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**DECISION SUPPORT FOR
LIVESTOCK PRODUCTION: INTEGRATION OF
INFORMATION MANAGEMENT, SYSTEMS MODELING, AND
COMPUTER SIMULATION TECHNIQUES**

By

James Walter Lloyd

A DISSERTATION

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ABSTRACT

DECISION SUPPORT FOR LIVESTOCK PRODUCTION: INTEGRATION OF INFORMATION MANAGEMENT, SYSTEMS MODELING, AND COMPUTER SIMULATION TECHNIQUES

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Recent advances in the understanding of livestock biology have compounded the difficulty of choice between alternative technologies for livestock producers. To facilitate this choice toward better achievement of decision maker objectives, a decision support system (DSS) was developed through integration of information management, systems modeling, and computer simulation techniques. In conjunction with the Swine Health Information System, the economics of health management in growing and finishing pigs was used as a framework for DSS development. Data on physical production, animal health, and financial production were accumulated in a single database. Techniques were developed to obtain health data from market hog slaughter without disrupting the ordinary marketing patterns of participating producers. Based on these data, necessary sample sizes to achieve statistical confidence were estimated. Depending on herd size and desired confidence level, recommendations for the participating producers ranged from 8 to 53 slaughter health checks per year. Further, an analytical model was formulated through a systems approach, emphasizing the generation of producer-specific, stochastic, technological expectations. During simulations using this model, changes in subclinical disease prevalence, feed additive use, and available floor space per pig served to modify current production (as determined from physical production data). Financial production data were subsequently included, thus allowing thorough evaluation of technological alternatives. Application to producer-specific health management situations was demonstrated by considering the financial effects of altering specific disease rates over distinct time periods. Recommendations for future DSS developments centered on expanded data collection to enable rigorous external validation.

**As with everything else I do, this work is wholeheartedly dedicated to Penny,
Kelby, Janelle, Brandon, and Danton.**

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Next, key participants in the Swine Health Information Management System (SHIMS) project warrant mention. The financial and cooperative support of United States Department of Agriculture, Food Safety and Inspection Service; United States Department of Agriculture, Economic Research Service; Michigan Agricultural Experiment Station; and Michigan Cooperative Extension Service were essential. Achievement of the initial grant would not have been possible without Eileen vanRavenswaay. Further, the success of the project was only achieved through the willing cooperation of participating producers, marketing agents, and slaughter plants. The critical importance of this cooperation cannot be over-emphasized and gratitude is extended to the entire SHIMS group.

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- ^aDairyComp, Valley Agricultural Software, Tulare, California.
- ^bCowSearch, Vermont Computer Software, Inc., Vergennes, Vermont.
- ^cPigChamp, Department of Large Animal Clinical Sciences, College of Veterinary Medicine, University of Minnesota, St. Paul, Minnesota.
- ^dCash Flow Planner (CFP), Cooperative Extension Service, Michigan State University, East Lansing, Michigan.
- ^eFinPack, Department of Agricultural and Applied Economics, Minnesota Extension Service, University of Minnesota, St. Paul, Minnesota.
- ^fFAHRMX, Department of Large Animal Clinical Sciences, College of Veterinary Medicine, Michigan State University, East Lansing, Michigan.
- ^gNAHMS, USDA/APHIA, Ft. Collins, Colorado.
- ^hSwineGraphics, Webster City, Iowa.
- ⁱTelFarm, Department of Agricultural Economics, Cooperative Extension Service, Michigan State University, East Lansing, Michigan.
- ^jNOMAD2, D&B Computing Services, Wilton, Connecticut.
- ^kdBASE III Plus, Ashton-Tate, Torrance, California.
- ^lMicroTSP, Quantitative Microsoftware, Inc., Irvine, California.
- ^mMicrosoft QuickBASIC, Microsoft Corporation, Redmond, Washington.
- ⁿM-OPTSIM, Department of Electrical Engineering and Systems Science, Michigan State University, East Lansing, Michigan.
- ^oPlotIT, Scott P. Eisensmith, Department of Crop and Soil Sciences, Michigan State University, East Lansing, Michigan.

CHAPTER 1

BACKGROUND AND GENERAL PURPOSE

INTRODUCTION

In his book Economics of Agricultural Production and Resource Use, Earl O. Heady (1952) stated that the role of the production economist in the area of farm management "... is that of facilitating choice in production patterns and resource use so that the ends or objectives of farmers and consumers can be attained." Generally, this role has been approached through: (1) assisting resolution of the choices farm managers face between production alternatives (offer prescriptions) toward the achievement of individual decision maker objectives and (2) attempting to predict the behavior of farm managers faced with particular circumstances toward optimal policy considerations. The first approach holds the individual farmer's well being as the primary focus, while the second is concerned mainly with economy wide issues, including consumers' interests. Though the ultimate targets of these two approaches differ, a solid understanding of the decision making process of the farm firm is paramount to either type of analysis.

T.W. Schultz (1939) aptly described farm decision making as a two-step procedure. The first step involves formulation of price and technological expectations. These expectations, in turn, form the basis for the second step, development of a production plan. This framework can be used to categorize the work of agricultural economists in the area of farm management: marketing research and formulation of marketing strategies provide the basis for work in price expectations; production analysis supports formation of technological expectations (TEs); and decision analysis, along with the entire body of decision theory, offers assistance in formulating production plans. Though this categorization may appear to be nicely discrete, much of the work done in

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farm management may involve two, or even all three, of these areas. For instance, production economics generally involves aspects of both production and decision analysis.

One analytical approach used by many agricultural economists is that of first gathering background information and then constructing a mathematical model to represent the problem of concern. The relative complexity of this exercise varies across a spectrum from pure intuition to extremely sophisticated, computerized processes. However, regardless of the complexity involved, collection of data and processing it into useful information constitutes an *information management system*. And since the entire procedure is used to assist the decision making of managers, the result is often referred to as a *decision support system*. Admittedly, these terms are somewhat loosely defined at this point, but will be further developed in Chapter 2.

Because agricultural production faces continual uncertainty from biological, environmental, and economic sources, the difficulty in conducting economic analyses for farm management is substantial. This is especially true of livestock production. Effective research in recent years has markedly improved the understanding of livestock biology in areas such as nutrition, genetics, and health management (among others). Considerable growth in the number of technological options available to livestock producers has followed. Since many of these options are new and unfamiliar to individual producers, uncertainty has also been effectively increased. This situation occurs across livestock species, places growing importance on the formation of TEs, and poses a special challenge for the agricultural economist.

Returning to the two-step paradigm of Schultz (1939), it is apparent that if uncertainty affects the formation of both price and technological expectations, the ensuing production plans are also influenced. Accordingly, uncertainty has been the nemesis of agricultural economists interested in farm management. Whereas the farm management economist is usually judged by the production plan's success in achieving decision maker objectives, it is quite obvious from Schultz's analysis that the quality of

the plan is directly limited by the quality of the underlying expectations. Often, however, the production aspect of this vital step is not sufficiently emphasized. Agricultural economists have traditionally paid much attention (in a relative sense) to decision analysis and marketing strategies, but have tended to base their TEs on assumption or on the work of biological and physical scientists.

Several authors have discussed the comparative lack of emphasis on technology (Heady, 1952; Schultz, 1939; Nix, 1979; Johnson, 1957; and Johnson, 1963), and some important points they make are:

1. relatively little incentive exists for subject matter and problem solving research since disciplinary acclaim is achieved mainly through basic (theoretical) work;
2. the interdisciplinary nature of investigations into the formation of TEs leads to administrative inconvenience and poses further problems if mutual intellectual respect between investigators is inadequate; and
3. many of the modeling techniques applied to the area of TEs are inadequate in their representation of agricultural production, since assumptions of linear, deterministic, static, and fully understood processes are generally inappropriate.

PROBLEM STATEMENT

The problem that has arisen from these circumstances is that, despite the marked importance of TEs, structured methods of TE formation have not been incorporated into rigorous economic analyses for livestock production. The agricultural economist's skills in data collection, mathematics, abstract modeling, problem solving, and understanding decision maker objectives have not been fully utilized in the area of technological elucidation. Since TEs are critical to virtually all work in the area of farm management, an increased emphasis on interdisciplinary research of this type is warranted.

An area of agricultural production where this problem is especially prominent is animal health management. While the capability of veterinarians to advise in the management of livestock health toward prespecified, health-related goals is quite well developed, the ability to effectively assess the associated economic ramifications is weak to non-existent. Generally, this results from not including expertise from both veterinarians and economists into single, rigorous economic analyses. Consequently, TEs associated with alternative health management practices are frequently very poorly developed.

Research Goal

The goal of this research is to construct a prototype decision support system for livestock production using growing pigs (weaning to market) as an analytical framework. Computerized information management and mathematical modeling techniques will be employed to form the TEs on which production plans will be based. While many aspects of market hog production will be addressed, special emphasis will be placed on the economics of animal health management. In that regard, the relative adequacy of the existing market hog disease knowledge base will be assessed. Though Schultz (1939) has noted the critical importance of both prices and technology, resource limitations preclude explicit inclusion of methods for price expectation formation. Thus, it will be extremely important to maintain flexibility to accommodate varied sources of price information.

Research Objectives

Initially, information management techniques applicable to livestock production will be reviewed to consider their usefulness in supporting the formation of accurate TEs. In addition, the various approaches which have been used to model livestock production and/or formulate production plans will be reviewed for their general strengths and weaknesses. These reviews will be presented in Chapter 2.

Once these reviews are complete, the capabilities of the agricultural economist will be combined with input from the biological sciences in order to build both an

information management system and a production model for growing pigs which form TEs and production plans. The information management system will include techniques for data collection, computerized processing, and output generation, while the modeling process will utilize systems analysis and computerized simulation. Special emphasis will be placed on the economic importance of animal health and its management. Though this work only addresses growing pigs from weaning to market, both the approach and the principles employed should be applicable to other livestock enterprises.

Presentation of these aspects of the research will occur in Chapters 3, 4, 5, and 6. Development of the information management system and preliminary data collection results will appear in Chapter 3. In Chapter 4, the analytical model will be presented, while initial application results for the composite decision support system will be presented and discussed in Chapter 5. Finally, Chapter 6 will summarize the results and put forth recommendations for building on the progress this research attains.

Research Benefits

Immediate benefits of this research will include:

1. identification of useful techniques and potential limiting factors for building information management systems to support TEs and production plans in livestock production;
2. identification of useful modeling techniques for formation of TEs and production plans in the production of livestock;
3. identification of critical economic factors in livestock management, especially those concerning animal health; and
4. identification of areas where further technological research is needed to adequately understand the economic aspects of the biological processes involved.

Ultimately, the knowledge gained from this research will make decision maker objectives more obtainable in livestock production. Further application should include:

1. a starting point for further research (to include possible revisions of the production model and the potential incorporation of price expectations);
2. a teaching tool to convey modeling techniques to future researchers, and to teach management techniques to future livestock producers and/or advisors;
3. support of direct consulting with livestock producers regarding management techniques;
4. individual use by livestock producers in support of their own decisions; and
5. use by policy makers to evaluate the potential ramifications of various regulatory options.

SUMMARY

Livestock producers face a widening array of production options. The uncertainty involved makes the pursuit of decision maker objectives an increasingly complex undertaking. Through a structured, interdisciplinary approach, this research seeks to make successful pursuit of decision maker objectives more achievable by designing a prototype decision support system which facilitates the formation of technological expectations and production plans.

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CHAPTER 2

REVIEW OF THE LITERATURE

INTRODUCTION

Using the production of livestock as a framework, this chapter will review those **general features** that agricultural economists should consider important when choosing **information management systems and mathematical models** to support individual farm **prescriptions**. Accompanying these general reviews, the specific **information management and mathematical modeling techniques** commonly used to guide decisions **in livestock production** will be evaluated individually and examples will be cited. Strengths and weaknesses will be assessed in relation to the adequacy of the resulting **production plan**. While the integral role of price expectations is once again recognized, only **production information and production and decision models** will be considered in an attempt to maintain a manageable scope while providing an adequate background for the **information management system and livestock production model** to be formulated later.

CONCEPTUAL DEVELOPMENT

As presented in Chapter 1, T.W. Schultz (1939) described the decision making process in managing agricultural production as having two steps: formation of expectations for prices and technology, and development of a production plan. But formation of expectations for agricultural production, regardless of the exact technique(s) involved, requires prior information on either the market or the production process of interest. For this reason, Schultz's first step really involves two phases: obtaining information and the actual expectation formation.

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However, deciding exactly what information is important and how it should be obtained is no trivial task. Just as the quality of the production plan is constrained by the expectation (as Schultz states), the quality of the expectation is very closely tied to the caliber of available information. As a result, the sufficiency of the information obtained is ultimately determined by how well the production plan achieves the decision maker's objectives. Therefore, to understand the relative importance of various information and its best utilization in forming expectations, it is necessary to actually use the information to derive expectations and to implement the ensuing production plan. For production information, this is an iterative and interactive process and involves management of production information, formation of technological expectations (or TEs) using a mathematical production model, and guidance for production planning with an analytical decision model. Figure 2.1 helps adapt the Schultz paradigm to the decision support system framework introduced in Chapter 1. Again, though similar processes are involved when prices are considered (as indicated in Figure 2.1), focus will be maintained on physical production.

Initially, the decision maker must personally decide which production information is deemed necessary to appropriately form TEs and how it should be obtained. This beginning phase, construction of the information management system (or IMS), may rest solely on prior experience of the decision maker or may utilize outside sources of information (referred to in Figure 2.1 as "Experts"). The resulting IMS may be simple or complex, depending on the characteristics of the situation.

Once this body of information is obtained, the decision maker takes the next step in the process—use of a mathematical model to form TEs. Again, the degree of sophistication can range from a purely mental model (involving, for instance, only extrapolation from previous production levels) to one that is extremely complicated. Regardless of its exact structure, some sort of mathematical model must be employed to form TEs. Following their formation, the decision maker combines TEs with available price information to design a production plan which is anticipated to best meet

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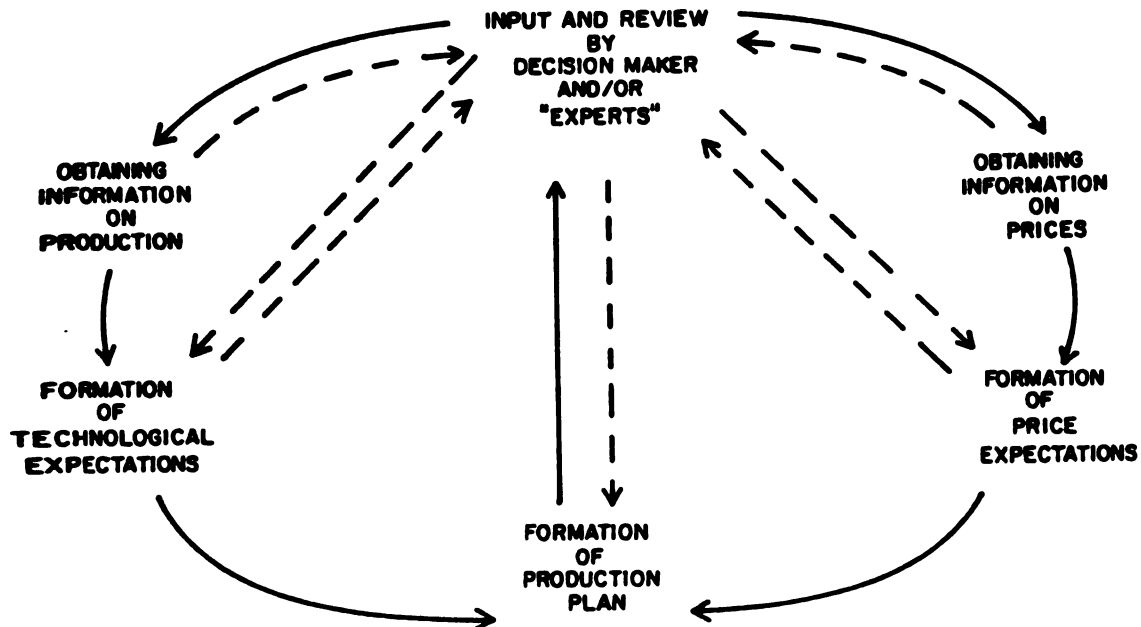


Figure 21 The agricultural production decision making process

his/her personal objectives. This process involves use of an analytical decision model, which can also vary from simple "status quo" policies to rigorous optimizations.

When the actual outcome of the production cycle is compared to original expectations (in light of decision maker objectives), input from the decision maker and/or "experts" is repeated. Input at this point starts the second iteration and serves to guide potential changes for the other stages of the process. For example, it may be discovered from the first iteration that information regarding a certain specific area of the production process is quite unimportant to management of the eventual outcome. In this case, resources could be conserved by not obtaining such information in successive cycles. Alternatively, information regarding other aspects of production might prove insufficient for adequate support of the production plan. Obviously, the next iteration should seek to enhance the quality of information in these areas. Finally, critical review may well point to a problem in the formation of TEs, rather than with the production information obtained. Such a finding would then warrant alterations in

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the analytical model employed. Once all changes have been implemented, the second iteration continues through the remaining phases to complete the cycle.

While the main flow of information is sequential from one stage to the next, the decision maker can interact directly with any individual stage at virtually any time by either obtaining feedback or exerting influence and making changes. In effect, the perpetual process measures the value of production information to the decision maker. Information is only of value if it is found to hold a net positive effect on the amount of welfare the decision maker derives from the production process. In this regard, the process closely parallels the position taken by Davis (1974), who asserts that the inherent value of information is determined by the net change in outcome achieved if the information is employed in production.

Through this iterative procedure, the producer is constructing a system which obtains production information, and then uses it to support production decisions. Though, as discussed, the degree of sophistication, complexity, and sufficiency surely varies between producers, the perpetual process is that of building a decision support system (DSS).

INFORMATION MANAGEMENT SYSTEM CHARACTERISTICS

Harsh, *et al.* (1981) defined four types of information required by the farm manager: descriptive, diagnostic, predictive, and prescriptive. In this context, the IMS provides descriptive information by collecting and processing production data into useful summary information which describes the critical aspects of the production process. Then the information is "fed" to the mathematical model portion of the DSS. Here the production model, regardless of its exact nature, provides diagnosis and prediction. Diagnosis is accomplished through processes such as sensitivity analysis, comparative statics, and shadow pricing whereby critical factors limiting production are discovered and evaluated. Pursuant to diagnosis, prediction occurs by appropriately altering input and production levels in successive solutions of the production model. Finally,

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prescription is provided by using the decision model to evaluate these successive input/output combinations in light of given objectives. Because the analytical production and decision models (and their resulting diagnostic, predictive, and prescriptive information) will be discussed subsequently, only the management of descriptive production information will be reviewed at this point. This information management lies entirely within the "Obtaining Information on Production" stage of Figure 21.

Management of descriptive production information involves two major phases: data collection and processing/summarization. Though some important features warrant consideration in virtually all production situations, it is impossible to conceive a single list of criteria to be followed in every single case. Variability is introduced by differences in production process characteristics, decision maker objectives, decision maker capabilities, production and decision models to be employed, and available resources from farm to farm. However, appropriate attention must always be paid to the accuracy and timeliness of both data collection and processing. Accuracy and punctuality are critical to the success of an IMS. Not only must errors in data collection and processing be minimized, but time lags in collection and extended processing turnaround must also be avoided. To be successful, an IMS must provide the decision maker "good" information when it is needed.

Data Collection

In spite of these differences, certain factors are critical to nearly all data collection efforts. These need to be given appropriate attention to prevent potential problems with the accuracy and punctuality with which the data are collected. Leading this list is the amount and types of data to be collected. As discussed in the *Conceptual Development* section, it is often difficult to know precisely what information is important. Ultimately, the value of any data to be collected is determined by behavioral changes and the resulting net change in outcome achieved (Davis, 1974). However, when collecting data one point should never be overlooked: each datum to be collected,

whether regarding production inputs or outputs, must have an intended purpose. Unused data not only wastes collection and processing resources, but also dilutes the attention given to truly useful data, thereby increasing the potential for inaccuracy and tardiness. On the other hand, if support for specific decisions is desired, the amount and types of data collected must be adequate for those purposes.

Closely related to the "What to collect?" question is that of "How to collect?" If the desired data can only be obtained through expending a huge physical and/or intellectual effort, then problems may again ensue. Further, the immediate method of data recording must be considered. The technique should be both straightforward and easy to complete to prevent unnecessary errors and/or delays.

A final consideration for data collection is the motivation(s) of the person(s) involved. While this certainly varies between individuals, adequate motivation is a necessary prerequisite to successful data collection.

Data Processing

Following these concerns for collection of the data are similar issues regarding its processing and/or summarization. Topping this list are questions surrounding the output of the process. As discussed previously, it is usually difficult to know precisely what information is important short of at least one full iteration through the process described in Figure 2.1. However, an initial desired content must be defined before outputs for data processing are actually formulated. Further, the desired destination of the output must be known. Whether headed for a computerized file or a printed report, content is closely followed in importance by format. Regardless of content, if the output format is not readily usable, the effectiveness of the entire process is seriously damaged.

After considering output content and destination/format, it is necessary to review data entry and storage issues. The amount of data to be handled, the relative complexity of the desired processing, and the available resources should guide the choice between

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viable options. When evaluating data entry options, it is again important to remember the degree of physical and intellectual difficulty involved.

As with data collection, the last consideration for data processing is the motivation(s) of the person(s) involved. The relative success achieved in this phase is often very closely tied to human factors for the people involved. Success cannot be attained if motivation is inadequate.

Finally, it is important to recall the value of information at this point. All data collection and processing procedures must be reviewed in the context of Figure 2.1 and the position taken by Davis (1974). Individual facets of an IMS should only be maintained if they make a net positive contribution to the outcome of the production process.

INFORMATION MANAGEMENT SYSTEMS FOR LIVESTOCK

Using these characteristics as a base, selected information management systems (IMs) useful in support of livestock production management decisions will now be reviewed. For the most part, two general approaches are used for livestock information management systems: individual farm and multi-farm. As the names imply, the individual farm method involves management of information from a single farm, while the multi-farm technique includes both information from one farm of special interest and information from a group of similar farms. Examples of individual farm systems which will be reviewed are DairyComp,^a CowSearch,^b PigChamp,^c Cash Flow Planner (CFP),^d and FinPack^e while FAHRMX,^f NAHMS,^g SwineGraphics,^h and TelFarmⁱ are the multi-farm systems to be considered.

Though managerial use of the individual farm IMs listed provides substantial descriptive information on the production process, each has its particular strengths and limitations. To begin with, the amount of data collected with these systems is probably nowhere excessive, and may not actually be adequate to provide decision support in all areas of production. More specifically, DairyComp,^a CowSearch,^b and PigChamp^c all

focus on historical output levels and current status of physical production while largely ignoring both physical inputs and the financial aspects of production. On the other hand, CFP^d and FinPack^e (which can be used to support the production of almost any species of livestock) tend to focus on the history and current status of production's financial management, giving only limited attention to inputs, outputs, and the current status of physical production.

While the adequacy of the data may present some limitations for these particular systems, the other important aspects of data collection discussed above present no problems. Overall, techniques of data collection and recording are more than adequate. Further, user motivation is generally high as individuals use the systems in hopes of improving production's performance. As a result, motivation is usually adequate to assure sufficient accuracy and punctuality in data collection.

The data processing aspects of these systems are also favorable. As with data collection, user motivation is normally high. Also, data entry and storage are facilitated by being entirely on-farm and computerized. When combined, these factors have marked positive effects on the accuracy and punctuality of data processing. Finally, the outputs from these systems are generally satisfactory. Substantial flexibility exists, allowing the individual to select between alternative output options according to particular preferences for content and format.

In summary, decisions requiring only historical physical output and current production status information for the individual farm are supported quite well by information management systems such as DairyComp,^a CowSearch,^b and PigChamp.^c On the other hand, those decisions which require financial management information for the individual farm are well supported by systems such as FinPack.^e However, support for formation of TEs and production plans is somewhat restricted by these types of systems, since none possess comprehensive information on *both* physical production (inputs and outputs) and financial management. Further, while production's "track record" is indeed very useful to the livestock manager, support for diagnosis and

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prescription (such as non-historical, "What if?" questions) would require combination with information from other similar farms and/or a quantitative production model.

Toward this end, multi-farm information management systems incorporate information from similar farms. Examples of these include the Food Animal Health Resource System (FAHRMX^f) for dairy producers, SwineGraphics^h for hog producers, the National Animal Health Monitoring System (NAHMS^g) for dairy and hog production, and TelFarmⁱ for virtually all livestock species. These systems report information both for the particular farm of interest and parallel information from a group of comparable farms. However, once again data collection is not uniform across the various areas of production. FAHRMX^f and NAHMS^g tend to lean toward description of physical production's historical output and current status (especially health status) and away from physical inputs and financial management. On the other hand, TelFarmⁱ is much more complete in describing the financial aspects of management than in physical production. SwineGraphics^h begins to bridge the gap between financial and physical production. Generally speaking, SwineGraphics^h provides information on physical input quantities, input costs, physical output quantities, and output values. Also, the current status of production is included except for some aspects of livestock health. SwineGraphics^h provides the most comprehensive body of production information of the systems reviewed.

While data may be inadequate in some areas, the techniques of data collection and the driving motivation for SwineGraphics^h and TelFarmⁱ are similar to those discussed for the individual farm systems and, as such, present no real problems. On the other hand, FAHRMX^f was a pilot demonstration and NAHMS^g originated as a research effort. On both projects, producers were specially selected for participation. As a result, data collection duties for these systems were divided between producers, project managers, and research co-workers. Although the specific data collection techniques involved are adequate, the producers' motivation for participation might cast a shadow on data accuracy. This point has been recognized by coordinators for both

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systems and considerable effort is expended by data collecting co-workers to assure that data quality is acceptable.

