Pigs Sold[1]

	County	State	Bu Corn[2]	Acres[2]	Bu/Ac
1	Henry	Ill	22,457,593	215,608	104.16
2	Pike	Iowa	9,393,650	114,773	81.84
3	Cedar	Iowa	14,545,654	113,488	108.97
4	Delaware	Iowa	9,256,666	104,767	88.35
5	Plymouth	Iowa	16,507,120	187,576	88.00
6	Sioux	Iowa	18,409,230	193,059	95.36
7	Washington	Iowa	10,603,047	105,129	100.86
8	Clinton	Iowa	15,735,537	145,581	108.09
9	Johnson	Iowa	9,336,883	97,084	96.17
10	Dubuque	Iowa	7,745,639	82,658	93.71
11	Grant	Wisc	10,634,145	107,913	98.54
12	Kossuth	Iowa	23,669,658	210,046	112.69
13	Clayton	Iowa	9,495,380	98,735	96.17
14	Benton	Iowa	14,537,283	146,394	99.30
15	Keokuk	Iowa	7,785,355	88,903	87.57
16	Adams	Ill	8,496,476	117,468	72.33
17	Carroll	Iowa	11,853,406	125,380	94.54
18	Jones	Iowa	9,848,398	101,519	97.01
19	Mahaska	Iowa	8,255,802	94,659	87.22
21	Jasper	Iowa	13,206,929	134,365	98.29
21	Crawford	Iowa	11,530,141	123,618	93.27
22	Tama	Iowa	13,278,195	135,033	98.33
23	Iowa	Iowa	7,807,435	86,414	90.35
24	Bureau	Ill	25,885,843	233,912	110.66
25	Pottawattami	Iowa	18,116,542	175,679	103.12

[1]Source: U.S. Bureau of the Census, 1969 Census of Agriculture. Special Reports: Ranking Agriculture Counties, p. 29.

[2]Source: U.S. Bureau of the Census, 1969 Census of Ag. Area Reports.

Table C-2 (Continued)

	County	State	Bu Corn	Ac	Bu/Ac
26	Mercer	Ill	13,043,326	126,864	102.81
27	Whiteside	Ill	21,095,351	191,066	110.41
28	Scott	Iowa	11,044,171	101,111	109.23
29	Knox	Ill	15,947,032	151,448	105.30
30	Butter	Iowa	9,003,785	108,338	83.11
31	Winneshiek	Iowa	7,317,239	82,772	88.40
32	Woodbury	Iowa	14,021,916	153,921	91.10
33	Jackson	Iowa	7,907,854	49,325	99.69
34	Fayette	Iowa	9,908,887	110,227	89.90
35	Franklin	Iowa	11,743,071	120,071	97.80
36	Hancock	Ill	11,620,988	141,284	82.25
37	Warren	Ill	15,072,663	139,371	108.15
38	Shelby	Iowa	11,259,176	116,381	96.74
39	Sac	Iowa	12,188,397	125,800	96.89
40	Buena Vista	Iowa	12,810,165	126,528	101.24
41	Marion	Iowa	5,353,674	64,232	83.35
42	Buchanan	Iowa	9,497,783	102,311	92.81
43	Linn	Iowa	11,160,209	121.579	91.79
44	Hardin	Iowa	12,398,743	120,293	103.07
45	Dane	Wisc	13,055,004	132,033	98.88
46	Poweshiek	Iowa	8,217,660	91,426	89.88
47	O'Brien	Iowa	14,757,636	132,816	111.11
48	Hancock	Iowa	12,024,940	117,189	102.61
49	Stephenson	Ill	11,651,086	117,571	99.10
50	Vodaway	Missouri	6,467,617	87,347	74.04
51	Greene	Ill	7,449,357	84,217	88.45
52	Cherokee	Iowa	11,523,497	112,941	102.03
53	Carroll	Ind	9,677,730	87,785	110.24
54	Muscatine	Iowa	8,389,344	81,512	102.92
55	Grundy	Iowa	11,701,108	122,298	95.68
56	Rush	Ind	8,061,170	83,010	97.11
57	Adair	Iowa	6,531,219	75,405	86.62

Table C-2 (Continued)