As with the individual farm systems discussed, the output of these multi-farm systems has content and format that is quite useable. Further, these systems accomplish data processing centrally. While this may alleviate potential accuracy problems arising from user processing, the possibility of turnaround time lags is introduced. Finally, though motivation for processing is not directly tied to the user's financial success, central processing is usually performed by professionals whose own financial remuneration is often correlated with the quality of their work.

In summary, the adequacy of information provided by these multi-farm information management systems is generally improved over the individual farm systems discussed. Addition of information from similar farms lends assistance to diagnosis and prescription. However, formation of TEs and production plans remains difficult due to lack of comprehensive physical and financial data.

ANALYTICAL MODEL CHARACTERISTICS

Consensus among economists on the exact attributes which are important for inclusion in good analytical models of production will probably never be achieved. However, several general features provide key focal points for both model builders and reviewers. Four such model characteristics were proposed by VanDyne and Abramsky (1975) when they reviewed many quantitative models developed for agriculture. Their framework for review involved the following categories: 1) resolution, 2) realism, 3) generality, and 4) precision.

Resolution and realism refer to how well the model represents reality. For a livestock production model to accurately depict reality, it should first include sufficient resolution to capture both the biology and economics involved. The direct effects of biological factors such as animal environment, sex, age, diseases, nutrition, and genetics need to be considered for possible relevance. Similarly, a livestock decision model

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should consider economic factors such as decision maker objectives, market conditions, and certain aspects of financial management. Attention here should include the decision maker's attitudes toward risk, social status, standard of living, human-animal bonds, and growth of the firm while concurrently recognizing the importance of actual input and output prices, the time value of money, cash flows, labor and facility availability, asset liquidity, and financial leverage.

Mere inclusion of those factors deemed relevant is not sufficient unless the model appropriately addresses the actual relationships that exist. For this reason, livestock models should allow for the realism of complex factor interactions, random (stochastic) variation, and dynamic progression. For example, interactions are known to exist between such factors as dietary energy and protein levels, animal environment and health management inputs, and animal concentrations and nutrition. Also, virtually all biological production processes in agriculture contain elements of random variation, both within and between farms. Similarly, the economic environment provides perpetual market stochasticity in the form of changing demand and supply conditions, which ultimately leads to variation in output marketability, input availability, and prices of both inputs and outputs.

Finally, because biological and economic factors (such as relative animal health and factor prices) are never constant, it is critical to permit change in system parameters over time. To attain this dynamic realism, time-paths can be followed continuously or in discrete increments. If time is continuous, differential calculus is necessary, while difference equations are used to capture discrete changes (Chaing, 1974). If the discrete time intervals are very small (infinitesimal), the solution of the difference equations approaches that of the corresponding differential equations as a mathematical limit. As a practical matter, either approach can be used to model livestock production. However, if discrete intervals are employed, the time-step must be small enough to allow the difference equation solution to closely approximate the differential equation solution.

In contrast to resolution and realism, generality and precision refer to the performance of the model when applied to actual situations at various production levels. For instance, generality with livestock models at the farm level indicates that the model is broadly applicable across farms with similar production types, while precision implies an ability to represent events on one particular farm over time. At another system level, generality with animal-level livestock models indicates that the model is broadly applicable across similar animals in the same herd, while precision implies the ability to predict the events of one particular animal over time.

Generality and precision often pose antagonistic goals, since an increase in generality often necessitates a loss of precision, and vice versa. The degree that each may be achieved depends in large part on the source of the data used to build and run the model. Use of primary data (collected by the model builder/user) might be expected to meet generality-precision goals more effectively than one using secondary data (collected by someone else), since primary data provide much greater familiarity with data strengths, weaknesses, and interpretations. Regardless of the ultimate focus, a certain amount of precision is necessary for a model to be generally applicable, since all groups are composed of discrete individuals.

In addition to these four general characteristics forwarded by VanDyne and Abramsky (1975), models intended for use in livestock decision support should be reviewed for a fifth attribute: their applicability. For example, when attempting prescription for decision problems that occur in the production of livestock, the capacity for constrained optimization is often valuable. Then, once decision maker objectives have been considered, costs can be minimized subject to output constraints, profit can be maximized subject to cost constraints, output can be maximized subject to technological constraints, etc. Also, model flexibility is important since similar problems often arise in non-identical situations. For instance, the asset replacement decision is very similar whether considering livestock or machinery, but the associated cash flows and asset lives could be expected to differ considerably. Finally, the capability for

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sensitivity analysis is extremely useful. This allows the researcher to define critical areas of insufficient information and allows the decision maker to explore the possible consequences of not exactly following the prescription dictated by the model.

When reviewing models for livestock production according to the five major characteristics suggested, the ultimate question becomes, "How good is good?" This question must be addressed within the context of each individual modeling situation by first asking, "How well does the model achieve the modeler's (or user's) objectives within the constraints on modeling resources?" Resource application in modeling efforts should not exceed that amount necessary (or available) to meet the modeler's needs. Thus, while certain modeling situations may require a higher order of technical sophistication, the problems faced in other cases might be met with a more straightforward, simplistic approach.

Care must also be taken, however, to avoid over-simplification, or the model may not be "good" enough in the areas discussed to meet the modeler's objectives. This position was echoed by Dent (1975) during a review of systems theory application in agriculture. Dent categorized agricultural production processes into four system levels. These are:

Level 1: Biochemical and physical systems,

Level 2: Plant and animal systems,

Level 3: Farm business systems, and

Level 4: National and international systems.

Most of the models at Levels 1 and 2 are constructed by biologists, while economists tend to model at Levels 3 and 4. Dent suggested that an important reason for failure of models at Levels 3 and 4 is a lack of appreciation by the modeler(s) for the structure and/or function of the various underlying biological subsystems (or Levels 1 and 2).

In the context of VanDyne and Abramsky (1975), the models' failures indicate lack of generality and/or precision and result from a lack of realism and/or resolution. Or, in the mode of Schultz (1939), the production plan (decision model) might fail if

insufficient attention is paid to formation of technological expectations (production model). These attitudes were mirrored in Johnson and Zerby's (1973) statement that "... there is little virtue in a simplicity that distorts reality."

At the same time, Bywater and Baldwin (1984) argued that too much concern for detail can doom an otherwise healthy modeling effort. Their contention was that a model can easily become mired in details that are irrelevant for the immediate problem, and that often substantial aggregation and generalization is warranted in order to facilitate ease of use and smooth model performance. In this case they seem to be joined by J.L. Dillon (1979), who wrote:

The mathematical solution for determining the path of a thrown baseball requires solving complex differential equations; however, those who can catch baseballs need not solve those equations, even though their catches imply that they do.

Thus, while the modeler's objectives are probably the most important underlying criteria for model construction or review, either inadequate or inordinate attention to the details of the actual production and decision processes involved can easily limit the usefulness of the resulting models.

ANALYTICAL MODELING TECHNIQUES FOR LIVESTOCK

Various approaches have been taken to analytical modeling in livestock production. Those which have received substantial attention in the literature will be reviewed individually.

Traditional Production Economics

Over the years, a rather large, well-structured body of theory has evolved in the production area of microeconomics (Beattie and Taylor, 1985). However, integration of structured economic theory into the analytical efforts of applied farm management specialists has not strictly paralleled the development achieved by theoreticians. Moreover, the extent to which the neoclassical approach allows the farm management analyst to meet the theoretical objectives of prediction and/or prescription has been the

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focus of much debate (Schultz, 1939; Johnson, 1957; Johnson, 1963; Nix, 1979; and Heady, 1952). While a comprehensive, rigorous review of all of the debate's constituent arguments will not be attempted, several perceived strengths and weaknesses will now be explored. This takes place in the course of reviewing applications of traditional microeconomics to the formulation of livestock production plans.

Though it was both preceded and followed by numerous publications with a similar orientation, probably the single largest collection of work in the application of economic theory to agriculture was the book written by Heady and Dillon (1961). The basic approach, which is centered around formulation of a production function and corresponding isoquants, has been repeated more recently in the area of livestock production by such authors as Epplin and Heady (1982) to determine optimal rations, Russell and Young (1983) to evaluate technical efficiency, and Adeyemo (1986) (who formulates both production and cost functions) to review factor proportion issues. Relatively minor variations of the approach appear in Sonka, *et al.* (1976); Bhide, *et al.* (1980); and Brokken and Bywater (1982), who all estimated isoquants directly in an effort to define optimal ration formulations.

Basically, this approach is both a production and decision model; it actually formulates a technological expectation along with recommending a production plan through formal optimization. Herein lies its primary strength. Following optimization, sensitivity analysis around the recommended production point can be performed via comparative statics.

However, several important limitations must also be noted. First, the approach inherently assumes that production can be adequately described with a single, well-behaved, deterministic, statistically estimated production function which contains all information relevant to production and considers only the current time period as important. Unfortunately, livestock production is far too complex to be described with such a function, as changes (often abrupt) are known to occur in response to factors such as disease, weather changes, and estrus. Previous production levels are likewise

important. However, none of these factors were included in the above studies. If they were adequately captured, a dynamic production function with "corners" (or undifferentiable points) would have been necessary. Also, the very nature of biological processes brings stochasticity (random variation) to nearly all agricultural production, with or without random effects of the environment. Thus, the underlying single, well-behaved, deterministic, static, representative function assumption is violated in reality. As a result, the production model may lack resolution, realism, generality, and precision.

Statistical estimation of production in the absence of a thorough understanding of the technology involved can lead to grossly inappropriate results (Bywater and Baldwin, 1984). For instance, estimation across a group of "seemingly similar" farms may well result in reasonable generality, but poor precision. On the other hand, estimation from a single farm or experimental trial (as in the examples cited) might yield adequate precision, but regardless which of these sources is utilized, the relationships determined from the data are virtually never generalizable to non-identical situations (Lloyd, *et al.*, 1987a), even if they are based on a firm understanding of the process involved rather than a statistical "best fit." So generality is also absent, making the model quite impractical to use for individual farms, since (even if all other aspects of the approach were acceptable) it would be necessary to "re-fit" for each new farm to be analyzed.

It might be argued that this is a problem of misspecification. However, a thorough technical understanding of livestock production would include recognition of inherent limitations in the current knowledge base. For example, it is not possible to say that "two hogs raised under identical environmental and nutritional conditions will perform precisely the same if they are of the same breed" because considerable variation exists even within individual breeds. Similarly, the effects of disease on production cannot be expected to be identical across farms and over time. Again, substantial variability exists (Lloyd, *et al.*, 1987a). Thus, even if the "functions" are specified to the full limit of current knowledge, problems may arise from untempered statistical estimation.

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Finally, this analytical approach implies that the critical decision faced by producers is one of absolute production toward profit maximization (or cost minimization if the output level is fixed), is discretely faced in the current time period (static), and is based on perfect (deterministic) price information. But, in reality, livestock producers more often face a relative production question (adjustment), based on both the levels and rates of current and past production (dynamic), toward achieving personal objectives. These objectives may or may not be purely profit maximization, since factors such as firm growth, risk preference, and aspects of financial management are known to be important. In addition, input and output prices are virtually never certain, since their respective markets are inherently stochastic. Thus, the decision model also lacks resolution, realism, and precision.

Most of these shortcomings were astutely anticipated by Schultz (1939). Together his perceptions of the attempt to formulate single, well-behaved static functions which were constant across farms and across time lead to the statement, "There are, however, I am convinced, a number of reasons for believing that is a poor use of resources for agricultural economists to try to work up these constants."

More recently other authors have also used the literature as a forum to air some of their concerns about the limitations of this traditional approach. For example, Upton (1979) discussed the realism and resolution problems of the production model when he said that the choice of functional form is arbitrary and mentions that farming is so complex and dynamic that "any attempt to represent such a system by a single equation is unlikely to be operationally meaningful." Also, he addressed the lack of generality problem with the production model when he discussed the difficulties associated with attempted aggregation. Conversely, Leibenstein (1979) was more concerned with the decision model and focused on how the maximization of profits to the exclusion of all other possible decision maker objectives is inappropriate.

Expected Utility

In trying to overcome some of these criticisms, theorists have made various attempts to broaden the approach. Most common among these is the expected utility framework, which was well presented with numerous applications by, among others, Robison and Barry (1986). Basically, the technique involves the addition of uncertainty to the production and/or decision model (in the form of stochastic technology and/or prices, respectively) and modification of the decision model objectives to maximization of expected utility. When broadly approached, expected utility theory involves specification of the decision maker utility function across the entire range of possible production outcomes and their respective probabilities of occurrence. The utility level of any given outcome is discerned by considering the resulting possible output levels, the corresponding output values, their probabilities of occurrence, and all other relevant aspects of such production. Once defined, this function then facilitates choice between production alternatives through allowing maximization of the utility which the decision maker expects to achieve. To identify a global maximum, this approach requires a utility function with the same mathematical properties discussed for the traditional production economics approach.

Theoretically, expected utility may be attractive. However, comprehensive, mathematically tractable utility functions which consider output levels, values, probabilities of occurrence, and other relevant production aspects are difficult to accurately specify in most real world situations. Even if accurate specification is possible, it may not be a cost effective exercise if solely directed toward providing management assistance. Therefore, the broad approach described above is frequently forgone in favor of a procedure which considers only the potential profit levels and their respective probabilities of occurrence. In this special case, the utility level is determined by the mean and variance of the profit distribution (certainty equivalent profit).

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Strengths of this approach include those mentioned for the traditional model: both technological expectations and production plan are addressed, the capacity for formal optimization is inherent, and sensitivity analysis around the recommended production point is again possible through comparative statics. Further, the addition of uncertainty to the production and/or decision model and the relaxation of exclusive profit maximization objectives for the decision model are admirable. However, significant weaknesses remain.

Though uncertainty is now allowed in the production model, the violations of other assumptions have not been addressed. Specifically, the theory still assumes that a single, well-behaved, statistically estimated production function based entirely in the current time period contains all the relevant information to form technological expectations. As a result, the production model again lacks resolution, realism, generality, and precision if applied to the production of livestock.

In turning to the decision model, more problems are encountered. While movement away from exclusive, current-period profit maximization has occurred, it is easily debatable whether or not exclusive, current-period maximization of expected utility (certainty equivalent profit), which is based only on the mean and variance of the profit distribution, represents an improvement. At least for livestock production, the assumption remains too restrictive, and as a result, the decision model again lacks resolution, realism, and precision.

Finally, nothing has been done to alleviate the generality problems, since individual farm or experimental data are still the basis for model formulation. In addition, when more than one source of stochasticity is incorporated, the model becomes mathematically intractable and it becomes necessary to specify the individual decision maker's risk preference in order to solve the decision model. Since the production of livestock nearly always entails a minimum of two sources of random variation (biology and price), and since it is extremely difficult to definitively specify risk attitudes of decision makers, the applicability of the approach is severely limited.

Again, the literature debating the merits of this approach is quite extensive, from which a few extractions will be made. Antle (1983a) recognized that a dynamic, stochastic production model is necessary, and wrote that the decision model has "... little relation to the decision problems farmers face." In suggesting direction for future work, he acknowledged the vital importance of technological expectations to production plans by appropriately recommending that "... measurement of production risk must precede analysis of production risk" and proposed formulation of "... dynamic, risk-neutral models as a first step."

Similarly, Jolly (1983) noted the need for both a dynamic production model and a decision model that more closely depicts the actual management process in agriculture. In addition, he accurately perceived production as extremely site- and time-specific. He expressed that:

... the gap between the rapidly growing economics literature on risk response and the farm management techniques and needs of producers and agricultural advisors is both alarming and discouraging.

Like Antle (1983a), Jolly recognized the importance of technological expectations, since he suggested that in the future, "... greater attention must be paid to realistically modeling the technical and institutional relationships that determine the firm's performance."

Both Chambers (1983) and Holt (1983) concurred with the need for dynamic, stochastic production and decision models. Holt went further to join Johnson and Zerby (1973; Chapter XI) in suggesting that perhaps systems modeling and computerized simulation offer a viable alternative with relatively great potential.

For the most part, nearly all the remaining production and decision model techniques developed and used in agricultural economics have been the result of the traditional model's shortcomings. These approaches range from mild variations to those that are completely different. Again, each of the major categories will be reviewed (at least briefly) in light of the needs of livestock producers.

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Other Variations of Traditional Production Economics

A stochastic production function model was applied to livestock by Anderson and Griffiths (1981). Strengths of their approach include provision of an expectation for production in the form of a probability distribution. This feature allows the decision maker not only to review the effects of particular inputs on the output level, but also to evaluate their effects on the amount of risk involved.

However, serious limitations remain. First of all, the problems discussed above regarding the attempted comprehensive description of livestock production with a single, static function are present in this approach. Secondly, a decision model was not discussed and therefore the capacity for optimization and sensitivity analysis is not apparent. Finally, the source of data for this exercise was across farms and over time. As a result, the site- and time-specific nature of livestock production bring a function with low predictive power, in spite of some complex mathematics. In summary, though stochasticity has been added to the production model and perhaps some useful insights result, the approach still lacks resolution, realism, precision, generality, and applicability.

An approach which perhaps goes one step further is that of Antle (1983b), who incorporated both stochasticity and dynamics. The basic technique involved division of the relevant decision horizon into discrete stages, and then fitting a stochastic production function in each stage. These within-stage functions contained information from either previous stages, successive stages, or both. To achieve dynamics, then, the entire system of equations for the relevant decision horizon was solved simultaneously.

The strengths of this attempt begin in similar fashion to those of the expected utility model: elements of both production and decision models are present, formal optimization is possible, sensitivity analysis around the recommended optimum should be possible, and random variation can be included. In addition, the simultaneous solution of the equation system allows the model to be dynamic.

On initial inspection, this technique appears to have been successful in overcoming the most serious criticisms of more traditional efforts. However, significant

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limitations remain because it is still assumed that production can be adequately described with a single, well-behaved, statistically estimated function (now within individual time periods). If the time periods are very small, the truly continuous nature of production can be effectively approximated. However, the single, statistical equation problem makes the accuracy of such a model questionable. Therefore, the resolution, realism, generality, and precision of the production model are again suspect.

For the decision model the same small discrete periods vs. actually continuous issue applies. Further, even if dynamics are effectively achieved, the decision criterion is still limited to a single maximization. So, in spite of substantial progress, the decision model also remains limited.

As an alternative to the single equation per discrete time period approach, Antle and Goodger (1984) proposed the use of several equations: one each to predict the first three moments of the output's probability distribution. As with Anderson and Griffiths (1981), this approach is very insightful when evaluating the effects particular inputs may have on the probability distribution of output. Also, it might be possible to combine this approach with Antle's (1983b) small, discrete period technique to approximate a dynamic system. However, the single, statistically estimated equation problem would remain, in addition to the problem of adequately representing the actual objectives of the decision maker and a potential lack of generality.

Rather than pursuing small, discrete time periods to model the dynamics of agricultural production, Chavas, *et al.* (1985) have proposed a continuous time approach using differential equations to achieve technological expectations. Though their model was deterministic, the authors claim that stochasticity can be accommodated (at the expense of mathematical simplicity). This model should then be expected to perform better than those discussed previously, but the single, statistically estimated equation and the generality problems remain. Also, possible decision maker objectives are still somewhat limited. Nevertheless, the movement to a continuous time approach may represent significant progress when modeling physical production. However, it may not

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be necessary for the decision model, since a decision horizon of one day (discrete time step) is quite consistent with most decisions made in livestock production.

In summary, the theoretical work that has been done in attempts to make traditional production economics more realistic and usable for agricultural economists interested in farm management prescriptions has made important advances, but remains short of completion when the production of livestock is used as an analytical framework. The lingering areas of weakness are:

1. the complex process of livestock production cannot be captured in a single mathematical equation, even if that equation is stochastic and dynamic;
2. when using statistical techniques to arrive at a "best fit" equation to represent even a small facet of livestock production, it is imperative to incorporate familiarity with the underlying biological processes into the models;
3. once the relationships are estimated using data from one farm or from a controlled experiment, they cannot be expected to hold true for non-identical situations (either for different farms or for the same farm at different times); and
4. it is inappropriate to limit the decision maker's objectives to a single optimization, whether cost minimization, profit maximization, or certainty equivalent profit maximization.

Other analytical approaches will now be reviewed.

Linear Programming and Variations

Outside the "mainstream" theoretical developments discussed thusfar, an analytical technique which has seen much use in agricultural economics is linear programming (LP). A good, basic presentation of the technique can be found in Anderson, *et al.* (1985). Generally speaking, LP contains an objective function to be maximized or minimized subject to constraints. The optimum solution (the production point that maximizes or minimizes the objective function) provides a recommended production plan. While it is not strictly necessary to specify an explicit mathematical production model, such a technological expectation is often included either as part of the objective function or as part of the constraints. This is usually the case for LP models formulated to address livestock production.

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Though LP provides both technological expectations (production model) and recommended production plans (decision model), the basic approach has several limitations. When considering the production model, all functional relationships contained in both the objective function and the constraints must be linear and deterministic, and it is assumed that these functions contain all the relevant information about production. Further, the relationships contained in the model are again typically determined from farm- or experiment-specific data and thus are not generalizable and the approach is generally static. These limitations present problems similar to those encountered when production economics assumes that a single, well-behaved, static, deterministic function estimated over a relatively narrow database can adequately represent production across similar farms.

Considering the decision model, LP assumes that the objective function accurately represents the individual decision maker's objectives. This presents limitations similar to those discussed for traditional production economics. As a result, the basic approach of LP as applied to livestock production generally lacks a certain degree of resolution, realism, generality, and precision in both the production and decision models.

However, the capacities for formal optimization and rigorous sensitivity analysis make the approach attractive for its applicability. Various modifications of the LP technique have been aimed at one or more of the production and decision model limitations. Some examples follow.

Traditionally, LP has been used to address a wide array of problems in agricultural economics. Probably the most common use of LP in the field has been to formulate least-cost rations for livestock production, considering only feed ingredients, their costs, and their nutrient contents. Pope and Heady (1983), having recognized the limitations of such a restricted problem formulation, broadened this approach to also include the availability and cost of labor and capital, while still maintaining a primary

focus on the nutritional program for feeding beef cattle. Their objective function maximized returns to labor and management over a single time period.

In similar fashion, Klein, *et al.* (1986) have maximized a proxy for profit over a single time period for dairy cattle subject to constraints on nutrition, technology, labor, and capital. However, they have also recognized the fact that milk production is non-linear, and have accordingly separated the production process into several linear stages in an effort to approximate the curvilinear relationship that actually exists.

Gutierrez-Aleman, *et al.* (1986a,b) have also taken technology, labor, and capital into account toward maximization of gross margin. But, in contrast to the single enterprise models, their approach reflects a recognition that management of livestock production frequently goes beyond strictly livestock considerations, and have thus included crop production and family factors in their whole-farm LP for small ruminant producers in Brazil.

A similar whole "farm" approach was used by Thomas, *et al.* (1983) when they sought to maximize profits from reindeer herd management. This model also included such biological as factors for calf survival, calving percentage, and mortality rates, which all appear as functions of controllable management parameters.

Reyes, *et al.* (1981) used comparable techniques when they maximized income-over-feed-cost (IOFC) for dairy cattle, since the technological realism of nutrition and seasonal variation were combined with attention to calving intervals and weight losses. They, like Klein, *et al.* (1986) have divided the production process into linear segments (a multistage approach) in an effort to approximate a curvilinear relationship. In addition, the importance of cash flow is recognized and is incorporated in the exercise.

In a combination of some techniques previously discussed, Rozzi, *et al.* (1984) have formulated a whole-farm LP for a dairy which also has the option of raising beef and crops. This model considers land, labor, capital, and nutrition as constraints, and

adopts a multistage production approach in an attempt to circumvent potential nonlinearity problems.

In contrast to the technique of formulating multiple production stages within a single time period as in Klein, *et al.* (1986), Reyes, *et al.* (1981), and Rozzi, *et al.* (1984) the method of Talpaz, *et al.* (1986) involved setting an extremely short time horizon (one day) for the entire linear model for feeding broilers, and then resetting model parameters and repeating problem solution. This procedure not only aspired to address nonlinearities, but also has partially overcome the static nature of LP through resetting parameters in each time period. Though not truly continuous, this segmentation of time provides a more dynamic framework which increases the realism in both the production and decision models.

Janssen and Hassler (1981) combined this type of dynamic framework with multistaging for growing and finishing market hogs. Every two weeks the price expectations for inputs and outputs were reset and a new solution was obtained. Again, the attempt was to minimize the effects of nonlinearities and to more adequately capture the dynamic nature of the system involved toward maximizing expected net revenue.

Fawcett, *et al.* (1978a,b) and Glen (1983) used similar procedures in considering growing pigs. However, a major difference with these works was their reliance on a biological description of the growth process. This interdisciplinary approach was used to maximize pig growth in Fawcett, *et al.* (1978a) and to minimize pig feeding costs in Fawcett, *et al.* (1978b) and Glen (1983). Though this increase of biological factors in the model offered more resolution to the formation of technological expectations, the models still lacked consideration of important factors such as disease and random variation.

To this point, variations in the basic LP format have been discussed which attempt to overcome problems with nonlinearities and dynamic relationships that occur

in the reality of livestock production. Also, the incorporation of biologically formulated production models has attempted to address the assumption that a single mathematical function can capture the resolution necessary to model livestock production accurately. However, the fact that LP optimizes only a single objective function remains as a serious hurdle, since decision makers may hold several objectives concurrently in reality. For this purpose, goal programming has been developed.

Goal Programming

Goal programming has been described by Romero and Rehman (1984) and involves incorporation of more than one decision maker goal into the modeling process. Basically, either the goals are simply prioritized and the problem is solved lexicographically, or a weighting scheme is applied according to relative importance of the various goals and the problem is solved using appropriate penalties. Rehman and Romero (1984, 1987) suggested using this technique for feeding livestock, while Sandiford (1986) proposes a use in fishery management.

Finally, when the precision and generality of these various LP-based modeling procedures are reviewed, it can be seen that applications of the techniques are invariably founded on data of limited scope. This problem was also encountered with production economics. Because the data are collected either in an experimental setting or across a very limited number of commercial farms, model applications should be carefully limited to the confines of the environment in which the data were collected; generalization to non-identical situations must be avoided.

In summary, linear programming suffers from many of the same limitations as traditional production economics if used only in its basic form. However, the technique is flexible and achieves some success in addressing theoretical criticisms through technique modification. As discussed previously, an analytical technique must possess several important qualities to be truly useful in formulating technological expectations and production plans in the livestock industry. It should contain the resolution of biological accuracy, financial management, and actual decision maker objectives. It

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needs the realism of random variation and dynamic interactions. Precision is necessary for the technique to be useful on particular farms, and generality is required to be useful across farms. Optimization and sensitivity analysis help achieve applicability. Through the modifications discussed, LP makes considerable progress toward meeting these goals, but shortcomings remain. Other major approaches to decision and production modeling will be considered next.

Other Decision Models

Because of the difficulties encountered when attempting to model agricultural production accurately, agricultural economists commonly use analytical models which are solely decision-oriented. In such cases, the formation of technological expectations (TEs) occurs independently from the analytical decision process. Those techniques commonly used in this fashion include budgeting exercises (both total and partial), decision trees, and dynamic programming.

Budgeting. Application of budgeting to agricultural production was discussed in Harsh, *et al.* (1981). Budgets of some form are used in the day-to-day management of virtually all livestock production. Budgeting can be considered a "passive" decision model, in that the process doesn't actively recommend the best production plan, but merely compares alternatives. However, once the expected financial outcome of the production choices being considered is known, the individual decision maker involved can then choose the alternative which most completely achieves his/her objectives.

In this manner, budgeting implicitly employs the decision maker's utility function without requiring its explicit specification. The decision maker can effectively weigh the financial aspects of the budget with the associated non-financial aspects en route to maximizing his/her utility over the production options considered. When reviewed in this theoretical light, budgeting offers a technique which should be extremely attractive to economists interested in the welfare of producers.

Strengths of budgeting include wide applicability, ease of use, and passive decision model. The implicit use of utility functions avoids misspecification errors.

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Either adjustment or absolute production questions can be addressed. Uncertainty can be included by repeating the process over the range of possible values for the uncertain variable(s), and then associating a probability of occurrence with the respective outcome. The realism, resolution, and precision of this approach are limited only by the caliber of the underlying price and technological expectations. Also, because each application mandates individual farm data, the technique can achieve excellent generality; it can be applied in virtually all farming situations.

Though use of individual farm data provides certain strengths, the requirement for such data might also be viewed as the major source of limitation for budgeting. With only information from a single farm, the total input and output effects of proposed production changes can be troublesome to accurately project if such alternatives have not been previously employed on the farm being evaluated. As a result, accurate TEs can be difficult or even impossible to achieve for certain proposed changes in production. Thus, problems with generality and precision can occur.

Finally, sensitivity analysis is possible with budgeting exercises, but is often time consuming. This is due to the fact that the sensitivity of outcome to various production factors can only be assessed by repeating virtually the entire budgeting exercise. In this regard, the assistance of a digital computer can be invaluable. Partial budgeting (Harsh, *et al.*, 1981) can also expedite this process. But caution must be exercised so that important changes in inputs and/or outputs are not inadvertently omitted.

Decision Trees. Another decision model which is used in agricultural production is the decision tree. A review of this technique can be found in Anderson, *et al.* (1985). Examples of application to livestock production are provided by Fetrow, *et al.* (1985) and Parsons, *et al.* (1986). The decision tree is more of an "active" decision model than budgeting, since a definite course of action is recommended based on its estimated monetary value (EMV) (Anderson, *et al.*, 1985).

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Strengths of this technique include its relative ease of use and wide applicability. Again, adjustment or absolute production options can be considered. Also, the EMV incorporates a measure of the uncertainty involved.

However, the decision tree holds several serious limitations. Underlying production model notwithstanding, the realism, resolution, and precision of this decision model are questionable. Though the EMV does incorporate uncertainty, its ability to accurately represent the decision maker's utility function or personal objectives is arguable at best. Further, the need for individual farm data can lead to precision and generality problems as discussed previously with budgeting exercises. Finally, sensitivity analysis is again achieved only through iterative analysis and true global optimality is once more impossible due to the inherent limitations of comparing production alternatives.

Dynamic Programming. The last decision model to be considered is dynamic programming (DP). This technique, mentioned briefly in the linear programming section, deals with sequential decision problems and is explained in detail by Bellman and Dreyfus (1962) and Bellman and Kalaba (1965). In its pure form, DP involves the charting of a time-path for decision maker action over discrete steps, and is an "active" decision model since a specific time-path is recommended as the best action(s) among available alternatives.

The relative quality of DP as a decision model depends heavily on the attributes of the underlying calculations. Thus, the degree of realism, resolution, precision, and generality depend on these calculations, and how well they relate to the actual objectives of the decision maker involved. However, the technique is quite flexible and applicable to a broad array of sequential decision problems.

Examples of the application of DP to livestock production include the work by Glen (1983) cited above, which used linear programming to perform calculations over time in addressing problems associated with growing pigs. Also, Dijkhuizen, *et al.* (1985, 1986) employed DP to address livestock replacement questions for dairy cattle and swine,

respectively. These authors use partial budgeting and net present value techniques to perform the underlying calculations.

In summary, budgeting, decision trees, and dynamic programming are analytical decision models that require additional information on physical production if they are to be effectively used to support livestock production decisions. While each technique has individual attributes and limitations, the quality of the decision support provided is very closely tied to the underlying information quality.

Other Production Models

Having recognized the need for a better understanding of livestock production's biological and physical aspects, one group of scientists has endeavored to construct mathematical models which accurately represent the relationships involved. This group is largely composed of animal scientists and agricultural engineers, with scattered input from statisticians, physiologists, economists, and veterinarians. For the most part, the resulting models are solely concerned with production, avoiding the analytical decision questions. Such modeling efforts exist for virtually all livestock species.

In general, biological production models seek to overcome the criticism that other techniques attempt to describe the complex livestock production process with a single, well-behaved mathematical equation. Though stochasticity is not a common ingredient in these biologically-based models, most are calculated over a small enough time period (usually one day) to effectively achieve dynamics. Overall, three primary considerations that affect the relative realism, resolution, generality, precision, and applicability of these models are:

1. the trade-offs between deduction, empiricism, and statistics, as introduced earlier and discussed by Dent (1975), Bywater and Baldwin (1984), and Whittemore (1986),
2. the model's biological focus (such as nutrition, reproduction, or growth/production), and
3. the model's intended use.

Major efforts will be reviewed according to the species being modeled.

Broilers. Reece and Lott (1983) used linear regression to build a statistical model of growth for broilers. The model's limitations arise from predicting body weight solely as a function of age over a range of environmental temperatures. Also, the model depicted a discrete entity (or single animal) without regarding interactions with the remaining population. Consideration of factors such as nutrition, sex, health, and random variation were not included.

Sheep. Orsini and Arnold (1986) presented a more deductive model of growth for grazing sheep. They included some age and nutritional considerations, but fail to address environment, disease, sex, flock, and random variation.

Beef. A similar model for growth of feedlot beef cattle is found in Oltjen, *et al.* (1986). This model sought to explain growth as a function of body type and dietary metabolizable energy. However, again environment, disease, sex, herd, and random variation were not included. Loewer, *et al.* (1983) also used a basic deductive approach to model the growth of feedlot beef cattle. In contrast to Oltjen, *et al.* (1986), this model considered a broader array of nutritional factors (metabolizable energy, digestible protein, and percent dry matter) along with the effects of temperature, humidity, sex, and pregnancy. Still, the model failed to include disease, herd, and random variation.

Dairy. Switching to dairy cattle, Koong, *et al.* (1982) constructed a deductive model for growth and milk production. This model included nutritional nitrogen and energy, giving much attention to metabolism and energy flows. Limitations arose as a result of exclusion of environment, disease, herd, and random variation. Hulme, *et al.* (1986) also considered dietary protein and energy in a more empirical model of dairy production, and sought as well to include the effects of genetic potential and pregnancy. However, once again disease, environment, herd, and random variation were not included.

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Swine. The last class of production models to be reviewed are those for hogs. Quijandria and Robison (1971) have formulated a statistical model of hog growth, regressing weight on age and regressing backfat on both age and weight over a single growth phase between 119 and 154 days of age. The consideration of only a single growth phase prohibited dynamics. In addition, environment, sex, disease, herd, nutrition, and random variation were excluded. Close and Mount (1971) and Verstegen, *et al.* (1973) also used a statistical approach to estimate the relationship between growth and environmental temperature in hogs. In subsequent papers, Close and Mount (1975, 1978), Close, *et al.* (1978), and Close (1978) evaluated growth as a statistical function of environmental temperature and dietary metabolizable energy. Other factors were not considered. Finally, Irvin, *et al.* (1975) also used statistics to model hog growth in relation to dietary protein level and certain genetic factors.

Teter, *et al.* (1973) used a deductive approach, but have also formulated hog growth as a function of environmental temperature and metabolizable energy intake. The deduction was broadened by Bruce and Clark (1979) to include the effects of air velocity, floor type, body weight, and group size along with metabolizable energy and environmental temperature. However, sex, disease, herd, and random variation were still lacking.

Christianson, *et al.* (1982) considered virtually the same factors as Bruce and Clark (1979), but focused on estimating compensatory growth. Moughan (1985) concentrated on the deductive relationship of nutrition to hog growth. Though other factors were not included, their sensitivity analysis indicated that values used for the maximum rate of protein deposition and the energy required for maintenance were extremely critical to the outcome of such production models.

Finally, Whittemore (1983) developed a model of hog growth based partly on deduction and partly on empiricism. Explanatory factors included dietary protein and digestible energy, environmental temperature, floor type, air movements, and hog body

Figure 6

(a) $\log_{10}$ of the number of reads per sample

(b) $\log_{10}$ of the number of reads per sample

(c) $\log_{10}$ of the number of reads per sample

(d) $\log_{10}$ of the number of reads per sample

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type and sex. Though disease, herd, and random variation were excluded, this model is probably the most complete of all those reviewed in its representation of hog growth.

In summary, the models reviewed whose sole focus is the actual livestock production process are quite diverse in their basic approach and in the explanatory factors included. As a result, the relative degree of realism, resolution, precision, generality and applicability that each achieves is highly dependent on the model's intended use.

Computerized Simulation Models

The final type of analytical model to be reviewed for livestock production is computerized simulation. Under its broadest definition, a computerized simulation model is nothing more than computerization of virtually any mathematical model to allow ease of implementation, analysis, and solution. The underlying model can be anything from a simple budget (purely decision) to an extremely complex biological production model (purely production). It can be static or dynamic, and can be deterministic or stochastic.

In this regard, the computer should be viewed only as a tool to assist computation, and the caliber of the simulation's performance should be solely attributed to the quality of the underlying mathematical model. So, once again, the attributes of a computerized simulation model are evaluated by reviewing the attributes and limitations of a given mathematical production or decision model in light of its intended use. However, because of the enormous computational power involved, these computerized simulation models theoretically hold a much greater potential for accurately modeling a complex production or decision process.

Examples of many computerized simulations which have been constructed for livestock production can be found in the literature. In order to structure the process, the following specific categories were evaluated during review:

Nutrition—Does the model consider quantity and/or quality of feed involved?

Environment—Does the model contain environmental effects?

Reproduction—Is reproduction considered?

Disease—Are factors included to account for common diseases?

Time step—How frequently does recalculation occur? This is critical to the model's relative ability to represent dynamic situations.

Stochasticity—Does the model contain random variation?

Aggregation—Does the model focus on the individual or the population? If concern is with discrete individuals, are dynamic interactions within the population considered? If concern is with the aggregate population, is the distribution of individual characteristics maintained?

Sensitivity analysis—Is sensitivity analysis performed?

Decision model—Is the decision model active or passive?

Economics—Does the model contain explicit economics of any type?

Within each of the mentioned categories considerable variation can occur, and the resulting realism, resolution, generality, precision, and applicability will change accordingly. However, the list provides a useful format for at least cursory evaluation of computerized simulation models for livestock production and provides a structure by which the important attributes can be reviewed.

Though the current review will not be exhaustive, most major efforts will be included. For organizational purposes, review of the major features is summarized in Tables 2.1, 2.2, 2.3, and 2.4. Models concerned with broiler, sheep, and beef production have their resolution summarized in Table 2.1 and their realism and applicability are reviewed in Table 2.3. Evaluation of the resolution of models for dairy and swine production can be found in Table 2.2, while their realism and applicability are addressed in Table 2.4.

Within the criteria of realism, resolution, precision, generality, and applicability provided, computerized simulation models offer a valuable contribution both to the management of livestock production and to corresponding research (Lloyd, *et al.*, 1987b). Prospective management changes can be easily evaluated at a relatively small marginal cost. This capability is useful for diagnosis, prediction, and prescription in farm

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Table 2.1 Summary of resolution attributes for computerized simulation models in broilers, sheep and beef cattle production

Author(s)	Nutrition	Environment	Reproduction	Disease
Broilers				
Aho & Timmons, 1985	-	+	NA	-
Sheep				
Meek & Morris, 1981	+	+	NA	+
White, et al., 1983	+	+	+	-
Blackburn & Cartwright, 1987	+	-	+	-
Beef cattle				
Clarke, et al, 1982	+	-	+	-
Levine & Hohenboken, 1981	+	-	+	-
Sere & Doppler, 1981	-	-	-	-
Fox & Black, 1984	+	+	NA	-
Congleton, Jr. & Goodwill, 1980	-	-	+	+
Sanders & Cartwright, 1979	+	-	+	-
Halter & Dean, 1965	+	+	NA	-
Kahn & Spedding, 1983, 1984; Kahn & Lehrer, 1984	+	-	+	-
Forster, et al., 1984	+	-	NA	-
Oltjen, et al., 1986	+	-	NA	-
Johnson & Notter, 1987	-	+	+	-

+ = present; - = absent; NA = not applicable

Table 22. Summary of resolution attributes for computerized simulation models in dairy cattle and swine production

Author(s)	Nutrition	Environment	Reproduction	Disease
Dairy cattle				
Bywater & Dent, 1976; Bywater, 1976	+	-	+	-
Oltenacu, et al, 1980	-	-	+	-
Oltenacu, et al, 1981	-	-	+	-
Lovering & McIsaac, 1981	+	+	-	-
Gartner & Herbert, 1979; Gartner, 1981, 1982a,b	-	-	+	-
Boneschanscher, et al, 1982	-	-	+	-
Forbes, 1983	+	-	-	-
Congleton, Jr, 1984; Congleton, Jr. & King, 1984	+	-	+	+
Arendonk, 1985	+	-	+	-
Brockington, et al, 1983, 1986	+	-	+	-
Swine				
Watt, et al, 1987	+	+	NA	-
Blackie & Dent, 1976	+	-	NA	-
Jolly, et al, 1980	+	-	+	-
Allen & Stewart, 1983	+	-	+	-
Tess, et al, 1983a,b,c	+	-	+	-
McPhee & Macbeth, 1984 Macbeth & McPhee, 1986	+	-	+	-
Singh, 1986	+	-	+	-

+ = present; - = absent; NA = not applicable

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Table 23 Summary of realism and applicability attributes for computerized simulation models in broiler, sheep and beef cattle production

	Time Step (days)	Random variation	Aggre- gation	Sensi- tivity analysis	Decision model	Economics
Broilers						
Aho & Timmons, 1985	?	-	AE	+	P	+
Sheep						
Meek & Morris, 1981	7	+	DE	+	P	+
White, et al, 1983	7	+	DE	+	P	+
Blackburn & Cartwright, 1987	15	-	DE	+	P	-
Beef cattle						
Clarke, et al, 1982	14	-	DE	+	P	+
Levine & Hohenboken, 1981	?	-	DE	+	P	-
Sere & Doppler, 1981	?	-	AE	+	P	+
Fox & Black, 1984	1	-	DE	+	P	-
Congleton, Jr. & Goodwill, 1980	7	-	AE	+	P	-
Sanders & Cartwright, 1979	30	-	AE	-	P	-
Halter & Dean, 1965	?	-	AE	+	P	+
Kahn & Spedding, 1983, 1984; Kahn & Lehrer, 1984	1-30	+	DE	+	P	-
Forster, et al, 1984	1	+	AE	+	P	+
Oltjen, et al, 1986	.01-100	+	DE	+	P	-
Johnson & Notter, 1987	?	+	DE	+	P	-

? = unclear; - = absent; AE = aggregate entity
+ = present; P = passive; DE = discrete entity

Table 24. Summary of realism and applicability attributes for computerized simulation models in dairy cattle production

	Time Step (days)	Random variation	Aggre- gation	Sensi- tivity analysis	Decision model	Economics
Dairy cattle						
Bywater & Dent, 1976; Bywater, 1976	1	-	DE	+	P	-
Oltenacu, et al, 1980	1	+	DE	+	P	-
Oltenacu, et al, 1981	1	+	DE	+	P	+
Lovering & McIsaac, 1981	365	-	AE	+	P	+
Gartner & Herbert, 1979; Gartner, 1981, 1982a,b	365	-	DE	+	P	+
Boneschanscher, et al, 1982	365	-	AE	+	P	+
Forbes, 1983	.0007	-	DE	-	P	-
Congleton, Jr., 1984; Congleton, Jr. & King, 1984	1	+	DE	+	P	+
Arendonk, 1985	?	+	DE	+	P	+
Brockington, et al., 1983, 1986	1	+	DE	+	P	+
Swine						
Watt, et al, 1987	1	-	DE	+	P	+
Blackie & Dent, 1976	?	-	AE	+	P	+
Jolly, et al, 1980	14	-	?	+	A	+
Allen & Stewart, 1983	1	+	DE	+	P	-
Tess, et al, 1983a,b,c	1	-	DE	+	P	+
McPhee & Macbeth, 1984; Macbeth & McPhee, 1986	?	-	?	+	P	+
Singh, 1986	1	+	DE	+	P	+

- = absent; DE = discrete entity; + = present; P = passive
 AE = aggregate entity; ? = unclear; A = active

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management. Further, if models based on current knowledge of the production processes involved fail to predict accurately, effective sensitivity analysis can focus research attention on the areas where existing knowledge is weak.

Because of the computational power involved, use of computers should promote the inclusion of increased realism, resolution, generality, precision, and applicability in production and decision models for livestock agriculture. When coupled with their potential for information management (data entry, storage, and processing and information output), computerized simulations should greatly enhance livestock decision support systems.

SUMMARY

Various information management and analytical modeling techniques have been applied to livestock production. Individual strengths and weaknesses have been discussed. In an attempt to expand upon these strengths and alleviate the weaknesses, a unique decision support system for growing and finishing hogs will be presented in the remaining chapters. The decision support system will emphasize livestock health management.

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CHAPTER 3

INFORMATION MANAGEMENT SYSTEM

INTRODUCTION

As presented in the literature review of Chapter 2, decision support for livestock production requires information on the specific farm of interest and a (set of) mathematical model(s) to analyze its technological aspects in light of decision maker objectives. In an effort to provide such support, this research was undertaken to evaluate the individual usefulness and potential for integration of various information management, systems modeling, and computer simulation techniques when applied to livestock production. The goal is to develop a prototype decision support system for production of growing and finishing hogs with emphasis on animal health management. This chapter describes the portion of the resulting decision support system which corresponds to a more traditional information management system. Both design features and initial data collection results will be included. Successive chapters will discuss analytical model development and results from initial applications of the composite decision support system, respectively.

MATERIALS AND METHODS

Swine Health Information Management System

The specific information management system (IMS) to be described was developed as part of the Swine Health Information Management System (SHIMS). SHIMS was a cooperative research project between the United States Department of Agriculture's Economic Research Service (USDA-ERS) and Michigan State University (MSU) whose main goal was to design a prototype information management system for

swine production with emphasis on health management. The initial project was conducted from July 1, 1985 through June 30, 1988 and enjoyed the additional support (both cooperative and financial) of the USDA's Food Safety and Inspection Service (FSIS), the Michigan Agricultural Experiment Station, the Michigan Cooperative Extension Service, and the Departments of Agricultural Economics, Animal Science, and Large Animal Clinical Sciences at MSU. Specific objectives were to:

- a. design a swine health information management system to monitor disease frequency and assess the effects of disease problems and treatments on swine growth and production costs,
- b. implement the system in cooperation with a sample of swine producers at their places of business, and
- c. monitor the implementation in order to allow assessment of the benefits and costs of the system.

These objectives were to be achieved by collecting relevant data regarding the production, finance, and health of hogs commercially produced in Michigan. Initially, a pilot producer group was to be selected based on willingness to participate. To provide improved statistical capabilities, the pilot phase was to be followed by an expanded sample phase involving 75-80 herds selected by multistage random techniques.

To facilitate pilot group selection, an informational meeting and presentation on SHIMS was held in Battle Creek, Michigan on February 26, 1986. Battle Creek was chosen because of its proximity to the primary hog-producing region of the state. Twelve hog producers were invited to this meeting with SHIMS personnel from MSU. Invitations were issued based on knowledge held by either MSU staff or extension agriculture agents regarding producer attitudes toward progressive production practices, university activities, and cooperation. Of those 12 producers, 6 were interested in voluntary participation, and thus formed the pilot group.

All six members of the SHIMS pilot group produced hogs in farrow-to-finish, total confinement systems. In addition to hogs, two participants had beef cow-calf

enterprises and all six raised feed crops. During the pilot phase, the smallest producer's mean herd size was 125 breeding females, while the largest was 1365. All producers used crates for farrowing, and the number of crates per farm ranged from 24 to 296. Typical of a large proportion of the state's market hog production, SHIMS pilot producers were located in the south-central and southwest regions of Michigan's lower peninsula, including Branch, Jackson, Eaton, and Kalamazoo counties.

Pilot participants were not compensated monetarily, but received the benefits of interaction with university personnel, periodic farm management reports, and quarterly market hog health evaluation at no charge. These aspects provided producer motivation for data collection.

Though the broad array of support attained across academic disciplines and government agencies indicated wide acceptance of the project's goals, it also provided administrative difficulties. Interagency and interdepartmental communication gaps coupled with a certain amount of "disciplinary territoriality" somewhat hindered the project's progress. One direct result is the fact that an expanded sample (75-80 herds) was not attained during the period of the initial project as had been intended. However, most of the administrative hurdles were successfully overcome through concerted efforts toward maintaining adequate communication and promoting a healthy atmosphere of mutual intellectual respect. Without such personal contributions by virtually all project participants, the achievement of any level of success might well have been precluded.

The first step in designing the IMS was to define the data to be collected. For this purpose, the advice and assistance of a broad array of individuals was sought. This was accomplished through formation of an "expert" advisory group consisting of slaughter industry representatives, marketing agents, extension agriculture agents, producer group representatives, and government officials. A summary of the affiliations of those people who have contributed to SHIMS in various capacities appears in Table 3.1

Table 3.1 SHIMS participation in Michigan, 1986 to 1988

Affiliation	Number of people
University	
Direct participants	8
Additional resource people	11
Extension agriculture agents	2
Slaughter industry	8
Producer group representatives	3
Federal government-USDA	8
State government	1
Marketing agents	3
Pilot producers	6
Practicing veterinarians	4
Total	54

Only data thought to be important for monitoring the frequency of disease and in assessing its economic importance to production were considered for collection on SHIMS. Arriving at a precise definition of this body of data was extremely difficult due to two factors: (1) the problems being addressed were multidisciplinary in nature, and (2) the broad array of "experts" provided an equally broad array of implicit research objectives. The multidisciplinary nature of the problems necessitated the broad group of participants, but also resulted in a multiplicity of discipline-related sub-objectives all within the project's broader scope. Though at any specific juncture the scope of the database may have seemed to be very discretely defined, in reality the development was (and continues to be) a dynamic, iterative process.

Figure 3.1 provides an organizational scheme for the SHIMS project. Sources of data are included categorically at the top of the figure. In addition to elucidating the spectrum of data collection, Figure 3.1 also points out the destinations for the resulting information. Once again, it is crucial to note that not only did the IMS support a summary report and an analytical model, but it also provided basis for perpetual system re-evaluation. Feedback from producers and advisory group members has been invaluable in this regard.