	County	State	Bu Corn	Ac	Bu/Ac
58	Cass	Iowa	9,394,253	102,244	91.88
59	Lyon	Iowa	12,066,567	125,980	95.78
60	Ogle	Ill	19,758,453	191,437	103.21
61	Hamilton	Iowa	12,262,227	130,790	93.76
62	Lincoln	Missouri	3,102,638	46,882	66.18
63	Macoupin	Ill	11,431,639	126,190	90.59
64	Lanaster	Penn	9,652,854	96,069	100.48
65	Cerro Gordo	Iowa	10,990,388	110,071	99.85
66	Lafayette	Wisc	6,714,079	70,610	95.09
67	Marshall	Iowa	13,360,127	125,554	106.41
68	Page	Iowa	7,708,152	86,155	89.47
69	Cuming	Neb	8,115,570	105,503	76.92
70	Andubon	Iowa	7,498,925	78,613	95.39
71	Martin	Minn	14,797,214	140,092	105.62
72	Stearns	Minn	3,419,516	61,768	55.36
73	Fillmore	Minn	8,743,650	92,473	94.55
74	Carroll	Ill	10,602,640	99,020	107.08
75	Morgan	Ill	11,670,976	105,455	110.67
76	Lafayette	Missouri	4,955,882	70,917	69.88
77	Ida	Iowa	8,797,935	88,510	99.40
78	Knox	Neb	5,307,688	96,790	54.84
79	Saline	Missouri	5,731,642	86,400	66.34
80	Balck Hawk	Iowa	8,961,514	99,745	89.84
81	Story	Iowa	12,688,601	124,020	102.31
82	Henry	Iowa	7,316,080	75,520	96.88
83	Allamahee	Iowa	5,070,809	51,963	97.58
84	Wright	Iowa	13,588,970	130,901	103.81
85	Jackson	Minn	12,068,555	122,791	98.28
86	McDonough	Ill	13,800,924	140,364	98.32
87	Fulten	Ill	13,884,927	143,351	96.86
88	Clinton	Ind	11,424,495	98,723	115,72
89	Nobles	Minn	10,713,953	122,707	87.31
90	Green	Wisc	5,448,499	62,481	87.20

	County	State	Bu Corn	Ac	Bu/Ac
91	Guthrie	Iowa	7,423,905	83,787	88.60
92	Clinten	Ohio	6,494,899	64,918	100.05
93	Dallas	Iowa	10,958,160	109,558	100.02
94	Mower	Minn	7,579,063	91,069	83.22
95	Cedar	Neb	7,058,274	107,041	65.94
96	Mitchell	Iowa	7,699,318	80,839	95.24
97	JoDaviess	Ill	6,305,512	68,364	92.23
98	Pocahontas	Iowa	12,147,188	116,540	104.23
99	McLean	Ill	38,437,599	329,617	116.61
100	Chickasaw	Iowa	5,850,630	70,214	83.32

Table C-3: Ranking of Observations of Corn Yield, Beginning with the Lowest, Where R_1 Identifies Michigan Counties' Rankings

Yield	Population	R_1 = Ranking of population number 1: Michigan
54.84	U.S.	
55.36	U.S.	
65.94	U.S.	
66.18	U.S.	
66.34	U.S.	
66.84	Mi.	6
68.14	Mi.	7
68.68	Mi.	8
69.88	U.S.	
70.23	Mi.	10
71.37	Mi.	11
71.59	Mi.	12
72.04	Mi.	13
72.33	U.S.	
74.04	U.S.	
74.18	Mi.	16
75.62	Mi.	17
75.76	Mi.	18
76.68	Mi.	19
76.92	U.S.	
77.35	Mi.	21
77.38	Mi.	22
79.79	Mi.	23
81.84	U.S.	

Table C-3 (Continued)

Yield	Population	R_1 = Ranking of population number 1: Michigan
82.25	U.S.	
82.29	Mi.	26
82.46	Mi.	27
83.11	U.S.	
83.22	U.S.	
83.27	Mi.	30
83.32	U.S.	
83.35	U.S.	
86.62	U.S.	
87.20	U.S.	
87.22	U.S.	
87.31	U.S.	
87.57	U.S.	
88.00	U.S.	
88.35	U.S.	
88.40	U.S.	
88.45	U.S.	
88.60	U.S.	
89.47	U.S.	
89.62	Mi.	44
89.84	U.S.	
89.88	U.S.	
89.90	U.S.	
90.35	U.S.	

Table C-3 (Continued)

Yield	Population	R_1 = Ranking of Population number 1: Michigan
90.40	Mi.	49
90.59	U.S.	
91.10	U.S.	
91.77	Mi.	52
		ΣR_1 = 431

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