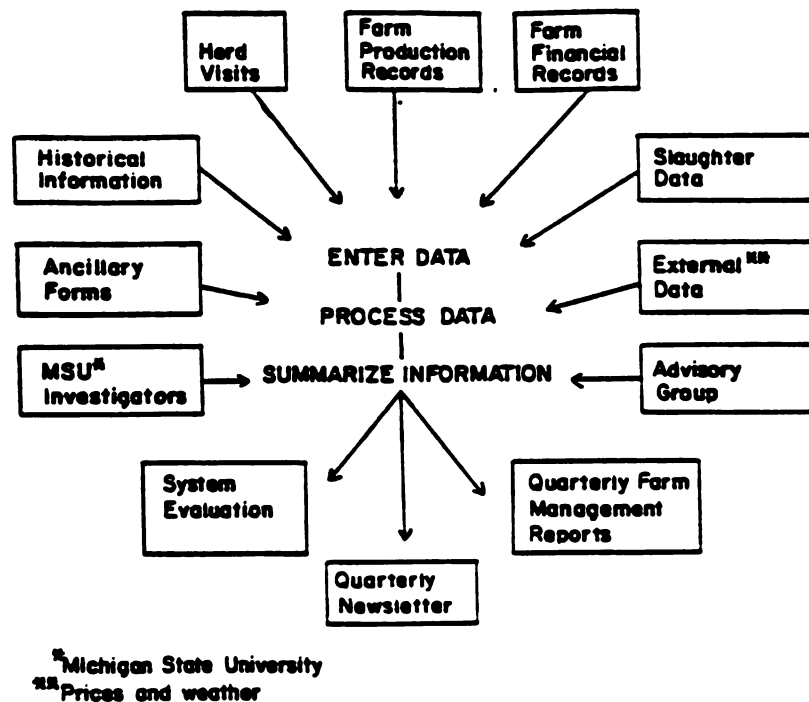


Figure 3.1 SHIMS organizational scheme

On-farm Data Collection

Once the important data were defined, techniques were needed to facilitate both ease and accuracy in collection and processing. Development of the forms to be used involved several steps. First, several existing data collection systems for swine production were examined to discover features desirable for SHIMS. Included in the review were PigCHAMP^c, Swine Graphics^h, Telfarmⁱ, and the Michigan Swine Record-Keeping Project (Schwab and Hogberg, 1983). Useful attributes were then combined and modified in an attempt to meet the specific needs of the SHIMS project. Finally, the resulting collection of modified forms was compared to the predetermined definition of the desired data. Where differences occurred, original forms were designed to fill the voids. The entire body of data collection forms appears in Appendix A. In addition to supporting the project's objectives, specific concerns in their development were: (a) the completeness of the data to be collected, (b) the ease of data collection, (c) the format in which the data were to be collected, and (d) the ease of data processing.

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Once these forms were developed to the satisfaction of SHIMS personnel, they were combined with a producer consent form containing a guarantee of confidentiality and then submitted to the University Committee for Research Involving Human Subjects at MSU. Approval of the project and its data collection forms was achieved from the committee following initial submission; no changes were requested, nor was pretesting required.

Data regarding general management practices, historical disease problems, current herd observations, nutrition, and facilities were obtained on an initial farm visit by MSU personnel. Since this required walking through all swine facilities, extreme caution was exercised to maintain the highest possible disease control standards. Including travel, interview, facility tour (with herd observation), and attending discussion, these visits generally consumed a total of 6 to 8 hours per farm.

Following the farm visit, SHIMS producers initiated data collection in the areas of physical production, marketing, feed usage, death losses, and production expenses according to the respective data collection forms presented in Appendix A. For the pilot group, the exact techniques employed varied by producer according to individual record systems which may have already been in place. SHIMS forms were used where other systems were not employed, but flexibility was maintained to minimize double recording by SHIMS producers. As a result, the mechanics by which these data were supplied to MSU personnel varied between producers according to time schedules and data formats.

The primary strength of SHIMS on-farm data collection centers on the comprehensive, well-structured approach to production. The system combines aspects of facility description, physical productivity, and economics in a single database, reflecting the multiple disciplines involved.

However, some notable limitations exist regarding certain areas of excessive data, other data insufficiencies, and a few weaknesses in collection technique. Since the goals of the SHIMS project focus solely on the health and production of market hogs,

data regarding other aspects of swine production are probably excessive. While the importance of breeding herd and preweaning management is readily acknowledged, its immediate relevance to the health and productivity of growing/finishing pigs is limited. Maintenance of these extra data has definite potential benefits for producers and might prove useful to researchers at some future point, but the associated collection efforts tend to jeopardize the quality and quantity of the remaining data, which are more important to the immediate SHIMS goals.

On the other hand, thorough economic evaluation of grow/finish hog health management should probably encompass several potentially relevant areas not included in the SHIMS database. These include the firm's debt load and cash flow characteristics, clinical animal health observations (antemortem and on-farm), further subclinical observations (through subsampling and laboratory testing), and description of the micro environments of the growing pigs involved. Because of limitations in data collection resources and capabilities, these admittedly important factors have necessarily been excluded from SHIMS.

Finally, technique flexibility is an integral part of a pilot data collection project, but each additional data format and submission routine represents considerable added entry/processing effort. Further, structured techniques for periodic update of descriptive data need to be developed. These would capture any potentially important changes in facilities and/or management.

Off-farm Data Collection

Sources of SHIMS data also existed outside the farm (see Figure 3.1). The first of these is "External Data" and refers to time series data sets of importance to hog production, but maintained independently from SHIMS. Included in this category are weather and price data. These data can be retrieved from the National Weather Service and the USDA if warranted by future analyses.

The other major, off-farm data are obtained through postmortem health evaluations. Of primary concern are the so-called "production diseases," which are rarely

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evident clinically, but are generally thought to have major effects on production efficiency. The presence or absence of these diseases by degree of severity is noted at slaughter and is then included in the database. Table 32 provides a description of the categories used for SHIMS.

Development of the technical aspects of data collection at slaughter was a two-stage process. Initially, a slaughter health check (SHC) was conducted for the sole purpose of evaluating potential data collection procedures. After this was complete, the techniques required refinement before application to SHIMS pilot herds. Conducted on November 5, 1985, the initial SHC involved a group of 12 hog producers selected only because they were interested in the health status of their slaughter hogs, and not based on a special potential for eventual SHIMS pilot herd status. As a result of this "trial run," the importance of maintaining the regular marketing channels of potential SHIMS producers became apparent. Several producers in this first group (whose usual marketing patterns were disrupted by the slaughter check) were not content with the prices they received for their hogs, and as a result expressed hesitation about future participation.

Thus, an integral part of the SHC technique modification was to maintain producer satisfaction with market price by following hogs through their routine marketing channels. This involved:

1. establishing communication with intermediate hog marketing agents (since only 15-20% of hogs produced in Michigan are marketed directly to slaughter),
2. gaining approval from a wider array of slaughter plants, some of which were not previously accustomed to SHCs, and
3. development of SHC evaluation techniques to accommodate successful data collection at high processing line speeds.

High speed capabilities were necessary because a large proportion of the slaughter hogs

Table 32. SHIMS disease classification at slaughter, Michigan, 1985 to 1988

Category	Score	Description
Pneumonia		Percent of total lung volume involved
None	0	0
Mild	1	1-9
Moderate	2	10-19
Severe	3	20+
Ascariasis		Number of scars on diaphragmatic surface
None	0	0
Mild	1	1-5
Moderate	2	6-10
Severe	3	11+
Mange		Location of papules
None	0	absent
Mild	1	axillary/inguinal
Moderate	2	diffuse ventral
Severe	3	entire carcass
Atrophic Rhinitis		Average size of ventral nasal meatus in millimeters
None	0	<5
Mild	1	6-7
Moderate	2	8-9
Severe	3	10+
Pleuritis		Degree of pleuritis
Absent	0	none
Present	1	any
Pericarditis		Degree of pericarditis
Absent	0	none
Present	1	any
Nasal septum deviation		Degree of nasal septum deviation
Absent	0	none
Present	1	any

produced in Michigan are normally processed in high speed slaughter facilities (line speeds in excess of 1000 hogs per hour).

The slaughter facilities involved in the pilot phase of the SHIMS project are descriptively listed in Table 3.3. As discussed, these plants were selected based the usual marketing patterns of the SHIMS pilot producer group. Though eventual cooperation was excellent in all plants, initial participation was offered with considerable hesitation in those plants unaccustomed to routine SHCs. Based on the volatility of the retail pork markets, resulting from recent chemical residue and bacterial contamination issues, and in light of the large financial losses which would be associated with virtually any disruption of routine processing procedures on high-speed lines, this initial hesitation was entirely understandable. Management personnel in these plants warrant commendation for being willing to take a chance and contribute to this research project in an attempt to benefit the entire industry. At the same time, any researchers potentially involved in similar efforts need to continually recognize and respect the risks that slaughter plant management assumes when their participation is offered.

During the pilot phase, SHCs were completed four times per year for each SHIMS producer. For organizational purposes, calendar years were divided into four quarters: January to March, April to June, July to September, and October to December. Within each quarter, market hogs were selected based on both the normal marketing schedule of individual producers and administrative convenience for MSU personnel conducting the postmortem evaluations. Once a workable date was identified for a given producer, as many of the hogs marketed on that day were evaluated as was technically feasible. Total size of groups evaluated during the pilot phase ranged (approximately) from 60 to 400 hogs. In general, the technical limitations occurred in three areas: marketing coordination, hog identification, and actual postmortem evaluation.

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Table 3.3. Participating SHIMS slaughter facilities, 1985 to 1988

Name	Location	Approximate Processing Speed
		(pigs per hour)
Utica Packing Company	Utica, Michigan	1000+
Thornapple Valley, Inc. Frederick Division	Detroit, Michigan	1000+
Dinner Bell Foods, Inc.	Troy, Ohio	350+
Wilson Foods, Inc.	Logansport, Indiana	350+

The usual SHC activity sequence follows.

1. The producer was contacted to establish acceptable market date and to request that hogs be tattooed.
2. If hogs were not marketed directly to the slaughter plant, the marketing agent was contacted to:
 - a. confirm the acceptability of date,
 - b. ascertain location of slaughter (given producer and date), and
 - c. arrange the time of arrival for hogs at slaughter plant.
3. The slaughter plant was contacted to confirm acceptability of date and time with hog buyers and management.
4. USDA-FSIS inspectors were contacted to confirm acceptability of date and time.
5. MSU personnel traveled to plant and conducted SHC.
6. SHC findings were summarized and the report was sent to:
 - a. the producer,
 - b. the producer's veterinarian,
 - c. the producer's extension agent, and
 - d. USDA-FSIS personnel.

When possible, hogs from two producers were combined on the same day to decrease total travel time required by MSU personnel. However, such combinations effectively increased the difficulty of coordination, since not only did producer market schedules need to mesh, but also the types/weights of hogs marketed needed to be similar to permit marketing at the same plant. Again, because pilot producers were not compensated for their participation, it was extremely important that routine marketing procedures be followed, so that neither a lower market price nor any other disruption of established market conditions could be associated with the SHCs of SHIMS. The excellent cooperation and support of marketing and slaughter plant personnel has been vital to coordination in this regard.

The proportion of a producer's hogs identifiable at slaughter directly affected the scope of SHC which was possible on any given occasion. Identification problems were found to hold serious potential for limiting data collection. For instance, sometimes as few as 20% of the desired hogs were definitively identifiable at slaughter. These problems were more common during the first two quarters of data collection, when maintenance of discrete hog groups by producer was essential due to absence of tattoos. To minimize such difficulties, the cooperation and support of marketing and slaughter plant personnel again provided invaluable contributions. From the third quarter of data collection until the end of the project, SHIMS market hogs leaving the farm for slaughter and subsequent health check received a back-slap tattoo to facilitate identification. Tattoo hammers were provided as part of a hog identification trial funded by the National Pork Producers Council (Thulin, *et al.*, 1988). These tattoos eliminated large scale identification problems. However, grouping hogs still made data collection easier due to the high-speeds at which processing occurred.

It is important to note at this point that the techniques available for identification coupled with the high-speed processing precluded individual hog identification. Therefore, use of disease rates (specific point prevalences), rather than individual hog disease conditions was mandatory.

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The stage of processing where health status of the viscera, carcass, and head were evaluated at slaughter depended on individual plant characteristics. These are summarized along with the possibilities of concurrent observations in Table 3.4. Also, SHC personnel requirements varied from plant to plant. These are summarized in Table 3.5.

Table 3.4 Stage of processing and possible concurrence for SHIMS slaughter health check observations, 1985 to 1988

Observation	Processing Plants			
	Utica Packing	Thornapple Valley	Dinner Bell Foods	Wilson Foods
Site of evaluation^a				
Viscera	PF	PF	PF	PF
Carcass	C or PF	C or PF	PF	C or PF
Head	C	C	PF	PF
Possible concurrent observations				
Viscera and carcass	yes	yes	yes	yes
Head and carcass	yes	yes	no	no
Head and viscera	no	no	no	no

^aC = cooler, PF = processing floor

In all plants, the condition of the viscera was evaluated at the processing floor's viscera tray following FSIS inspection. Pneumonia and ascariasis were the primary focus of this observation. However, other conditions normally noted by FSIS were also recorded at this point, including abscess, pleuritis, pericarditis, and peritonitis. Due to line speeds, two persons were often required at the viscera tray, one to observe pathology and one to record the observations. Even with two people, it often became necessary to skip some animals in order to keep up, though this occurred as infrequently as possible. Stopping the processing line to permit SHIMS data collection was never considered as an option and never occurred. Finally, comprehensive evaluation of the viscera usually required physical manipulation. To prevent cross-contamination of "clean" viscera, extreme care was always taken to avoid direct contact with those that had been condemned by FSIS inspectors. This also resulted in skipping of some animals,

Table 3.5. SHIMS personnel requirements per slaughter health check, 1985 to 1988

Observation	<u>Processing Plants</u>			
	Utica Packing	Thornapple Valley	Dinner Bell Foods	Wilson Foods
Personnel required (people)				
Viscera	2	2	1	1
Carcass	1	1	1	1
Head	1	1	1	1
Time required (hours)^a				
Viscera	0.25	0.25	0.75	0.75
Carcass	0.25	0.25	0.25	0.25
Head	1.50	1.50	1.50	1.50
Total personnel requirement (person-hours)^b	2.00-2.75	2.00-2.25	2.25-3.00	2.25-3.00

^aDoes not include travel or in-plant organizational times^bDepends on presence or absence of concurrent observations

since observation without manipulation was not always possible, and high speed processing provided insufficient time for hand washing between hogs.

Evaluation of the carcass for mange took place either on the processing line (by a person other than the one or two working at the viscera tray) or in the cooler (where it was often accomplished by the same people that evaluated viscera). Here again, other conditions normally diagnosed by FSIS, such as arthritis and abscess, were also recorded.

Observation of the head for atrophic rhinitis occurred in the cooler at some plants and on the processing floor at others. Before evaluation, transverse section of the snout was necessary at the level of the first cheek tooth. Slaughter plant management and employees provided assistance in this regard by either modifying the normal processing sequence of the head or by temporarily leaving a partial empty rail next to SHIMS hogs in the cooler, depending on individual plant variations. Such assistance was critical to successful observation. As a result, the number of hogs available for evaluation of atrophic rhinitis was determined either by the number of heads diverted from routine processing or by the extra cooler space available, respectively.

Recording of data at slaughter generally utilized the forms contained in Appendix B. Occasionally, however, SHIMS personnel shortages required the use of voice recording devices. While the background noise in the slaughter plants involved with SHIMS was substantial, attachment of a clip-on microphone to the shirt collar made it possible for a single person to achieve both successful observation and recording. Depending on the total number of hogs evaluated, the particular slaughter plant, and the number of SHIMS people involved, a typical SHC required 1.75 to 3.0 hours, excluding travel.

The main strengths of SHIMS data collection at slaughter center on the techniques developed to reliably follow hogs through routine marketing channels. Especially in regions such as Michigan where only a relatively small proportion of hogs are marketed directly to slaughter, the capability to perform SHCs without disrupting normal market activities is critical to gaining industry acceptance. The willingness of virtually all market participants to cooperate is most notable. Further, the ability to observe and record the postmortem condition of hog health at the rate of over 1000 hogs per hour is important.

Limitations of the methods used are also closely related to marketing channels. As mentioned, individual hog identification is not possible with the SHC system described. Though disease rates provide useful information, procurement of data on disease conditions of individual hogs would markedly increase the number of available individual observations, thereby greatly increasing the potential for meaningful scientific inference. Further, the locations of the slaughter plant array made the required travel time quite substantial, which might tend to diminish the practicality of routine, individual producer SHCs according to the scheme presented.

Computerized Database

Using the on- and off-farm data collection forms as templates, a computerized database was designed and programmed for data management. Since the amount of data to be collected for each farm was relatively large, and in anticipation of an eventual

SHIMS sample size of 75 to 80 farms, a mainframe database management system was selected. Computer software used was the NOMAD2^j database manager by Dunn and Bradstreet. Appendix C contains details of the file structures contained within the database. Data entry and processing were performed by MSU personnel.

To provide the information obtained on current production status to producers, their veterinarians, and their extension agents, a useful format for output was needed. Again, the advisory group provided valuable input on both the desired content and format for the periodic farm management reports. An example of the report appears in Appendix D and exposition of the calculations involved appears in Table 3.6.

Because of its research focus, the IMS was initially developed on a mainframe computer to facilitate handling of a relatively large database by a group of researchers (most notably for between-farm comparisons and to allow statistical analysis). However, a parallel version of the IMS is being programmed in DBASE III+ (Ashton-Tate)^k for use on IBM-compatible microcomputers. While development of this system, called the MSU Swine Record System, lags behind that on the mainframe, current intent is to generate a virtually identical system with equivalent ability for describing the current status of production and supporting a subsequent analytical model.

The main strength of the database and farm management report is the assembly of biological, physical, and financial production information in a single location. However, since the SHIMS project was intended to focus on health management, many facets of these three areas of production were probably not included at the level of detail needed for adequate production management in its broadest sense. Further, the strict quarterly report format is not frequent enough for some production parameters or types of production, but may be too often for others. For example, a continuously farrowing operation running on a 14 day schedule might need monthly reports to effectively maintain current knowledge of production, while one- and two-litter pasture operations might be adequately served at 6-month or yearly intervals. Greater flexibility in this regard is being developed in the microcomputer version.

Table 3.6. SHIMS farm management report calculations, 1986 to 1988

Underlying Calculations

Average inventory =

$$\frac{(\text{sum of all inventories for phase(s) over period})}{\text{total number of inventories taken over period}}$$

Gilts saved = (ending total female inventory for period) – (beginning total female inventory for period) + (total cull sows sold during period) + (total sow deaths during period) + (total bred gilts sold during period) + (total open gilts sold during period) – (total open gilts purchased during period) – (total bred gilts purchased during period)

Total hogs leaving finisher = (total number of market hogs sold during period) + (total number of underweight market hogs sold during period) + (total number of gilts saved during period) + (total number of hogs consumed during period)

Rolling quarterly average^a =

$$\frac{(\text{same calculation as quarterly but over up to four quarters})}{\text{total number of quarters included}}$$

Reproductive Efficiency Measures

Pounds marketable pork produced

per quarter = (total ending inventory weight for quarter) – (total beginning inventory weight for quarter) + (total weight sold) + (total weight consumed during quarter) – (total weight purchased during quarter)

per female =

$$\frac{\text{pounds marketable pork produced per quarter}}{\text{average total female inventory for quarter}}$$

per litter =

$$\frac{\text{pounds marketable pork produced per quarter}}{\text{total number of litters farrowed during quarter}}$$

Pigs produced

per quarter = (total ending inventory for quarter) – (total beginning inventory for quarter) + (total number sold during quarter) + (total number consumed during quarter) – (total number purchased during quarter)

per female =

$$\frac{\text{pigs produced per quarter}}{\text{average total female inventory for quarter}}$$

per litter =

$$\frac{\text{pigs produced per quarter}}{\text{total number of litters farrowed during quarter}}$$

^a Only calculated if producer's data exist for at least two quarters

Table 3.6. continued

Pigs born

per quarter = total pigs born during quarter

per female =

pigs born per quarter
average total female inventory for quarter

per litter =

pigs born per quarter
total number of litters farrowed during quarter

Pigs born live

per quarter = total live born during quarter

per female =

pigs born live per quarter
average total female inventory for quarter

per litter =

pigs born live per quarter
total number of litters farrowed during quarter

Pigs weaned

per quarter = total pigs weaned during quarter

per female =

pigs weaned per quarter
average total female inventory for quarter

per litter =

pigs weaned per quarter
total number of litters farrowed during quarter

Litters weaned

per quarter = total litters weaned during quarter

per female =

litters weaned per quarter
average female inventory for quarter

Female/boar ratio =

average total female inventory for quarter
average total boar inventory for quarter

Table 3.6. continued

Efficiency in Feed Usage**Lactation**

total pounds fed = total pounds lactation ration(s) fed during quarter

average pounds/female/day =

$$\frac{\text{total pounds lactation ration(s) fed during quarter}}{(\text{average lactation inventory for quarter}) * (\text{total number of days in quarter})}$$

Gestation

total pounds fed = total pounds gestation ration(s) fed during quarter

average pounds/female/day =

$$\frac{\text{total pounds gestation ration(s) fed during quarter}}{(\text{average gestation inventory for quarter}) * (\text{total number of days in quarter})}$$

Starter

total pounds fed = total pounds starter ration(s) fed during quarter

average pounds/pig/day =

$$\frac{\text{total pounds starter ration(s) fed during quarter}}{(\text{average preweaned inventory for quarter}) * (\text{total number of days in quarter})}$$

Nursery

total pounds fed = total pounds nursery ration(s) fed during quarter

average pounds/pig/day =

$$\frac{\text{total pounds nursery ration(s) fed during quarter}}{(\text{average nursery inventory for quarter}) * (\text{total number of days in quarter})}$$

Grower

total pounds fed = total pounds grower ration(s) fed during quarter

average pounds/pig/day =

$$\frac{\text{total pounds grower ration(s) fed during quarter}}{(\text{average grower inventory for quarter}) * (\text{total number of days in quarter})}$$

Finisher

total pounds fed = total pounds finisher ration(s) fed during quarter

average pounds/pig/day =

$$\frac{\text{total pounds finisher ration(s) fed during quarter}}{(\text{average finisher inventory for quarter}) * (\text{total number of days in quarter})}$$

Table 3.6. continued

Efficiency in Facility Usage

Litters farrowed/crate =

$$\frac{\text{total number of litters farrowed during quarter}}{\text{total number of farrowing crates}}$$

Pigs weaned/crate =

$$\frac{\text{total number of pigs weaned during quarter}}{\text{total number of farrowing crates}}$$

Nursery turnover =

$$\frac{\text{total number of pigs weaned during quarter}}{\text{total nursery capacity}}$$

Grower to finisher turnover =

$$\frac{\text{total hogs leaving finisher during quarter}}{(\text{total grower capacity}) + (\text{total finisher capacity})}$$

Marketing Measures**Market hogs sold**

number sold = total number market hogs sold during quarter

average market weight =

$$\frac{\text{total pounds market hogs sold during quarter}}{\text{total number market hogs sold during quarter}}$$

sales price per cwt =

$$\frac{(\text{total gross dollar receipts from market hog sales during quarter})}{(\text{total pounds market hogs sold during quarter}) * 100}$$

marketing costs per cwt =

$$\frac{(\text{total marketing costs for market hog sales during quarter})}{(\text{total pounds market hogs sold during quarter}) * 100}$$

Feeder pigs sold

number sold = total number feeder pigs sold during quarter

average market weight =

$$\frac{\text{total pounds feeder pigs sold during quarter}}{\text{total number feeder pigs sold during quarter}}$$

sales price per cwt =

$$\frac{(\text{total gross dollar receipts from feeder pig sales during quarter})}{(\text{total pounds feeder pigs sold during quarter}) * 100}$$

marketing costs per cwt =

$$\frac{(\text{total marketing costs for feeder pig sales during quarter})}{(\text{total pounds feeder pigs sold during quarter}) * 100}$$

Table 3.6 continued

Underweight market hogs sold^b

number sold = total number underweight market hogs sold during quarter

average market weight =

$$\frac{\text{total pounds underweight market hogs sold during quarter}}{\text{total number underweight market hogs sold during quarter}}$$

sales price per cwt =

$$\frac{(\text{total gross dollar receipts from underweight market hog sales during quarter})}{(\text{total pounds underweight market hogs sold during quarter})} * 100$$

marketing costs per cwt =

$$\frac{(\text{total marketing costs for underweight market hog sales during quarter})}{(\text{total pounds underweight market hogs sold during quarter})} * 100$$

Cull sows sold

number sold = total number cull sows sold during quarter

average market weight =

$$\frac{\text{total pounds cull sows sold during quarter}}{\text{total number cull sows sold during quarter}}$$

sales price per cwt =

$$\frac{(\text{total gross dollar receipts from cull sow sales during quarter})}{(\text{total pounds cull sows sold during quarter})} * 100$$

marketing costs per cwt =

$$\frac{(\text{total marketing costs for cull sow sales during quarter})}{(\text{total pounds cull sows sold during quarter})} * 100$$

Cull boars sold

number sold = total number cull boars sold during quarter

average market weight =

$$\frac{\text{total pounds cull boars sold during quarter}}{\text{total number cull boars sold during quarter}}$$

sales price per cwt =

$$\frac{(\text{total gross dollar receipts from cull boar sales during quarter})}{(\text{total pounds cull boars sold during quarter})} * 100$$

marketing costs per cwt =

$$\frac{(\text{total marketing costs for cull boar sales during quarter})}{(\text{total pounds cull boars sold during quarter})} * 100$$

^b Underweight was either as defined by producers or less than 200 pounds

Table 3.6. continued

Boars sold for replacement

number sold = total number boars sold for replacement during quarter

average market weight =

$$\frac{\text{total pounds boars sold for replacement during quarter}}{\text{total number boars sold for replacement during quarter}}$$

sales price per cwt =

$$\frac{(\text{total gross dollar receipts from boars sold for replacement during quarter})}{(\text{total pounds boars sold for replacement during quarter}) * 100}$$

marketing costs per cwt =

$$\frac{(\text{total marketing costs for boars sold for replacement during quarter})}{(\text{total pounds boars sold for replacement during quarter}) * 100}$$

Open gilts sold for replacement

number sold = total number open gilts sold for replacement during quarter

average market weight =

$$\frac{\text{total pounds open gilts sold for replacement during quarter}}{\text{total number open gilts sold for replacement during quarter}}$$

sales price per cwt =

$$\frac{(\text{total gross dollar receipts from open gilts sold for replacement during quarter})}{(\text{total pounds open gilts sold for replacement during quarter}) * 100}$$

marketing costs per cwt =

$$\frac{(\text{total marketing costs for open gilts sold for replacement during quarter})}{(\text{total pounds open gilts sold for replacement during quarter}) * 100}$$

Bred gilts sold for replacement

number sold = total number bred gilts sold for replacement during quarter

average market weight =

$$\frac{\text{total pounds bred gilts sold for replacement during quarter}}{\text{total number bred gilts sold for replacement during quarter}}$$

sales price per cwt =

$$\frac{(\text{total gross dollar receipts from bred gilts sold for replacement during quarter})}{(\text{total pounds bred gilts sold for replacement during quarter}) * 100}$$

marketing costs per cwt =

$$\frac{(\text{total marketing costs for bred gilts sold for replacement during quarter})}{(\text{total pounds bred gilts sold for replacement during quarter}) * 100}$$

Table 3.6. continued

Cash Expenses Per Cwt Pork

Purchased feed expense =	$\frac{(\text{total purchased feed expense during quarter})}{(\text{total pounds marketable pork produced during quarter}) * 100}$
Repairs and maintenance expense =	$\frac{(\text{total repairs and maintenance expense during quarter})}{(\text{total pounds marketable pork produced during quarter}) * 100}$
Veterinary care and drugs expense =	$\frac{(\text{total veterinary care and drugs expense during quarter})}{(\text{total pounds marketable pork produced during quarter}) * 100}$
Labor expense =	$\frac{(\text{total labor expense during quarter})}{(\text{total pounds marketable pork produced during quarter}) * 100}$
Supplies expense =	$\frac{(\text{total supplies expense during quarter})}{(\text{total pounds marketable pork produced during quarter}) * 100}$
Fuel expense =	$\frac{(\text{total fuel expense during quarter})}{(\text{total pounds marketable pork produced during quarter}) * 100}$
Electricity expense =	$\frac{(\text{total electricity expense during quarter})}{(\text{total pounds marketable pork produced during quarter}) * 100}$
Telephone expense =	$\frac{(\text{total telephone expense during quarter})}{(\text{total pounds marketable pork produced during quarter}) * 100}$
Trucking expense =	$\frac{(\text{total trucking expense during quarter})}{(\text{total pounds marketable pork produced during quarter}) * 100}$
Marketing expense =	$\frac{(\text{total marketing expense during quarter})}{(\text{total pounds marketable pork produced during quarter}) * 100}$
Insurance expense =	$\frac{(\text{total insurance expense during quarter})}{(\text{total pounds marketable pork produced during quarter}) * 100}$
Interest expense =	$\frac{(\text{total interest expense during quarter})}{(\text{total pounds marketable pork produced during quarter}) * 100}$
Taxes expense =	$\frac{(\text{total taxes expense during quarter})}{(\text{total pounds marketable pork produced during quarter}) * 100}$

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Table 3.6 continued

Replacement females expense =

$$\frac{(\text{total replacement females expense during quarter})}{(\text{total pounds marketable pork produced during quarter})} * 100$$

Replacement boars expense =

$$\frac{(\text{total replacement boars expense during quarter})}{(\text{total pounds marketable pork produced during quarter})} * 100$$

Other cash expenses =

$$\frac{(\text{total other cash expenses during quarter})}{(\text{total pounds marketable pork produced during quarter})} * 100$$

Disease Rates

Specific point prevalences (percent) =

$$\frac{(\text{total number of diseased hogs at slaughter by category}) * 100}{\text{total number of hogs evaluated at slaughter by category}}$$

Pig Mortality Summary

Stillborn percent =

$$\frac{(\text{number of stillborns during quarter}) * 100}{(\text{total pigs born during quarter})}$$

Mummies percent =

$$\frac{(\text{number of mummies during quarter}) * 100}{(\text{total pigs born during quarter})}$$

Preweaned pig deaths percent^c =

$$\frac{(\text{number of preweaned pig deaths by reason during quarter} / 3) * 100}{(\text{average preweaned pig inventory for quarter})}$$

Prenursery weaned pig deaths percent^c =

$$\frac{(\text{number of prenursery weaned pig deaths by reason during quarter} / 3) * 100}{(\text{average prenursery weaned pig inventory for quarter})}$$

Nursery pig deaths percent^c =

$$\frac{(\text{number of nursery pig deaths by reason during quarter} / 3) * 100}{(\text{average nursery pig inventory for quarter})}$$

Grower pig deaths percent^c =

$$\frac{(\text{number of grower pig deaths by reason during quarter} / 3) * 100}{(\text{average grower pig inventory for quarter})}$$

Finisher pig deaths percent^c =

$$\frac{(\text{number of finisher pig deaths by reason during quarter} / 3) * 100}{(\text{average finisher pig inventory for quarter})}$$

^c Monthly deaths as percent of average inventory

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Table 3.6 continued

Breeding Herd Removals**Sow culls percent^c =**

$$\frac{(\text{total sow culls during quarter} / 3) * 100}{(\text{average total female inventory for quarter})}$$

Sow deaths percent^c =

$$\frac{(\text{total sow deaths during quarter} / 3) * 100}{(\text{average total female inventory for quarter})}$$

Boar culls percent^c =

$$\frac{(\text{total boar culls during quarter} / 3) * 100}{(\text{average boar inventory for quarter})}$$

Boar deaths percent^c =

$$\frac{(\text{total boar deaths during quarter} / 3) * 100}{(\text{average boar inventory for quarter})}$$

Sow cull summary percent^d =

$$\frac{(\text{total sow culls by reason during quarter}) * 100}{(\text{total sows culled during quarter})}$$

Sow death summary percent^e =

$$\frac{(\text{total sow deaths by reason during quarter}) * 100}{(\text{total sow deaths during quarter})}$$

Summary Table—Annual Measures^f**Pigs born per sow per year =**

$$(\text{rolling quarterly average for pigs born per sow per quarter}) * 4$$

Pigs born live per sow per year =

$$(\text{rolling quarterly average for pigs born live per sow per quarter}) * 4$$

Pigs weaned per sow per year =

$$(\text{rolling quarterly average for pigs weaned per sow per quarter}) * 4$$

Pigs produced per sow per year =

$$(\text{rolling quarterly average for pigs produced per sow per quarter}) * 4$$

Pounds marketable pork per sow per year =

$$(\text{rolling quarterly average for pounds marketable pork per sow per quarter}) * 4$$

Litters weaned per sow per year =

$$(\text{rolling quarterly average for litters weaned per sow per quarter}) * 4$$

^c Monthly deaths as percent of average inventory^d Percent of total sow culls^e Percent of total sow deaths^f Only calculated if producer's data exist for at least two quarters

Table 3.6. continued

Pigs produced per crate per year =

$$\frac{(\text{rolling quarterly average for pigs produced per quarter}) * 4}{(\text{total number of crates})}$$

Annual nursery turnover =

$$(\text{rolling quarterly average for nursery turnover}) * 4$$

Annual grow-finish turnover =

$$(\text{rolling quarterly average for grow-finish turnover}) * 4$$

Whole farm feed efficiency =

$$\frac{(\text{total pounds feed fed during year})}{(\text{total pounds marketable pork produced during year})}$$

RESULTS AND DISCUSSION

Producer Attitudes

Slaughter Health Checks. Pilot producers responded very positively to SHIMS slaughter health checks and were generally eager to receive the resulting reports. The positive attitude even included an interest in broadening the scope of SHC to encompass chemical residue evaluation, which somewhat surprised Michigan State University personnel. Though not included on the pilot phase due to potential problems with confidentiality, residue evaluation remains a serious candidate for inclusion in future studies. Producers also provided valuable assistance when making necessary SHC arrangements, including gaining initial access to particular slaughter plants. This assistance, however, was contingent on the maintenance of routine marketing channels.

Hesitation to SHC was only encountered when introducing the tattoo technique, where concern was expressed with the disruption of usual hog sorting/loading sequences and the possibility of over-exciting the hogs involved. However, these concerns failed to materialize into any real problems, except for one producer, who talked his marketing cooperative into applying the tattoos when the hogs were unloaded, rather than doing it himself at sorting/loading. Hog identification was not appreciably affected.

On-farm Data Collection. Unfortunately, SHIMS pilot producers were not nearly as enthusiastic when supplying their on-farm data as when arranging SHCs. As a result,

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the data obtained was often incomplete and/or very late. Over the pilot project's two-year course, only one producer provided all the on-farm data requested, and then some of it was as much as a year old when obtained. Another producer provided data for the entire period, but was up to two years late and did not include any data on feed usage. One producer provided complete data for seven of eight quarters, but was up to one year late. Still another producer was religiously punctual, but only provided data from seven of eight quarters and these lacked feed usage. Finally, two producers failed to provide even one complete quarter of data.

Within the set of on-farm data that was provided, wide variation existed in the format in which data were made available to MSU. Some of the SHIMS data collection forms were used unchanged, while some were modified by individual producers to meet their own perceived management needs. Also, some data were provided electronically. Theoretically, this approach is appealing, but in reality the formats employed again varied widely. These included producer-programmed spreadsheets, PigCHAMP^c (both versions 1.2 and 2.1), and Telfarmⁱ. Because of this substantial format variability, much revision and modification was required to achieve compatibility with the SHIMS database.

These problems with on-farm data collection were severe enough to be fatal if encountered during a full-scale research project. However, as a pilot project, SHIMS is fortunate to have the opportunity to make substantial changes. Such changes are specifically discussed in Chapter 6, and are critical to the success of future efforts.

Reports. As mentioned, SHIMS pilot producers were generally eager to receive their SHC reports. How this information was used is uncertain, since the project's aim was merely to implement the information management system, and not to recommend management changes based on the information provided. Judging from the positive producer responses, however, the content and format of the reports (see Appendix D) was quite acceptable. These responses were elicited informally during telephone conversations and other personal communications. In general, all six pilot producers

expressed marked interest in the prevalence of disease in their market hogs, especially the changes in prevalence over time. Other specific responses included concern with persistent disease levels over time, association of uncharacteristically high levels with environmental and/or weather factors, and association of decreasing prevalence with particular health management practices. Also, producers frequently posed the question, "Now that we know how much disease I have, how much is it costing me?" Responses such as these indicate an implicit satisfaction with content and format.

Since problems existed in the on-farm data collection process, complete quarterly farm management reports were sporadic and producer response to these reports was therefore more difficult to assess. When provided, the reports were often very late or markedly incomplete. However, the historical calculation "Rolling Quarterly Average" (see Table 3.6 for computation) and the current SHIMS average were included partly as a result of producer requests. Also, producers suggested inclusion of information regarding the entire range of production values characteristic of other SHIMS producers. Thus, even though substantial management differences occur both over time and between farms, SHIMS pilot producers were definitely interested in having comparative production information at their disposal to complement information regarding their own current status.

Diseases at Slaughter

Data Summary. A summary of the pilot project SHCs appears in Table 3.7. A similar format to that presented was used when reports were provided following individual SHCs. Notice that the total number of hogs evaluated was dependent upon the disease category being considered. This was due to a combination of identification problems and high processing line speeds. As discussed, not all hogs were identifiable at slaughter, and some were identified but not evaluated because the high processing rate often precluded comprehensive pathology evaluation. Also, condemned viscera were often unobservable for pneumonia and/or ascariasis, but these hogs were readily evaluated for atrophic rhinitis and/or mange. Since the within-plant locations of

Table 37. SHIMS pilot herd slaughter health check summary, 1986 to 1988

Description	Number of Pigs	Percent
Pneumonia		
None	1534	29.12
Mild	2707	51.39
Moderate	612	11.62
Severe	415	7.88
Total	5268	
Ascariasis		
None	4286	81.25
Mild	593	11.24
Moderate	198	3.75
Severe	198	3.75
Total	5275	
Mange		
None	4671	85.50
Mild	667	12.21
Moderate	112	2.05
Severe	13	0.24
Total	5463	
Atrophic rhinitis		
None	1364	58.52
Mild	667	28.61
Moderate	233	10.00
Severe	67	2.87
Total	2331	
Pleuritis		
Absent	5139	97.55
Present	129	2.45
Total	5268	
Pericarditis		
Absent	5243	99.53
Present	25	0.47
Total	5268	
Nasal septum deviation		
Absent	1797	77.09
Present	534	22.91
Total	2331	
Tattoo quality		
Good	3045	89.64
Marginal	141	6.21
Illegible	211	6.21
Total	3397	

evaluation varied by disease category, and since the evaluation techniques varied inherently with the type of disease being considered, numbers of observations were seldom identical across all disease categories for any given group of hogs.

Because pleuritis and pericarditis were evaluated concurrently with pneumonia, their prevalence rates (found in the appropriate percent column) utilized the same denominator as the pneumonia rates. Similarly, the prevalence of nasal septum deviation used the same denominator as the atrophic rhinitis rates. Finally, note that evaluation of tattoo quality was also included in the report. In general, good quality tattoos were clear and easy to read. However, because the nature of each group's tattoo was known prior to SHC, a tattoo of marginal quality was legible, but might have been illegible had the character of the tattoo been truly unknown at the time of evaluation. Tattoos classified as illegible sometimes indicated very poor quality, but generally represented hogs that seemed to have been missed entirely during the tattoo application process.

The reader is reminded that these slaughter health data were obtained exclusively through non-random, or convenience sampling techniques. For this reason, their use as a basis for generalization must be strictly avoided, since the degree to which the pilot herds were actually representative of the entire industry was not established.

Sample Size Calculations. Information on the occurrence of disease in slaughter hogs has been obtained. While, as mentioned, these data are not sufficient for rigorous statistical analysis (due to limitations in sample size and selection technique), they are nonetheless useful for estimation of various sample sizes required for future investigations seeking inferential power to the entire population. To project these sample sizes, it was first necessary to estimate the population variance for the disease rates of interest based on the findings from this pilot project.

In effect, the SHIMS project involved a three-stage sampling procedure. In the first stage, individual herds were selected from the entire hog-producing industry in Michigan. For the second stage, individual shipments of hogs to slaughter were selected from the total number of groups marketed by individual producers over the course of

the project. And finally, within shipments, a subsampling (third stage) of hogs occurred for individual health evaluations. Sampling at all three stages occurred without replacement.

To estimate the population variance for each of the disease prevalence rates of interest, the approach of Farver (1987) was adopted. However, because Farver presented techniques for two-stage sampling, the approach required slight modification. For two-stage sampling without replacement, Farver presented the following formula to estimate the variance of a disease prevalence rate:

$$v(p) = (1-f) \frac{s_b^2}{n} + \frac{1}{nN} \sum_{i=1}^n \frac{M_i^2}{M'^2} (1-f_i) \frac{s_{wi}^2}{m_i}$$

The variables were defined as:

$v(p)$ = the unbiased estimate of the variance of the sampling distribution of p ;

N = the total number of herds in the population;

n = the total number of herds sampled;

f = n/N , the proportion of herds in the population sampled;

M' = the mean number of animals per herd in the population;

M_i = the total number of animals in the i th herd;

m_i = the total number of animals subsampled from the i th sampled herd;

f_i = m_i/M_i , the proportion of animals subsampled from the i th sampled herd;

p_i = the estimate of the proportion of the animals in the i th herd that are positive for the presence of a particular microorganism, obtained by dividing the number of animals found to be positive in the subsample from the i th herd by m_i ;

$p = \frac{1}{n} \sum_{i=1}^n M_i p_i / M'$, the estimate of the proportion of animals in the population that are positive for the presence of a particular microorganism;

$s_b^2 = \frac{1}{n-1} \sum_{i=1}^n \left(\frac{M_i p_i}{M'} - p \right)^2$, the estimate of the among-herd variance in the herd prevalence; and

$s_{wi}^2 = m_i (1-p_i)$, the estimate of the variance within the i th herd of the variable describing animal infection status.

Since, as mentioned, SHIMS involved three sampling stages, Farver's approach was first applied to individual herds for discerning the within-herd variance of each disease prevalence rate. Sampling stages for this analysis were selected shipments of hogs to slaughter within herds and selected animals for health evaluation within shipments. For this purpose, individual herds were considered as distinct populations, and the following variable definitions were employed:

$v(p)$ = the unbiased estimate of the within-herd variance of the sampling distribution of a given disease prevalence rate, p ;

N = the total number of shipments of hogs to slaughter over the course of the pilot project for an individual herd population;

n = the total number of shipments sampled from an individual herd population;

f = n/N , the proportion of shipments from the herd population sampled;

M' = the mean number of animals per shipment for the herd population;

M_i = the total number of animals in the i th shipment;

m_i = the total number of animals subsampled from the i th sampled shipment;

f_i = m_i/M_i , the proportion of animals subsampled from the i th sampled shipment;

p_i = the estimate of the proportion of the animals in the i th shipment that are positive for the presence of a particular disease, obtained by dividing the number of animals found to be positive in the subsample from the i th shipment by m_i ;

p = $\sum_{i=1}^n M_i p_i / M'$, the estimate of the proportion of animals in the herd population that are positive for the presence of a particular disease;

$s_b^2 = \frac{1}{n-1} \sum_{i=1}^n \left(\frac{M_i p_i}{M'} - p \right)^2$, the estimate of the among-shipment variance in the shipment prevalence; and

$s_{wi}^2 = m_i p_i (1-p_i) / (m_i - 1)$, the estimate of the variance within the i th shipment of the variable describing animal disease status.

Thus, an estimate of the variance of each disease prevalence rate was obtained from each of the six pilot producers.

Subsequently, Farver's approach was again applied, but this time across herds, to estimate the overall (industry) variance of each disease prevalence rate. Sampling stages for this analysis were herds within the (Michigan) industry and shipments within herds. For this purpose, the Michigan hog industry was considered as the single population of interest, and the following variable definitions were employed:

$v(p)$ = the unbiased estimate of the industry-wide variance of the sampling distribution of a given disease prevalence rate, p ;

N = the total number of herds in the industry population;

n = the total number of herds sampled;

f = n/N , the proportion of herds in the industry population sampled;

M' = the mean number of shipments to slaughter per herd in the industry population over the course of the pilot project;

M_i = the total number of shipments to slaughter over the course of the pilot project from the i th herd;

m_i = the total number of shipments subsampled from the i th sampled herd;

f_i = m_i/M_i , the proportion of shipments subsampled from the i th sampled herd;

p_i = the estimate of the proportion of the animals in the i th herd that are positive for the presence of a particular disease, obtained by dividing the total number of animals found to be positive in all shipments from the i th herd by the total number of animals evaluated in all shipments from the i th herd;

$p = \frac{1}{n} \sum_{i=1}^n M_i p_i / M'$, the estimate of the proportion of animals in the industry population that are positive for the presence of a particular disease;

$s_b^2 = \frac{1}{n-1} \sum_{i=1}^n \left(\frac{M_i p_i}{M'} - p \right)^2$; the estimate of the among-herd variance in the herd prevalence; and

s_{wi}^2 = the estimate of the variance within the i th herd of the variable describing animal disease status, obtained from first stage application of Farver's variance formula.

The outcome of these variance calculations appears in Table 3.8. While the limitations imposed by the methods of SHIMS sample selection are again acknowledged, these variances were used to estimate sample sizes necessary to achieve inferential

Table 3.8. Disease prevalence rate variances for SHIMS pilot producers, April 1986 through March 1988 (disease rates expressed as proportions)

Disease	Variance
Mild pneumonia	0.018590
Moderate pneumonia	0.001658
Severe pneumonia	0.002730
Pleuritis	0.000850
Pericarditis	0.000005
Mild ascariasis	0.001539
Moderate ascariasis	0.000525
Severe ascariasis	0.000467
Mild mange	0.003080
Moderate mange	0.000329
Severe mange	0.000004
Mild atrophic rhinitis	0.006798
Moderate atrophic rhinitis	0.001061
Severe atrophic rhinitis	0.000124
Nasal septum deviation	0.002545

confidence. For this purpose, the following formula was employed (Cochran, 1977):

$$n = \frac{t^2 * s^2 / d^2}{1 + (1/N) * (t^2 * s^2 / d^2)}$$

where **n** = the required sample size,

t = the abscissa of the normal curve that cuts off an area of α at the tails,

s² = an estimate of the variance of a given disease prevalence rate obtained from the SHIMS pilot project slaughter health checks,

d = the acceptable level of absolute deviation of the estimated disease rate from the true disease rate (with the disease rates and the deviation, d, expressed as proportions),

and **N** = the size of the reference population.

Due to the nature of the ratio and to be as conservative as possible, the two disease conditions whose prevalence rates held the greatest variance were used for calculation purposes. Results of sample size estimations based on the pilot phase appear in Table 3.9, 3.10, and 3.11.

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Table 39. SHIMS sample size calculations for number of herds, April 1986 through March 1988 (disease rates expressed as proportions; $\alpha = 0.05$)

Disease	Variance (s^2)	Absolute Deviation (d)	Population Size (N)^a	Required Sample Size (n)^b
Mild pneumonia	0.018590	0.02	800	151
		0.03	800	75
		0.04	800	44
Mild atrophic rhinitis	0.006798	0.02	800	63
		0.03	800	29
		0.04	800	17

^a Estimated total number of farrow-to-finish hog producers in Michigan with at least fifty sows (source—Thulin, 1986 and United States Department of Commerce, 1984).

^b Estimated number of herds required to achieve $(1-\alpha)$ level of confidence.

The value of d chosen for these analyses was somewhat arbitrary. As presented above, d represents the amount of statistical accuracy that is theoretically acceptable when estimating disease prevalence rates from the general population of market hogs produced in Michigan. However, an issue of equal importance is the amount of accuracy that is acceptable on an economic basis. While a certain sampling procedure may be necessary to achieve acceptable statistical results, perhaps attaining that level of confidence costs more than the information is worth. Therefore, the production value of disease prevalence information must be considered before definitive guidelines are set for economically acceptable sampling procedures. In the absence of reliable knowledge regarding the value of this disease information to hog production, and in an attempt to determine such a value, sampling guidelines should probably follow procedures necessary to achieve acceptable statistical results, since these provide an upper limit for the amount of accuracy required.

To have an adequate representation of the Michigan swine industry, the first sample size of interest is the number of individual farms necessarily included. As such, illustrative sample size estimations appear in Table 3.9. For example, to achieve 95% confidence ($\alpha = 0.05$) that observed prevalence rates of mild pneumonia (expressed as

Table 3.10. SHIMS sample size calculations for number of slaughter health checks per farm per year, April 1986 through March 1988 (disease rates expressed as proportions; $\alpha = 0.05$)

Disease	Variance (s^2)	Absolute Deviation (d)	Population Size (N)^a	Required Sample Size (n)^b
Mild pneumonia	0.018590	0.02	10	9
		0.03	10	9
		0.04	10	8
		0.02	50	39
		0.03	50	31
		0.04	50	24
		0.02	75	53
		0.03	75	39
		0.04	75	29
		0.02	10	9
		0.03	10	8
		0.04	10	6
Mild atrophic rhinitis	0.006798	0.02	50	29
		0.03	50	19
		0.04	50	13
		0.02	75	37
		0.03	75	22
		0.04	75	14

^a Estimated total number of shipments marketed annually for an individual producer.
For SHIMS pilot project, minimum = 10, maximum = 75, and median = 50.

^b Estimated number of shipments required for slaughter health checks to achieve (1- α) level of confidence.

Table 3.11. SHIMS sample size calculations for number of individual pig health evaluations per shipment to slaughter, April 1986 through March 1988 (disease rates expressed as proportions; $\alpha = 0.05$)

Disease	Variance (s^2)	Absolute Deviation (d)	Population Size (N)^a	Required Sample Size (n)^b
Mild pneumonia	0.018590	0.02	100	65
		0.03	100	45
		0.04	100	32
		0.02	240	105
		0.03	240	61
		0.04	240	39
Mild atrophic rhinitis	0.006798	0.02	100	40
		0.03	100	23
		0.04	100	15
		0.02	240	53
		0.03	240	27
		0.04	240	16

^a Estimated total number of pigs in one shipment. For SHIMS pilot project, this number varied from about 100 to about 240.

^b Estimated number of individual pig health evaluations per shipment to achieve $(1-\alpha)$ level of confidence.

proportions) fall within an absolute deviation of 0.03 from the true rates would require an estimated 75 herds. Other levels of confidence and the second highest variance have been evaluated for comparison purposes.

Within these herds, then, it becomes important to know how many of the market hog shipments leaving the farm for slaughter must be sampled. Obviously, this varies from farm to farm and depends not only on the variance and acceptable deviation, but also on the total number of shipments which occur from a particular farm over time. Again, representative calculations have been made and the results appear in Table 3.10. As with estimations of the farm level sample size, various levels of absolute deviation have been considered for both of the two largest disease prevalence rate variances. In addition, this evaluation included several potential population sizes. Of these, $N = 10$

represents the minimum number of market hog shipments in a year for the SHIMS pilot group, while $N = 50$ represents the median and $N = 75$ corresponds to the maximum.

Finally, once a shipment of market hogs has been selected for slaughter health check, it is critical to know how many of the hogs in that shipment must be evaluated to provide confidence in the disease prevalence rates observed. For this reason, representative calculations have been made and are presented in Table 3.11. As with previous calculations, various absolute deviations have been considered for the two largest disease prevalence rate variances. Also, different population sizes are included in the evaluation. In this case, $N = 100$ approximates some of the smaller shipments of hogs evaluated during the SHIMS pilot project and $N = 240$ represents the larger shipments. Incidentally, $N = 240$ can safely be considered as an upper limit, since it also depicts the maximum capacity for one truckload of market hogs.

These estimations provide useful sampling guidelines. It appears from these initial calculations that the proposed expansion to a sample size of 75-80 herds, which represents approximately 10% of the farrow-to-finish hog producers in Michigan with at least 50 sows (Thulin, 1986 and United States Department of Commerce, 1984), is statistically reasonable. Further, this evaluation suggests that quarterly SHCs may not be frequent enough to accurately assess the disease processes on all farms. It will be necessary to address this question on an individual-farm basis in the future. And finally, it has been shown that missed observations at slaughter can easily be tolerated (within reason). This is reassuring in light of the high processing line speeds discussed earlier.

As an ending note on sample sizes, the above equation can be solved mathematically to provide the amount of absolute deviation, d , which can be expected for given population sizes, sample sizes, disease variances, and statistical confidence levels. In an effort to document the fallacy of using these pilot data as a basis for generalization, this was performed for a sample of six Michigan farrow-to-finish hog producers from an industry containing 800 (commercial operations with at least 50 sows, from Thulin, 1986 and United States Department of Commerce, 1984). Using the largest

disease variance to provide conservatism, it was found that, even in absence of sampling bias, an absolute deviation up to ± 0.111 (or $\pm 11.1\%$) can be expected in industry disease rates estimated from these data. Given that many of these disease rates are expected to be around 0.10 (or 10%), this is unacceptable statistical precision. Following the earlier discussion regarding the amount of accuracy that is economical, this precision must also be viewed (at this point) as economically unacceptable.

Comparative Analysis. Again, the SHIMS pilot phase disease data are inadequate for rigorous statistical analyses and accompanying population/industry generalization. However, in addition to estimating sample size requirements, certain relationships were evaluated (as a matter of interest) explicitly within the pilot producer group. It was felt that such evaluations might provide initial disease insights such as seasonality, differences between farms, and differences over time.

Due to the limitations of the database, the disease classification scheme employed was modified slightly to facilitate cursory consideration of seasonality, farm differences, and time trend in disease prevalence rates. Because the insights being sought were admittedly preliminary, it was deemed acceptable to evaluate each class of diseases as a single entity. To accommodate this approach, a single measure of disease prevalence was sought for each of the four main disease classes: pneumonia, ascariasis, mange, and atrophic rhinitis. It has been reported that moderate and severe disease conditions are more important to the relative performance of production than is a mild condition (Straw, 1987). Therefore, a lone prevalence rate was constructed for each disease group by simply adding the appropriate moderate and severe prevalence rates. As a result, each SHC performed during the pilot SHIMS project yielded only four of these "combined" disease prevalence rates for use in the current analysis: pneumonia, ascariasis, mange, and atrophic rhinitis.

To evaluate the relationships of interest, multiple linear regression was performed. Initially, the following equation was used to evaluate simple linear relationships:

$$\begin{aligned} DR_i = & \beta_0 + (\beta_1 * QTR) + (\beta_2 * SEAS2) + (\beta_3 * SEAS3) + (\beta_4 * SEAS4) + \\ & (\beta_5 * FARM2) + (\beta_6 * FARM3) + (\beta_7 * FARM4) + (\beta_8 * FARM5) \\ & + (\beta_9 * FARM6) \end{aligned}$$

where DR_i = "combined" disease prevalence rates for pneumonia, ascariasis, mange, and atrophic rhinitis; (i = 1 to 4, respectively);

β_0 = regression intercept term;

β_j = linear regression coefficients (j = 1 to 9);

QTR = time trend variable taking values of 1 to 8 corresponding to the calendar quarters from spring (April, May, and June) 1986 to winter (January, February, and March) 1988;

SEAS2 = a discrete, (0,1) variable representing spring SHC (April, May, June);

SEAS3 = a discrete, (0,1) variable representing summer SHC (July, August, September);

SEAS4 = a discrete, (0,1) variable representing fall SHC (October, November, December);

FARM2 = a discrete, (0,1) variable representing farm number 2;

FARM3 = a discrete, (0,1) variable representing farm number 3;

FARM4 = a discrete, (0,1) variable representing farm number 4;

FARM5 = a discrete, (0,1) variable representing farm number 5;

and FARM6 = a discrete, (0,1) variable representing farm number 6.

The QTR variable is intended to capture time trend in disease rates, while the SEAS and FARM variables were included to adjust for seasonal and farm effects, respectively.

Regression analysis was performed using MicroTSP¹, and results are found in Table 3.12.

These analyses were undertaken with full recognition of the potential statistical problems associated with repeated observations on the same individuals (in this case, repeated SHCs on each of the six pilot farms). Since repeated disease prevalence rate observations for the same farm are certainly *not* independent, autocorrelation of the error term must be expected. While the Durbin-Watson statistics did not indicate a definitive presence of autocorrelation, they generally also failed to indicate that such a relationship was definitively absent. In the spirit of initial screening, and recognizing

Table 3.12 Results of linear regression analyses evaluating potential trend, season, and producer effects on disease prevalence rates for SHIMS pilot producers, April 1986 through March 1988

Disease	Variable	Coefficient	t-Statistic
Pneumonia $R^2 = 0.7924$ $\text{Adj}R^2 = 0.7432$	Intercept	0.04742	1.14071
	QTR	0.01846	3.76857
	SSN2	-0.00668	-0.21296
	SSN3	-0.03610	-1.22797
	SSN4	-0.01655	-0.58791
	FARM2	-0.05098	-1.50199
	FARM3	0.03246	0.95632
	FARM4	0.27138	7.99546
	FARM5	-0.04178	-1.23095
	FARM6	0.01843	0.54287
Ascariasis $R^2 = 0.2708$ $\text{Adj}R^2 = 0.0981$	Intercept	0.17805	2.65399
	QTR	-0.00986	-1.24749
	SSN2	0.00186	0.03666
	SSN3	0.03767	0.79405
	SSN4	-0.01414	-0.31140
	FARM2	-0.11461	-2.09228
	FARM3	-0.07495	-1.36822
	FARM4	-0.12491	-2.28030
	FARM5	-0.10554	-1.92679
	FARM6	-0.00766	-0.13987
Mange $R^2 = 0.3695$ $\text{Adj}R^2 = 0.2201$	Intercept	0.02153	0.64173
	QTR	-0.00423	-1.06922
	SSN2	0.01933	0.76358
	SSN3	-0.01107	-0.46667
	SSN4	-0.00303	-0.13328
	FARM2	-0.00117	-0.04268
	FARM3	0.08407	3.06926
	FARM4	0.01058	0.38627
	FARM5	-0.00013	-0.00490
	FARM6	0.05798	2.11670
Atrophic rhinitis $R^2 = 0.3483$ $\text{Adj}R^2 = 0.1939$	Intercept	-0.03176	-0.52510
	QTR	0.00633	0.88876
	SSN2	0.08033	1.76023
	SSN3	0.06706	1.56823
	SSN4	0.06893	1.68369
	FARM2	-0.00777	-0.15733
	FARM3	0.12004	2.43105
	FARM4	0.09491	1.92205
	FARM5	0.11677	2.36484
	FARM6	0.13082	2.64936

the efficiency problems (Pindyck and Rubinfeld, 1981) which accompany autocorrelation (artificial depression of estimated standard errors), an absence of statistical significance was deemed a more reliable finding than was its presence.

One of the primary reasons for evaluating SHIMS disease rates over time was to help address the question, "Were the SHIMS pilot producers able to use the information that they were provided to effectively decrease their disease rates?" For example, the presence of a significant negative trend when regressing disease rates against time might have suggested the ability for the producers involved to use SHIMS disease information toward decreasing disease frequencies. Admittedly, definitive documentation of this ability would require both expanded, random sampling and inclusion of a control group of producers not receiving SHIMS information. On the other hand, even if expanded, random sampling occurred with a control group included, absence of a negative trend could not be conclusively interpreted as an inability to successfully use the SHIMS disease information. Such an interpretation would necessitate a prior assumption that the SHIMS producers perceive all the diseases addressed as undesirable at any positive prevalence rate. This assumption would be invalid, and therefore cannot be accepted.

Other questions of interest included, "Was there a difference in disease prevalence between seasons on the SHIMS project?" and, "Was there a difference in disease prevalence between SHIMS producers?" These were addressed (within database limitations) by evaluating the non-time independent variables for the regressions. Any significance associated with a SEAS or FARM variable would suggest a difference in the prevalence of disease within the pilot group between seasons (as defined) and/or producers, respectively.

The regressions performed failed to show a significant negative trend for any of the diseases considered. However, pneumonia showed a significant positive trend. To understand the relative importance of this finding, the limitations of the database and the statistical analysis need to be fully recognized. As mentioned previously, definitive

conclusions are not possible from this cursory analysis since the sample was small relative to the entire Michigan swine industry, it was selected purely by non-random (convenience) techniques, and it fails to contain a control group not receiving the SHIMS information. When subjectively reviewing the pilot phase of the SHIMS project, it was found that two of the six producers experienced substantial increases in respiratory problems toward the end of the project which were related to specific, known environmental and management factors independent of the SHIMS project. One of these producers experienced mechanical difficulties with ventilation and the other experienced an acute outbreak of swine influenza.

Further, if the pneumonia regression is explored further, it can be seen that, relative to the significant differences between farms, the time trend variable contributes a small amount to the total variation in pneumonia prevalence rate. Thus, the potential economic importance of the positive trend in pneumonia is seriously discounted.

Finally, in light of the probable presence of autocorrelation, the coefficient of determination should be suspected of artificial inflation. The statistical significance achieved must be held in suspicion until more rigorous analysis can supply robust confirmation or rebuttal.

Probably more interesting than the amount of trend in this data set is the lack of seasonality and the marked consistence of significant variation between farms. The absence of seasonality suggests either that season is not important or that environmental conditions need to be defined more precisely than is afforded by a single seasonal variable. Reported information (Lindqvist, 1974) indicates that environmental conditions are important to the frequency of disease in hog production. What these preliminary results signify is that either the seasons have been inappropriately delimited, or that specific environmental factors such as temperature and humidity cannot be adequately captured in a seasonal variable when dealing with confinement hog production systems. Finally, the consistent variability between farms for all disease classes helps build a

strong case for obtaining individual farm data when performing economic analyses of animal health management.

For the last regression consideration, it was recognized that perhaps the strictly linear model might be inappropriate for predicting a proportion such as disease prevalence rates. As a result, corresponding analyses were performed using the logit (Pindyck and Rubinfeld, 1981) of disease prevalence as the dependent variable. Results of these are presented in Table 3.13. For the most part, the previous discussion also holds for the logit model.

Costs of the System

Because the SHIMS was developed as a cooperative research effort, the fixed, start-up costs were considered sunk; only the variable costs associated with system operation were considered. As such, Table 3.14 contains a summary of the estimated cost of obtaining the SHIMS information for a "hypothetically typical" SHIMS farm. Both first and subsequent year estimations are included. Also, expansion to a total cost for 80 herds is presented, based first on four SHCs per year (as occurred during the pilot project) and then assuming eight SHCs per year. It was felt that eight SHCs per year represented a reasonable lower end requirement for "typical" Michigan hog producers. The analysis was included only to show the effect of increasing the number of SHCs in a general sense, and not necessarily to accurately represent the characteristics of the Michigan swine industry. Explicit calculations can be found in Appendix E.

It should be noted that certain overhead costs relating to advisory personnel at MSU have been omitted. Also, a substantial economy of scale exists in the area of SHCs, since as the number of participating farms increases, the opportunity for coordination of data collection for more than one herd on the same day also increases. Savings on personnel and travel in this category may approach a maximum of 20%. Other less substantial economies may also exist in the areas of administration and report generation. The net effect of these economies, which were estimated subjectively based

Table 3.13. Results of logit regression analyses evaluating potential trend, season, and producer effects on disease prevalence rates for SHIMS pilot producers, April 1986 through March 1988

Disease	Variable	Coefficient	t-Statistic
Pneumonia $R^2 = 0.3744$ $\text{Adj}R^2 = 0.2263$	Intercept	3.18336	2.30067
	QTR	-0.30062	-1.84352
	SSN2	1.03264	0.98899
	SSN3	0.10441	0.10672
	SSN4	0.02420	0.02584
	FARM2	0.69906	0.61877
	FARM3	-0.26269	-0.23252
	FARM4	-1.63420	-1.44651
	FARM5	2.47656	2.19211
	FARM6	-0.07198	-0.06372
Ascariasis $R^2 = 0.4480$ $\text{Adj}R^2 = 0.3172$	Intercept	0.34629	0.09089
	QTR	0.42434	0.94506
	SSN2	-1.63082	-0.56723
	SSN3	2.98835	1.10925
	SSN4	5.16175	2.00119
	FARM2	5.39169	1.73322
	FARM3	-0.81373	-0.26158
	FARM4	10.80003	3.47179
	FARM5	6.82592	2.19426
	FARM6	2.46199	0.79143
Mange $R^2 = 0.3012$ $\text{Adj}R^2 = 0.1357$	Intercept	12.02918	2.75330
	QTR	0.52349	1.01670
	SSN2	-0.99151	-0.30074
	SSN3	2.35596	0.76260
	SSN4	0.62517	0.21136
	FARM2	0.08618	0.02416
	FARM3	-8.44310	-2.36682
	FARM4	-2.10635	-0.59047
	FARM5	-0.01208	-0.00339
	FARM6	-8.28596	-2.32277
Atrophic rhinitis $R^2 = 0.2382$ $\text{Adj}R^2 = 0.0578$	Intercept	8.02062	2.63601
	QTR	-0.21101	-0.58844
	SSN2	0.15008	0.06536
	SSN3	0.31566	0.14672
	SSN4	-1.80107	-0.87434
	FARM2	0.11697	0.04708
	FARM3	-5.02381	-2.02217
	FARM4	-2.94501	-1.18542
	FARM5	-4.75877	-1.91549
	FARM6	-5.04679	-2.03143

Table 3.14. Variable costs of SHIMS operation, April 1986 through March 1988

Source of Cost	Single Farm (four SHC/year)	Eighty Farms (four SHC/year)	Eighty Farms (eight SHC/year)
Initial visit	(\$/farm)	(\$/farm)	(\$/farm)
personnel	\$ 100.00	\$ 8000.00	\$ 8000.00
travel	26.40	2112.00	2112.00
forms	1.50	120.00	120.00
data entry ^a	1.83	146.40	146.40
data storage	2.40	192.00	192.00
subtotal	\$ 132.13	\$10,570.40	\$10,570.40
On-farm data collection	(\$/farm/year)	(\$/farm/year)	(\$/farm/year)
producer time	\$ 120.00	\$ 9600.00	\$ 9600.00
forms	3.00	240.00	240.00
data entry ^b	14.60	1168.00	1168.00
data storage	3.90	312.00	312.00
subtotal	\$ 141.50	\$ 11320.00	\$ 11320.00
Slaughter health checks	(\$/farm/year)	(\$/farm/year)	(\$/farm/year)
personnel	\$ 240.00	\$ 15,360.00	\$ 30,720.00
travel	70.40	4505.60	9011.20
forms	1.00	80.00	160.00
administrative	55.00	3960.00	7920.00
data entry ^c and report	65.28	4700.16	9400.32
subtotal	\$ 431.68	\$ 28,605.76	\$ 57,211.52
Quarterly report	(\$/farm/year)	(\$/farm/year)	(\$/farm/year)
personnel-run	\$ 4.00	\$ 320.00	\$ 320.00
computer time	12.84	1027.20	1027.20
mailing	2.88	230.40	230.40
subtotal	\$ 19.72	\$ 1577.60	\$ 1577.60
FIRST YEAR TOTAL	\$ 725.03	\$ 52,073.76	\$ 80,679.52
SUBSEQUENT YEAR TOTAL	\$ 592.90	\$ 41,503.36	\$ 70,109.12

^a Represents approximately 1081 individual data elements per farm per initial visit

^b Represents approximately 8640 individual data elements per farm per year

^c Represents approximately 26 individual data elements per farm per SHC

on a thorough understanding of the data collection process, is to decrease the cost per farm (up to a maximum of about 10%) as the number of participating farms increases.

Benefits of the System

The full benefits of the SHIMS project cannot be readily estimated at this juncture due to the incomplete nature of the data and its subsequent analysis. However, several general areas of potential benefit can be discussed.

Participating SHIMS producers should benefit directly. The information generated should assist these producers in choosing between alternative health management strategies and should help provide "bench marks" for evaluation of the success in health management. Thus, the decision support provided should decrease the uncertainty involved in hog production and thereby provide decision outcomes with higher value to the producers involved. This higher value may result from increased profit potential, assistance in risk management, or both, and its equivalent dollar amount is the value that Davis (1974) would assign to the information SHIMS provides.

Hog producers not participating with SHIMS stand to benefit indirectly because new knowledge will be generated by the research involved. Publication of the research results to disseminate this new knowledge should allow a broader range of producers to better manage the health of their market hogs and more effectively achieve their own management objectives.

Consumers should also directly benefit from the SHIMS project through a safer food supply. A better informed producer industry should lead to more appropriate use of chemical feed additives. Consequently, the potential exists for both fewer residue and health problems in the hogs sent to slaughter. While precise estimation of the dollar value of this benefit will be difficult, it can possibly be approached through techniques such as contingency valuation. Indirectly, consumers will also benefit if hog production becomes more efficient across the producer industry. Obviously, such a development will not be immediately achieved, but will result in a decreased price of pork if it should occur.

As production becomes more efficient, the competitive position of the U.S. hog industry will be improved. Such a development will allow hogs produced in the U.S. to be more attractive in the world economy, thus providing additional demand to domestic production in the form of increased export opportunity. At the same time, the domestic market will provide less opportunity for competition from imported hogs.

Finally, another very important, but perhaps somewhat intangible benefit has been the broad array of cooperation achieved on the SHIMS project. This cooperation includes: (1) the support of both the Cooperative Extension Service and the Agricultural Experiment Station across the academic disciplines of veterinary medicine, epidemiology, agricultural economics, and animal science; (2) the USDA agencies of Extension, ERS, and FSIS; and (3) the various levels of professional livestock production, spanning state and federal governments, the slaughter industry, marketing agents, academia, practicing veterinarians, extension agents, and livestock producers. The livestock industries currently face some complex problems that will be most effectively addressed through such broad, cooperative efforts.

Recommendations for the Future

In light of developments achieved during the pilot phase of the SHIMS project, several recommendations can be made for future information management efforts. These occur in four main areas: sample selection, data collection at slaughter, on-farm data collection, and administrative support.

First, if truly representative information on Michigan's hog industry is desired, participating farms need to be selected according to appropriate random procedures, rather than convenience. Also, future attention needs to be given to sample selection techniques within farm and within shipment of market hogs. Assurance must be achieved that the market hog shipments selected for SHC provide unbiased information on the farm of origin. Care must be taken to avoid sorting bias. Further, selection techniques during SHC (such as skipping hogs due to processing speed, skipping hogs due to FSIS condemnation, and unidentifiable hogs) must not introduce bias. This area

warrants special attention, since condemnations often are due to disease conditions present. Missing these observations would almost surely bias the sample.

Based on results of sample size calculations which appear in Table 3.8, the inclusion of 75-80 herds seems adequate to achieve both statistical and biological significance. Table 3.8 also indicates that it will be important to consider the normal marketing frequency on an individual farm basis. As can be seen, quarterly SHCs will not offer much confidence in the statistical accuracy of disease rates observed. In addition, it seems that, while the necessary number of hogs per shipment to be evaluated is directly dependent on the total group size of available hogs, a minimum of 50% for smaller groups (<100 hogs) and 25% for larger groups (>200 hogs) is reasonable. Not only do these calculations provide guidance for extended research, but they also carry an important message for veterinary practitioners who offer SHCs as a service. To reiterate: it appears that quarterly SHCs are generally not frequent enough to provide a 95% statistical confidence in the accuracy of the disease rates observed. Further, in lieu of desirable accuracy estimates based on economic analysis, a minimum of 40 to 60 hogs should be evaluated per SHC.

When considering on-farm data collection, it will be extremely important in the future to request only the minimum amount of data necessary to achieve the goals of individual projects. As discussed previously, requests for excessive data collection, especially by producers, will ultimately detract from the quality of the important data in both timeliness and accuracy. Also, standardizing the format for data collection is extremely important. Numerous formats greatly increase both entry/processing time and the probability of entry/processing errors. To improve the quality of on-farm data, it may become necessary to explicitly compensate participating producers, or to more adequately and convincingly document the direct benefits received from participation.

Finally, if the SHIMS project is to continue, increased support will be required from FSIS in the area of conducting SHCs. The hog market structure in Michigan mandates excessive travel for MSU personnel to provide the necessary SHCs for the

expanded sample size. Thus, the responsibility for this activity will need to be assumed by FSIS. Coupled with this increased support will be an increase in administrative duties to coordinate SHCs with FSIS. However, this should not present a problem given the success achieved and support garnered during the pilot phase in this regard.

SUMMARY

An information management system to support evaluation of the economics of market hog production and health management has been described. Techniques involved, strengths, limitations, and recommendations for the future have been included. While costs of the system have been specifically discussed, quantification of benefits is dependent on development of an analytical model, which will be described in the next chapter.

CHAPTER 4

THE ANALYTICAL MODEL

INTRODUCTION

As discussed in Chapter 2, the descriptive information supplied by an information management system (IMS) provides a basis from which further information for diagnosis, prediction, and prescription can be attained. For this purpose, mathematical production models help form technological expectations for diagnosis and prediction, while decision models support prescription. In the current research, an IMS and an analytical model for livestock production were simultaneously developed toward their joint application as a decision support system. Chapter 3 described the IMS; this chapter presents the analytical model.

Initially, the general approach of systems modeling will be explained. Then, a broad, conceptual overview of the current analytical model will be forwarded. Following this overview, the specific systems modeling concepts and computer simulation techniques which were employed for the current research will be presented. These aspects are necessarily presented together, since they are often virtually inseparable; many of the simulation techniques were developed specifically to implement the underlying systems modeling concepts.

Subsequently, the methods employed for estimation of system parameters will be presented. This section will deal with the approaches involved both in projecting exogenous input levels and in defining functional relationships included in the model. These relationships are critical to model performance since they determine the rate of change for states of the system and input variables.

Finally, a preliminary discussion is included based solely on the individual properties of the modeling techniques involved. Further discussion is diverted to Chapter 5, where results of initial decision support system application will be presented, and Chapter 6, where conclusions and recommendations will be made.

THE SYSTEMS APPROACH

The analytical model for this research was constructed via the "systems approach." Basically, the systems approach has been defined by Manetsch and Park (1982) as a method of problem solving which seeks to efficiently satisfy an identified set of needs in light of trade-offs between those needs and resource constraints. More specifically, this approach

... overtly seeks to include all factors which are important in arriving at a "good" solution to the given problem and ... makes use of quantitative models and often computer simulation of those models to assist in making rational decisions.

Further, they elaborate with the following illustration:

"Systems Approach" $> \sum_{i=1}^N x_i$
 (read "includes but is greater than")

x_1 = A methodology for planning/management
 x_2 = A multidisciplinary team
 x_3 = Organization
 x_4 = Mathematical modeling techniques
 x_5 = Disciplined non-quantitative thinking
 x_6 = Simulation techniques
 x_7 = Optimization techniques
 x_8 = Application of computers

Along the same lines, Sutherland (1975) listed four basic characteristics inherent in the problem solving methodology of a true systems scientist:

1. The approach must be interdisciplinary, since real-world problems inevitably cross the artificial boundaries drawn by academic disciplinarians.
2. The capacity for both quantitative and qualitative analysis is essential.

3. "... the properties of the problem at hand should determine the analytical approach we take, not any *a priori* methodological biases nor any convenient preferences we happen to hold independent of emerging problem realities." This means that such analyses should "... bring all the structure and order possible to the problems we face, without bringing so much that real complexities are sacrificed to analytical expedience."
4. There exists a holistic appreciation for the subjects involved, in which the basic units of analysis are "unreduced wholes."

As can be seen, the systems methodology borders on a problem solving philosophy. It assures that the "needs" associated with a particular problem situation are adequately, but efficiently fulfilled. The characteristics of the problem dictate the analytical technique employed. In this regard, the approach can (and perhaps should) be applied to problems of virtually any magnitude (large or small) and of any relative complexity (from simple to extremely complicated).

In the broadest sense, virtually any of the commonly used modeling techniques for agricultural production could be involved in a systems approach, given appropriate needs and resource constraints. At the same time, *a priori* selection of any particular analytical technique independent of the specific needs and constraints of a given situation violates the system scientist's credo.

CONCEPTUAL MODEL OVERVIEW

The system being modeled was a confinement, continuous production hog growing enterprise, including nursery, grower, and finisher phases. The model's goal was to predict income over variable costs and to evaluate the sensitivity of this prediction to alternative health management practices. For purposes of exposition, schematic representation of the model is divided into physical and financial aspects. These appear in Figures 4.1 and 4.2, respectively. To maintain clarity, references to specific model features will be indicated by use of italics with the exception of formulas and tables where normal script will be employed.

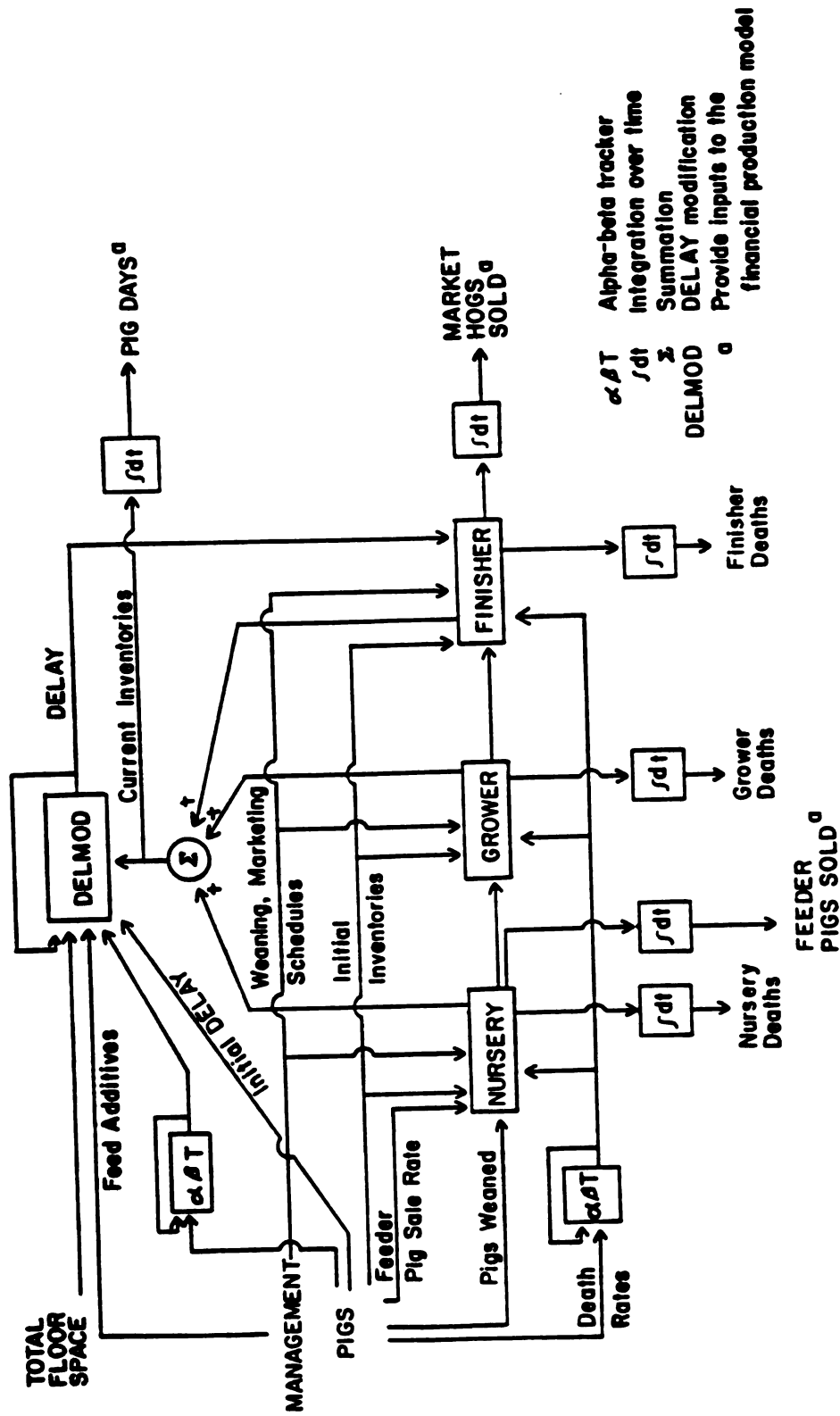


Figure 4.1. Schematic representation of the physical production model, Michigan State University SHIMS project

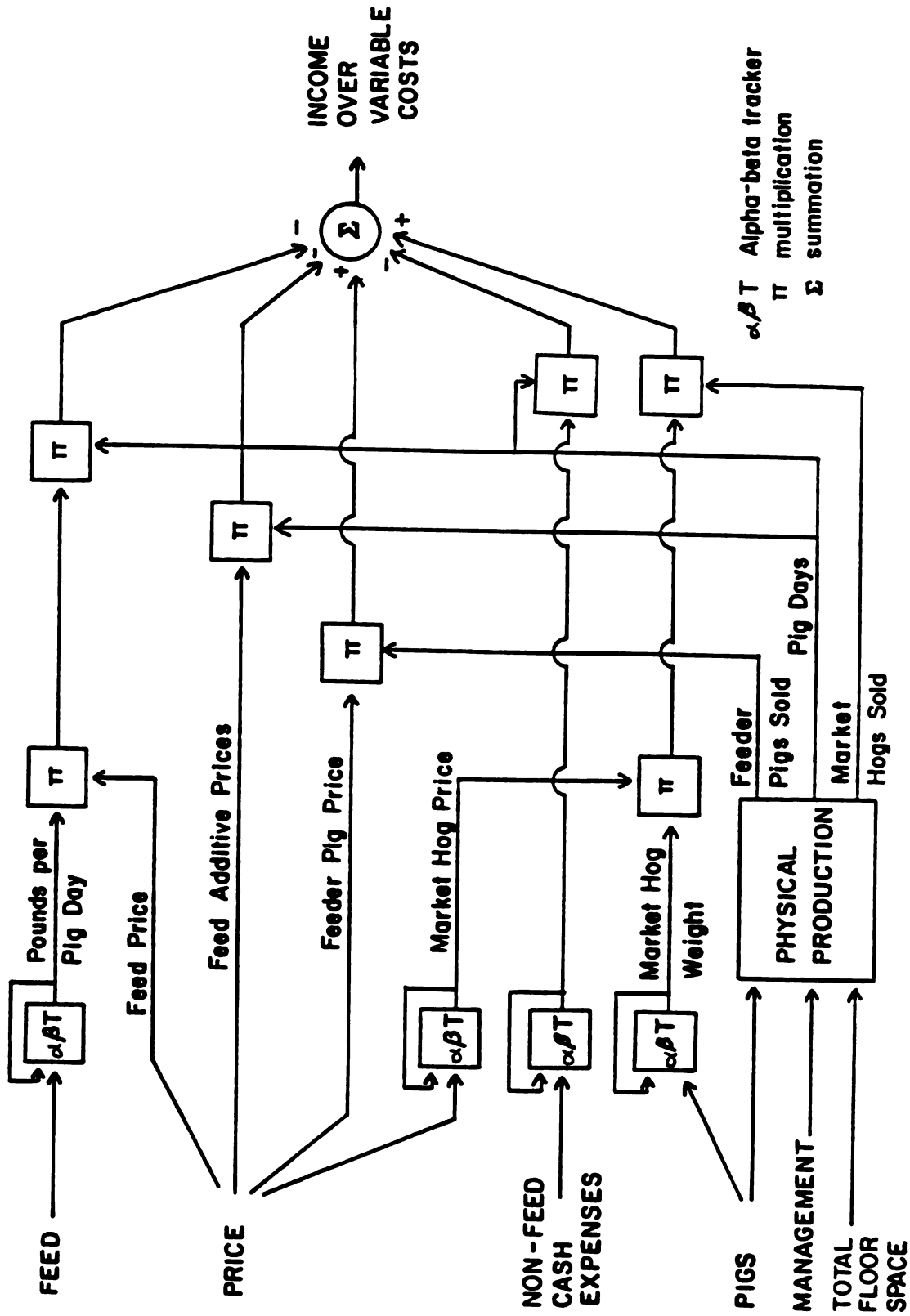


Figure 4.2. Schematic representation of the financial production model, Michigan State University SHIMS project

Figure 4.1 contains the backbone of the analytical model: physical production. Represented by the connected boxes labeled *NURSERY*, *GROWER*, and *FINISHER*, the main channel through the figure corresponds to flow of hogs through the respective production phases. Provided *Initial Inventories*, weaned pigs entered the nursery as inputs into the system and market hogs exited as outputs. Management controlled the amount of time spent in the *NURSERY* and *GROWER* through discrete *Weaning Schedules* (pig flows), while the variable time spent in the *FINISHER* phase (*DELAY*) was determined by the *Marketing Schedules* along with other factors in the system. Thus, total transit time for pigs in this system was variable.

The individual production factors which affected growth rate, and consequently transit time, are explicitly listed in Table 4.1, and include changes in *Feed Additive* use, available *Floor Space* per pig (as determined by *Current Inventories*), and *Disease Rates* (specific point prevalences at slaughter). Ultimately, these changing factors could exert their influence in any or all of the three production phases. However, their net effect on total transit time, regardless of the phase being influenced, was to alter *DELAY*. This process is represented by the box labeled *DELMOD*, where either the *Initial DELAY* (historical *DELAY* obtained from the IMS) or the immediate past period *DELAY* was appropriately modified to determine the future *DELAY*.

Disease Rates and *Death Rates* were projected using an alpha-beta tracker, which will be discussed later. These projection processes are represented by the boxes labeled $\alpha\beta T$ in Figure 4.1. Finally, the boxes containing $\int dt$ indicate numerical integration, where system flow rates were "gathered" over time. For example, market hogs exit the *FINISHER* phase according to a market rate expressed in hogs per day. Over time, a total *MARKET HOGS SOLD* can be calculated considering the marketing rate and the length of time (number of days) involved. Similar explanations are applicable for *Death*

Rates to calculate total numbers of deaths over time, for *Current Inventories* to discover the total number of *PIG DAYS*, and for *Feeder Pig Sale Rates* to provide total *Feeder Pigs Sold*.

Table 4.1. Production factors that affect hog performance in the physical production model, Michigan State University SHIMS project, 1985 through 1988

Disease Rates	Environment
Mild pneumonia	Available floor space per pig
Moderate pneumonia	
Severe pneumonia	Feed Additives
Mild ascariasis	Antibiotics
Moderate ascariasis	Sulfas
Severe ascariasis	Carbadox
Mild mange	Copper
Moderate mange	Anthelmintics
Severe mange	
Mild atrophic rhinitis	
Moderate atrophic rhinitis	
Severe atrophic rhinitis	
Nasal septum deviation	
Pleuritis	
Pericarditis	

Figure 4.2 depicts combination of the financial aspects of production with the outcome of Figure 4.1. Again, $\alpha\beta T$ indicates projection with an alpha-beta tracker. Here, feed consumption (*Pounds per Pig Day*), *Market Hog Price*, *NON-FEED CASH EXPENSES*, and *Market Hog Weight* were the variables projected. Basically, physical production levels were multiplied (in boxes labeled Π) by appropriate market prices and variable expense levels to attain (through the summation, Σ) an expected *INCOME OVER VARIABLE COSTS*. This projected financial outcome, then, was designed to provide information to the decision maker for consideration in light of his/her personal objectives.

Initial values of both the state and rate variables in Figures 4.1 and 4.2 were obtained from the Swine Health Information Management System (SHIMS) database

described in Chapter 3. Because the SHIMS database was maintained on a mainframe computer and the current model utilized a microcomputer, data transfer was necessary. This was accomplished both electronically and manually. In addition to the SHIMS data, projected prices for feed, feed additives, and feeder pigs, as well as the current status of the weaning and marketing cycles had to be provided. As presented, the current status of production was ascertained from the database and used as a basis for change. In this sense, the method was a production adjustment approach, as opposed to an absolute production approach.

The adjustment technique is theoretically appealing, since established producers following a continuous production scheme seldom ask, "How much should I produce?" in an absolute sense, but generally ask the same question in relation to current production levels. Further, gains in the model building process were achieved by using the adjustment approach. Much information about technology is implicitly included in the observation of production's current level and rate, and this information enhances the accuracy of prediction. It seems logical that accurately predicting the absolute magnitude of production might be more difficult than establishing current levels and then accurately predicting marginal changes. Therefore, by using a known starting point, many absolute production parameters which are critical to prediction but extremely difficult (if not impossible) to accurately quantify become irrelevant to the model since they don't change.

Included in the category of unchanging variables are genetic potential, farm-specific environmental effects, and many nutritional effects. For example, if genetics don't change, genetic potential is implicitly and adequately quantified by observing current production performance and using that observation as a basis for projection. As long as the herd's genetics are not changing, their effect on production will be the same (within limits of normal random variation) in future periods as it was in past periods, and will therefore be accurately included if past production performance levels, appropriately adjusted for factors that do change, are used for projection. If farm-

specific housing characteristics don't change (other than pig concentration), and if the rations being fed stay the same (other than amount consumed), the same line of reasoning can be used for certain environmental and nutritional parameters.

Not only are direct effects captured in this fashion, but also any interactions that may be present, however complex. Such an adjustment approach effectively addresses many of the modeler's toughest challenges.

SYSTEMS MODELING AND COMPUTER SIMULATION TECHNIQUES

General Features

The programming language used for computerization was QuickBASIC^m (version 4.0 by Microsoft). Development and initial implementation occurred on a COMPAQ Portable II microcomputer equipped with a math co-processor. In addition, an executive simulation program (MOPTSIMⁿ) provided an initial framework for several of the subroutines and functions used. However, extensive modifications were necessary in virtually all cases to meet the specific needs of this project. Programming code for the simulation appears in Appendix F.

Before discussing specific features of the model, the step-size (DT) employed warrants mention. Whenever numerical (Euler) integration is used, a certain amount of error is introduced via discrete approximation of the continuous processes being modeled (Manetsch and Park, 1982). The magnitude of this error is directly related to the size of the time step (DT) employed, and can be evaluated by considering the model's ability to conserve flow. For the current research, this evaluation entailed determining the percentage difference between (beginning inventory + pigs weaned) and (ending inventory + deaths + marketings).

Initially, the model was run with ten iterations per day ($DT = 0.1$). With this step size, errors in conservation of flow due to numerical integrations were generally $\leq 0.1\%$ over the course of simulating three months. When DT was increased to one iteration per day, errors were still $\leq 0.5\%$ over a similar time frame. Though a larger

DT (for instance $DT = 5$ days) would have perhaps provided acceptable simulation results, $DT = 1$ was maintained since it is consistent with normal discrete biological, environmental, and managerial activities. Associated simulation run-time on the COMPAQ Portable II was approximately one minute per producer-quarter (simulation for one producer over a single annual quarter). Because Monte Carlo analysis involved 200 simulations per producer-quarter for each scenario evaluated, a COMPAQ 386/20 (equipped with a math co-processor) was employed for Monte Carlo analyses. Simulation run-time on this computer involved about 10 seconds per producer-quarter.

Discrete Delays

In Figure 4.1, the boxes labeled *NURSERY* and *GROWER* refer to discrete time delays in the computer simulation model and correspond to the time pigs spend in the respective production phases on the farm. The length of these delays was determined by the weaning and pig flow schedules for the farm of interest. For purposes of simulation, it was assumed that on the day pigs were weaned and moved into the *NURSERY*, pigs were also moved from the *NURSERY* to the *GROWER* and from the *GROWER* to the *FINISHER*. With the beginning of simulation, the initial state of these discrete delays was determined by the current inventories and the current stage of the weaning schedule. During the respective delays, the *NURSERY* and *GROWER* experienced death losses at rates derived from the SHIMS database, and, as mentioned, an alpha-beta tracker. Inputs to the *NURSERY* delay were provided by weaned pigs entering the system. As discussed, pigs leaving the *NURSERY* provided input to the *GROWER*. Further, pigs left the *GROWER* according to the same weaning schedule. These delays were provided by the DCTDEL subroutine in Appendix F.

Distributed Delay

In contrast to the discrete delays of the *NURSERY* and *GROWER*, the box labeled *FINISHER* in Figure 4.1 refers to a distributed, or continuous delay (Manetsch,

1976; Abkin and Wolf, 1976). This technique represented the dynamic pig population in the finish phase, received input from the *GROWER*, and, like the other phases, experienced losses according to the death rate. When the entire population was considered, the distributed delay caused the different amounts of time (or delays) that individual hogs spend in the *FINISHER* phase to be distributed according to an Erlang probability density function (Manetsch and Park, 1982). The general form of this distribution can be represented as:

$$f(t) = \frac{(a * k)^k * (t)^{k-1} * e^{-kat}}{(k - 1)!}$$

where $E[t] = \frac{1}{a}$

and $Var[t] = \frac{1}{(k * a^2)} .$

For the distributed delay, t represents time, while k and a are constants which specifically define the particular delay process being modeled. Because, as stated, the mean of the Erlang distribution is $1/a$, the mean delay for a distributed delay process determines the value of the constant a . In Figure 4.1, the mean delay is represented by *DELAY*, and consequently

$$a = \frac{1}{DELAY} .$$

Thus, the shape of the output distribution was determined by its mean (*DELAY*), and variance.

As presented, the variance of the Erlang-distributed delay times is related to both the mean ($1/a$) and the parameter k . The effect of k on the shape of the Erlang distribution can be seen in Figure 4.3. As the figure illustrates, the distribution is exponential if $k = 1$, but as k increases, a Gaussian distribution is approximated. Thus, the value of a is determined by the mean delay time, and the value of k should be

selected specifically to match the output probability density function's shape with reality (as closely as possible) for the delay process of interest.

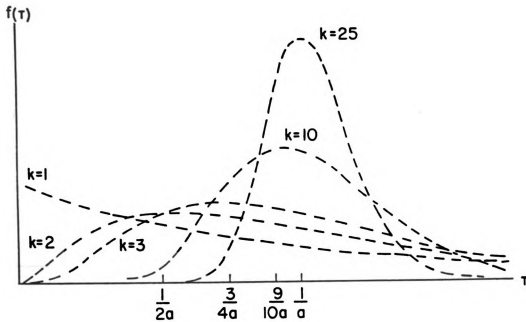


Figure 4.3. The Erlang family of probability density functions (from Manetsch and Park, 1982)

For current purposes, selection of an appropriate k value necessitated an understanding of hog growth patterns. In general, for any given group of hogs, some individuals will markedly out-perform the rest in terms of growth rate. Subsequently, the majority of the remaining hogs will experience a growth rate relatively close to the mean for the group. Finally, the slowest-growing portion of the group may contain individuals whose growth rate is extremely slow. Generally speaking, the performance of this slow-growing portion lies much further, in a relative sense, from the entire group's overall mean than does that of the fastest-growing portion. The resulting

distribution of growth rates is similar to a normal distribution, but is somewhat skewed to the right.

For further clarification, the following example is offered. Suppose 100 hogs of identical weight and sex were placed on performance test where all hogs experienced exactly the same nutrition and environmental conditions. Further, suppose these hogs were fed precisely to an arbitrary target weight, and the mean number of days required to achieve that weight was 100. The distribution of individual hogs' days-to-weight would be expected to follow the general pattern presented in Table 4.2. Note that absolute deviation from the mean of 100 days in this fabricated example is irrelevant. The important feature is the general distribution characteristics of days-to-weight.

Table 4.2 Hypothetical distribution of individual hog growth rates

Number of days to target weight	Number of individual hogs in group
less than 80	4
81 to 85	7
86 to 90	11
91 to 95	15
96 to 100	16
101 to 105	15
106 to 110	12
111 to 115	8
116 to 120	5
121 to 125	3
126 to 130	1
over 130	3

Because the Erlang distributions with k parameters in the range of 30 to 50 most closely match the described growth characteristics of market hogs, a value of 40 was chosen as a feasible mid-range. The distributed delay, which also experienced death losses, was accomplished by the following subroutine, adapted from MOPTSIMⁿ and programmed for QuickBASIC^m:

```

DEFINT I-N
SUB DELTV (UDTV, YDTV, QTV(), TQTV, Dths, DTV, DT, KDTV) STATIC
DDD1 = DTV / KDTV
BDD1 = 1 / DDD1
KDTV1 = KDTV - 1
FOR JJDD = 1 TO KDTV1
QTV(JJDD) = QTV(JJDD) + DT * (QTV(JJDD + 1) / DDD1 - QTV(JJDD) *
      BDD1) - (Dths * QTV(JJDD) / TQTV)
NEXT JJDD
QTV(KDTV) = QTV(KDTV) + DT * (UDTV - QTV(KDTV) * BDD1)
TQTV = 0
FOR IIDDD = 1 TO KDTV
TQTV = TQTV + QTV(IIDDD)
NEXT IIDDD
YDTV = QTV(1) / DDD1
END SUB

```

```

REM UDTV = input rate in pigs/day
REM YDTV = output rate in pigs/day
REM QTV() = intermediate storage array
REM TQTV = total storage
REM Dths = number of pig deaths per DT
REM DTV = DELAY
REM DT = time step
REM KDTV = number of intermediate stages (dimension of QTV())

```

As discussed, output from the distributed delay is continuous. However, hogs are marketed in discrete groups. Therefore, it was necessary for the model to convert the continuous flow of hogs out of the distributed delay into a flow of discrete groups, appropriately varying in size according to the inherent growth rates. To accomplish this, hogs exiting the distributed delay continuously were gathered and held in a "pool" awaiting market.

Though this programming technique was necessary for modeling purposes, it can be thought to correspond to those hogs that attain a marketable weight sometime between scheduled marketing days, but must be held on the farm for an additional period of time due to the fixed marketing schedule. As such, the pool in the model was emptied at discrete time intervals, which were determined by the marketing schedule. Also, because the pool was a legitimate part of the *FINISHER* phase, death losses occurred from the pool at the same rate as from the distributed delay. Since input to the pool was continuous and emptying occurred according to the normal marketing

interval, the mean amount of time hogs spent in the pool was one half of the marketing interval. Therefore, when combined with the mean time spent in the distributed delay, the expected total time in the *FINISHER* phase can be represented as follows:

$$E[\text{Total } \textit{FINISHER} \text{ Time}] = \text{DELAY} + \frac{\text{Marketing Interval}}{2}$$

Triangular Probability Density Functions

By their character, biological systems frequently exhibit substantial random variation. Considering the effects of various factors on hog production offers no exception. This is perhaps reflected in the fact that the literature often holds several different estimates of the "actual" performance effect of individual production factors. For current purposes, these various estimates formed the basis for the inclusion of stochasticity. Technically, the effect of each individual factor was hypothesized to form a triangular probability density function, as represented in Figure 4.4. Estimates were included for the lowest possible (A), most likely (B), and highest possible (C) production effect of each factor. During simulation, [0,1] random numbers were generated and then passed through inverse transformation (Manetsch and Park, 1982) based on these triangular probability distributions. The result was a unique, stochastically generated production effect each time the subroutine was called. Inverse transformation occurred in the TRIDIST subroutine of Appendix F.

Autocorrelation

Returning to the concept of an adjustment approach, it was deemed desirable to autocorrelate the random numbers generated from one period to the next. Thus, though ultimately stochastic, current production factor effects would be related to those of immediate past periods. Manetsch and Park (1982) described a technique useful in introducing exponential autocorrelation to a generated series of random numbers. The following equation defines the desired activity:

$$r(t) = (\beta^{DT} * r(t-DT)) + ((1 - \beta)^{DT} * s(t))$$

where

$r(t)$ = the value of the autocorrelated, random variable to use in the current time period,

DT = the time-step size in relation to the denominator of model rate variables,

$r(t-DT)$ = the value of the autocorrelated, random variable used in the immediate past time period,

$s(t)$ = an independent random number to be generated in the current time period,

and

β = the desired autocorrelation coefficient.

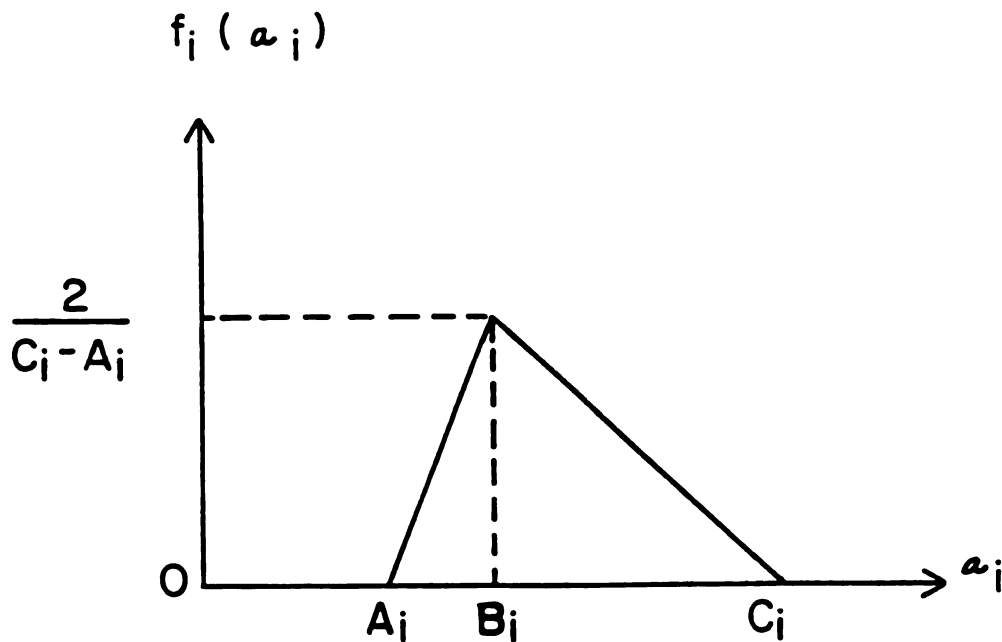


Figure 4.4. Triangular probability density function

As individual series of random numbers, $r(t)$, $r(t-DT)$, and $s(t)$ each has an associated probability density function which can be described, at least in part, by respective means and variances. In the long run, the $r(t)$ and $r(t-DT)$ distributions are

nearly identical, differing only in the first and last numbers generated. Since this distribution is generally predetermined, based on the stochastic process being modeled, the characteristics of the $s(t)$ distribution are dictated by the autocorrelation coefficient, β , the time step, DT , and the probability distribution, $r(t)$. Only in rare instances would $s(t)$ be expected to be identical to $r(t)$ or to be distributed as $[0,1]$ uniform.

Thus, it is critical to fully understand the statistical ramifications of the above equation so that the autocorrelated, random variables used possess the desired statistical properties. Along these lines, Ross (1985) showed that, if X and Y are independent random variables and a and b are constants, then

$$E[(a * X) + (b * Y)] = (a * E[X]) + (b * E[Y])$$

and
$$\text{Var}[(a * X) + (b * Y)] = (a^2 * \text{Var}[X]) + (b^2 * \text{Var}[Y]) .$$

For current purposes,

$$r(t) = (a * X) + (b * Y) ,$$

$$r(t-DT) = X ,$$

$$s(t) = Y ,$$

$$\beta^{DT} = a ,$$

and
$$(1 - \beta)^{DT} = b .$$

Now, because
$$E[r(t)] = (\beta^{DT} * E[r(t-DT)]) + ((1 - \beta)^{DT} * E[s(t)]) ,$$

it follows that
$$E[s(t)] = \frac{E[r(t)] - (\beta^{DT} * E[r(t-DT)])}{(1 - \beta)^{DT}} .$$

Also, since
$$\text{Var}[r(t)] = (\beta^{2DT} * \text{Var}[r(t-DT)]) + ((1 - \beta)^{2DT} * \text{Var}[s(t)]) ,$$

it can be seen that
$$\text{Var}[s(t)] = \frac{\text{Var}[r(t)] - (\beta^{2DT} * \text{Var}[r(t-DT)])}{(1 - \beta)^{2DT}} .$$

Finally, because $r(t)$ and $r(t-DT)$ are virtually identical,

$$E[r(t-DT)] = E[r(t)]$$

and
$$\text{Var}[r(t-DT)] = \text{Var}[r(t)] .$$

Thus, it is possible to determine the necessary properties of $s(t)$, based on knowledge of β , DT , $E[r(t)]$, and $\text{Var}[r(t)]$.

In the current exercise, $DT = 1$ because rates were expressed in quantities per day and step size was one day. As such, β became a simple correlation coefficient. Also, to maintain desired characteristics of the triangular distributions, the distribution of $r(t)$, and thus $r(t-DT)$, was $[0,1]$ uniform. For this reason,

$$E[r(t)] = 0.5$$

and
$$\text{Var}[r(t)] = 0.08333 \text{ (or } 1/12\text{)}.$$

Thus, the only remaining parameter to be defined was β .

Estimates of β are non-existent in the literature. However, certain restrictions can be derived from other properties of the processes involved, which constrain the statistical properties of $s(t)$. Since $DT = 1$ and $E[r(t)] = E[r(t-DT)] = 0.5$, $E[s(t)] = 0.5$ regardless of the β value. This can be illustrated mathematically as follows:

because
$$E[s(t)] = \frac{E[r(t)] - (\beta^{DT} * E[r(t-DT)])}{(1 - \beta)^{DT}}$$

by substitution
$$E[s(t)] = \frac{0.5 - (\beta * 0.5)}{(1 - \beta)}$$

by simplification
$$E[s(t)] = \frac{(1 - \beta) * 0.5}{(1 - \beta)}$$

and
$$E[s(t)] = 0.5 .$$

Thus, the mean of $s(t)$ was unaffected by β .

On the other hand, β is very important to the variance of $s(t)$; theoretical restrictions which may exist on $\text{Var}[s(t)]$ are therefore critical. Because of the definitive $[0,1]$ endpoints desired on $r(t)$, $s(t)$ also required $[0,1]$ endpoints. The maximum variance for a probability distribution with definitive $[0,1]$ endpoints is provided by the binomial distribution, whose variance is 0.25. The minimum possible variance for $s(t)$ was determined as follows:

because
$$\text{Var}[s(t)] = \frac{\text{Var}[r(t)] - (\beta^{2DT} * \text{Var}[r(t-DT)])}{(1 - \beta)^{2DT}}$$

by substitution
$$\text{Var}[s(t)] = \frac{(1 - \beta^2)}{(1 - \beta)^2} * 0.08333$$

or
$$\text{Var}[s(t)] = A * 0.08333$$

where
$$A = \frac{(1 - \beta^2)}{(1 - \beta)^2} .$$

From this it can be seen that to minimize $\text{Var}[s(t)]$ over the range $0 \leq \beta \leq 1$ is equivalent to minimizing A over the range $0 \leq \beta \leq 1$. Because

$$\frac{dA}{d\beta} > 0 ,$$

A was minimized over this range where $\beta = 0$. By substituting for β , a value of $A = 1$ was obtained. Therefore, the minimum variance obtainable for $s(t)$ was given by

$$\text{Var}[s(t)] = A * 0.08333$$

or
$$\text{Var}[s(t)] = 0.08333 .$$

Returning to the issue of a value for β , then, useful restrictions have been identified. At minimum $\text{Var}[s(t)]$, $\beta = 0$ as mentioned. At maximum $\text{Var}[s(t)]$, β was calculated from the above equation(s) as follows:

because
$$\text{Var}[s(t)] = \frac{(1 - \beta^2)}{(1 - \beta)^2} * 0.08333$$

by substitution
$$0.25 = \frac{(1 - \beta^2)}{(1 - \beta)^2} * 0.08333$$

so
$$3 = \frac{(1 - \beta^2)}{(1 - \beta)^2}$$

or
$$3 = \frac{1 + \beta}{1 - \beta}$$

and
$$\beta = 0.5 .$$

These values provided the feasible range as $0 \leq \beta \leq 0.5$, corresponding to a range in $\text{Var}[s(t)]$ of $0.08333 \leq \text{Var}[s(t)] \leq 0.25$. Without guidance from the literature, the median value of $\text{Var}[s(t)] = 0.1667$ was selected for current modeling purposes. Following the above procedure for calculating β (and remembering that both $r(t)$ and $r(t-DT)$ are distributed as $[0,1]$ uniform), this value of $\text{Var}[s(t)]$ dictated that $\beta = 0.333$. In practical terms, $\beta = 0.333$ assured that the proportional effect which individual production factors have on growth rate in the current period was related to the same factor's effect in the immediate past period by a simple correlation of 0.333. The remaining 0.667 of the proportional effect was determined by the probability distribution $s(t)$.

Considering the desired statistical properties of $s(t)$, it remained to define a probability density function to meet the requirements. The necessary properties included:

1. $s(t)$ distributed over $[0,1]$,
2. $E[s(t)] = 0.5$, and
3. $\text{Var}[s(t)] = 0.1667$.

Further, it was recognized that, by the definition of probability density function,

$$\int_0^1 s(t) * dt = 1$$

$$\begin{aligned} \text{and} \quad \text{Var}[s(t)] &= E[(s(t))^2] - (E[s(t)])^2 \\ &= \int_0^1 (t^2 * s(t) * dt) - 0.25 \\ &= 0.1667 . \end{aligned}$$

Thus, a suitable function for $s(t)$ was sought.

As when choosing a function appropriate for combining multiple proportional production effects, mathematical tractability was considered in the search for $s(t)$, but only after theoretical constructs were satisfied. The desired variance was greater than the value of 0.08333 which is characteristic of the uniform $[0,1]$ distribution. Such a variance required that relatively more area exist under the curve near the definitive $[0,1]$

endpoints of $s(t)$ than when near the mean of 0.5. Further, a smooth function was preferred which would be symmetrical while approximating an inverted Gauss distribution. It was recognized that, with relatively minor adjustment, a trigonometric function might provide the desired qualities. Therefore, by correcting for appropriate period and x-intercept, the following equation was used:

$$s(t) = a * [\cos(2\pi t) + 1]^b, \quad 0 \leq t \leq 1.$$

Given proper values for a and b , this function would meet current requirements.

As suggested by the aforementioned definition of a probability density function, simultaneous solution of

$$\int_0^1 (a * [\cos(2\pi t) + 1]^b * dt) = 1$$

$$\text{and} \quad \int_0^1 (t^2 * a * [\cos(2\pi t) + 1]^b * dt) - 0.25 = 0.1667$$

was possible. Doing so provided the following values:

$$a = 0.6974495$$

$$\text{and} \quad b = 1.903711.$$

Solution was accomplished iteratively with the aid of a microcomputer. The resulting function is represented graphically in Figure 4.5.

Finally, not only did it seem reasonable to correlate individual factor performance effects over time within production phases, but it also seemed logical to correlate these effects, at least initially, between phases for individual factors, and even between factors within similar factor groups. Therefore, the same modeling approach was used to introduce such initial autocorrelation. As a result, the effect that individual production factors had on performance was initially correlated between the *NURSERY*, *GROWER*, and *FINISHER* phases. Also, initial performance effects were correlated within groups of similar factors, resulting in relationships such as might be expected between the effects of mild, moderate, and severe pneumonia on a given farm.

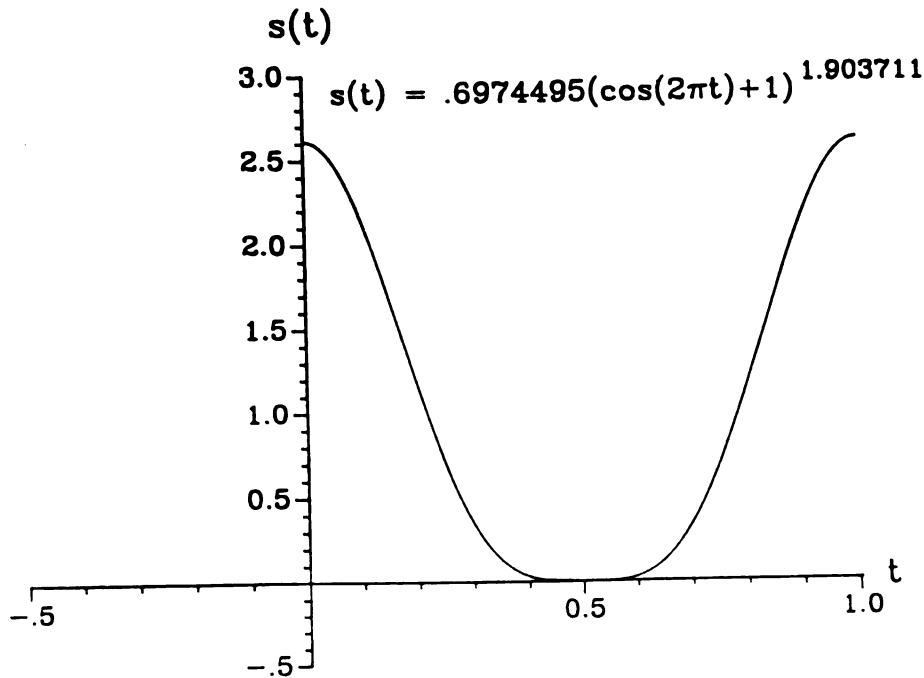


Figure 4.5. Autocorrelation function

All such production factor groups are listed in Table 4.3, where initial autocorrelations are indicated by arrows. For purposes of clarification, Table 4.3 indicates that for the pneumonia group, only the effect of mild pneumonia in the *NURSERY* had an independent, random initial variation for any given farm. The remaining pneumonia disease category effects across production phases were autocorrelated. As indicated, the effect of moderate pneumonia in the *NURSERY* was autocorrelated with the effect of mild pneumonia in the *NURSERY*. The effect of severe pneumonia in the *NURSERY* was then autocorrelated with the effect of moderate pneumonia in the *NURSERY*. Similarly, the effect of mild pneumonia in the *GROWER* was autocorrelated with the effect of mild pneumonia in the *NURSERY*. Then, the effect of moderate pneumonia in the *GROWER* was autocorrelated with the effect of

GROUP 1—PNEUMONIA						GROUP 4—ATROPHIC RHINITIS					
			Nursery Grower Finisher						Nursery Grower Finisher		
Mild	X	→	X	→	X	Mild	X	→	X	→	X
	↓		↓		↓		↓		↓		↓
Moderate	X		X		X	Moderate	X		X		X
	↓		↓		↓		↓		↓		↓
Severe	X		X		X	Severe	X		X		X
							↓		↓		↓
						Septal Deviation	X		X		X
GROUP 2—ASCARIASIS						GROUP 5—PLEURITIS, PERICARDITIS					
			Nursery Grower Finisher						Nursery Grower Finisher		
Mild	X	→	X	→	X	Pleuritis	X	→	X	→	X
	↓		↓		↓		↓		↓		↓
Moderate	X		X		X	Pericarditis	X		X		X
	↓		↓		↓						
Severe	X		X		X						
GROUP 3—MANGE						GROUP 6—SPACE PER PIG					
			Nursery Grower Finisher						Nursery Grower Finisher		
Mild	X	→	X	→	X		X	→	X	→	X
	↓		↓		↓						
Moderate	X		X		X						
	↓		↓		↓						
Severe	X		X		X						

mild pneumonia in the *GROWER*. Thus, the pattern for initial autocorrelation of production effects is apparent.

The arrows in Table 4.3 indicate the order in which correlation is introduced by the computer simulation model. However, this order is not mathematically critical to the underlying systems model; the arrows could all be reversed without changing the mathematical results. Thus, for example, the interpretation should be that the effects of moderate and mild pneumonia in the *NURSERY* are correlated, without concern for which is determined first by the computer.

To summarize autocorrelation, the $[0,1]$ random number which was passed to a triangular probability distribution for inverse transformation has been referred to as $r(t)$. This number was independently generated only during the initial time step and only once for each production factor group. Remaining $r(t)$ values within the first time step were autocorrelated across production phases for a given factor group, and across individual factors within groups for a given production phase. In subsequent time steps, all values of $r(t)$ were autocorrelated with immediate past values for the same individual production factor. These autocorrelations were, in effect, simple correlations of the magnitude 0.333. The remaining 0.667 was determined independently from the probability density function which has been discussed and referred to as $s(t)$. To obtain a value from $s(t)$, a number was generated independently from a $[0,1]$ uniform distribution and passed through $s(t)$ for inverse transformation. When this value from $s(t)$ was appropriately combined with the autocorrelated portion, the result was a value for $r(t)$ which was both autocorrelated and distributed as $[0,1]$ uniform. Thus, the desired properties of the triangular distribution were preserved.

Table Look-up Function

The trigonometric function developed for autocorrelation purposes nicely satisfied the desired statistical properties. However, one other property of the function was its relative difficulty for digital solution. Though the computer employed was certainly capable of such solution, the frequency with which the function was called for

inverse transformation (up to 63 times per time step) resulted in considerable lengthening of simulation run-times. For this reason, a table look-up function was introduced.

The table look-up function can be thought to store ordinate values of a particular function in an array ordered according to the value of the abscissa. When the ordinate value corresponding to a given abscissa value is sought, the table look-up locates the array values between which the abscissa of interest lies and performs linear interpolation on the corresponding ordinate values.

As might be expected, the accuracy of the table look-up function is directly related to the size of the abscissa increments stored in array. Precision can be increased by decreasing the increment size. Though limited sacrifice may be made on the side of accuracy, the speed with which digital computers can perform the relatively simple tasks involved greatly exceeds that required to do complex mathematics such as contained in the $s(t)$ function defined previously. To restrict accuracy problems, the increment size employed in the current model was 0.01 over the desired abscissa range of [0,1]. The process was accomplished by the TABEX subroutine of Appendix F.

Delay Modification

Initially, *DELAY* entered the model as an observed parameter from past production (*Initial DELAY* from Figure 4.1). However, *DELAY* experienced modification, as represented by the box labeled *DELMOD* in Figure 4.1. This modification, as mentioned, resulted from changes in feed additive use, available floor space per pig, and disease rates observed at slaughter.

Though some of these factors have their biological effect in the *NURSERY* or *GROWER* phases, their net impact is to change the amount of time pigs take to reach market weight. Because of the predetermined, management-controlled discrete delays in earlier phases, the only flexibility in total transit time for the model (and generally also in reality) is to change the time spent in the *FINISHER* phase. In the model this

was accomplished by changing *DELAY*. An example of how these effects are experienced in the actual system is provided by a hypothetical *GROWER* pig with atrophic rhinitis. Because this pig is diseased, it will be expected to grow more slowly than if it were disease-free. However, because the amount of time spent in the *GROWER* is fixed, the net effect is delivery of a smaller pig to the *FINISHER* phase. As a result, the amount of weight gain (and consequently the length of time) required in the *FINISHER* is increased. Explanation of the *DELAY* modification technique follows.

As discussed, the model used an adjustment approach to represent production. For *DELAY* modification, this meant that feed additives might be introduced or withdrawn, available floor space per pig may expand or contract, and disease rates might escalate or decline. Again, these changes may occur in any of the three production phases, and resulting changes in *DELAY* can be increases or decreases. The magnitude of expected change corresponding to a known, discrete change in disease rates, feed additives, or space per pig were determined through survey of the literature.

Usually, research in these areas has published an expected proportional (or percentage) effect on average daily gain (ADG), rather than transit time (or "days to market." Mathematically, this usual approach can be expressed as:

$$ADG(t+DT) = ADG(t) * (1 + PrEff_{ADG}) ,$$

where ADG = average daily gain,

t = current time period,

DT = time step,

and $PrEff_{ADG}$ = expected proportional effect of change in production factor on growth rate over a time period of length DT .

Verbally, this equation says that the new growth rate, $ADG(t+DT)$, is equal to the current growth rate, $ADG(t)$, multiplied by the quantity one plus the expected proportional change, or $(1 + PrEff_{ADG})$.

Assuming target weight for any particular production phase is relatively constant, the above format can be modified to address transit time instead of growth rate, since days-to-weight is the mathematical inverse of growth rate. For factors that affect the entire population, such as space per pig and feed additives, the following technique was used:

$$DTW(t+DT) = DTW(t) * \frac{1}{(1 + PrEff_{ADG})}$$

or $DTW(t+DT) = DTW(t) * (1 + PrEff_{DTW})$,

where $DTW = \text{days to target weight}$,

$$PrEff_{DTW} = \frac{-PrEff_{ADG}}{(1 + PrEff_{ADG})},$$

and other variables are as defined above. For factors that only affect part of the herd, like disease rates, the following approach was used:

$$DTW(t+DT) = (DTW(t) * (1 - DDR)) + (DTW(t) * DDR * \frac{1}{(1 + PrEff_{ADG})})$$

or $DTW(t+DT) = DTW(t) * (1 + (DDR * PrEff_{DTW}))$,

where $DDR = \text{the change in disease rate from time (t) to time (t+DT)}$,
and other variables are as defined previously.

Basically, this is a weighted average approach. The proportion of the herd not experiencing a change in disease status $(1 - DDR)$ has no change in performance $(DTW(t))$. However, the proportion of the herd whose disease status changes undergoes an alteration of performance according to $PrEff_{ADG}$. If the entire herd experiences a change in disease status, then DDR would equal one. In this situation, these equations become equivalent to those in the preceding section which were developed for factors affecting the entire population, and the two adjustment techniques are seen to be consistent. As previously mentioned, all specific factors that affect production in this

model are listed in Table 4.1. Though only one list appears, each item can change performance in any of the *NURSERY*, *GROWER*, or *FINISHER* phases.

For single factor changes considered discretely, this approach would seem to be adequate. However, when the simultaneous effects of numerous potential changes in production need to be evaluated, an acceptable approach for their concurrent consideration is not as definitive, and suggested techniques are not available in the literature. Theoretically, since the individual factor adjustment techniques discussed are mathematically consistent, it should be possible to combine the individual effects of a group of changing factors into a single, "total" proportional effect. Then, this combined effect would change days to target weight as:

$$DTW(t+DT) = DTW(t) * (1 + \text{TotPrEff}_{DTW}) ,$$

where TotPrEff_{DTW} represents the combined effect as discussed.

If all factors contributing to TotPrEff_{DTW} have equal relative importance, ie. an expected one percent production difference from changing disease rates is as important as a one percent change from space per pig, the following theoretical boundaries can be placed on TotPrEff_{DTW} :

1. $\text{TotPrEff}_{DTW} > -1$, since $\text{PrEff}_{DTW} \leq -1$ would result in $DTW(t+DT) \leq 0$;
2. $|\text{TotPrEff}_{DTW}| \leq |\sum_{i=1}^n \text{PrEff}_{DTW}(i)|$ for production factors 1 to n;
and
3. TotPrEff_{DTW} monotonically increases (and thus has no maximum), but increases at a continually decreasing rate.

The first of these conditions provides that when increasing performance and consequently decreasing the number of days required to reach a target weight (greater than the current weight), it is biologically impossible to have a negative value for days-to-weight. Increasing growth rate can substantially decrease the number of days

required to achieve a prescribed weight gain, but it is not possible to decrease the number of days-to-weight beyond zero.

The second condition states that the combined proportional effect of n factors on production ($\text{TotPrEff}_{\text{DTW}}$) is not greater in absolute magnitude than the simple linear sum of the n individual production effects. For example, if two different factors change simultaneously and each is expected to increase growth rate by five percent, the combined effect would not be expected to exceed ten percent.

Finally, the first part of the third provision allows days-to-weight to increase infinitely, establishing no maximum for days-to-weight. Such a provision is theoretically sound, since even though individuals may grow very, very slowly, there can be no definitive, absolute upper limit established for the number of days required to attain a given target weight. The second part of the condition merely says that a negative proportional effect on production probably has a smaller relative effect on a hog that is already slow-growing than it has on a high-producing individual.

Based on these properties, the following relationship was hypothesized and included in the model:

$$y = \begin{cases} e^x - 1 & \text{for } x \leq 0 \\ \ln(x+1) & \text{for } x \geq 0 \end{cases}$$

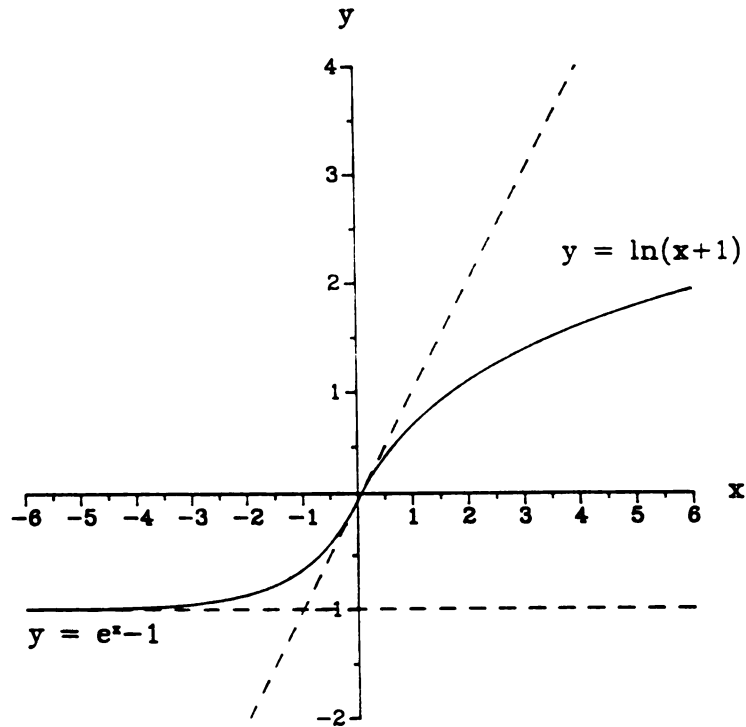
where x = the linear sum of individual proportional production factor effects

and y = the net proportional production effect resulting from simultaneous consideration of all individual production factor effects contained in x .

This relationship is illustrated graphically in Figure 4.6.

Though the choice was ultimately arbitrary, this function was first chosen because it satisfied the theoretical conditions discussed. In addition, the function $y = f(x)$ is mathematically well-behaved, since it is both continuous (uninterrupted) and continuously differentiable (possessing a first derivative everywhere on the function). From evaluation of the figure, it can be seen that $\text{TotPrEff}_{\text{DTW}}$, represented as the solid curve, is everywhere greater than negative one. Thus, the first conditions is

satisfied. Also, the absolute value of $\text{TotPrEff}_{\text{DTW}}$ is always less in absolute magnitude than the simple linear sum of the n individual production effects, represented by the broken-line diagonal, satisfying the second condition. Finally, as the simple linear sum of individual factor proportional effects increases, $\text{TotPrEff}_{\text{DTW}}$ also increased, but at a decreasing rate. $\text{TotPrEff}_{\text{DTW}}$, therefore, has no maximum, and condition three is satisfied.



x = linear sum of individual proportional
production factor effects

y = net combined proportional production effect

Figure 4.6. Combined proportional production effects

Thus, to summarize, *DELAY* was stochastically modified with the assistance of triangular probability distributions which were autocorrelated. The net proportional production effect resulting from combining the effects of several individual production factors was determined by the function presented in Figure 4.6. A schematic overview

of the *DELAY* modification process (contained in subroutine *DELMOD* of Appendix F) appears in Figure 4.7. For purposes of clarification, the following hypothetical example is offered.

If pigs become crowded and simultaneously experience an increase in respiratory disease, the net effect of these concurrent changes would be captured as follows. The effect of decreasing available floor space per pig would be stochastically obtained from a triangular probability density function. This function is defined by the highest possible, most likely, and lowest possible effects expected for the given change in space per pig. However, the stochastic event would not be independently generated: it would be autocorrelated with the effects experienced as a result of changing available floor space per pig in the immediate past time period. Thus, the response of the pigs would be random, but would also be related to previous responses to changes in floor space.

A similar process would generate an expected effect for the increasing respiratory disease. Again, the result would be obtained stochastically from a characteristic triangular probability density function, with the outcome autocorrelated with the production effect associated with changing pneumonia in past periods.

Finally, the net production effect expected from experiencing simultaneous changes in these two production factors would be obtained through use of the function proposed for combining individual production effects. This would be accomplished by first adding the individual proportional effect obtained for changing floor space to that obtained for changing respiratory disease. The resulting sum would then be "passed through" the natural logarithm function presented above. Thus, the function's value corresponding to the given sum would provide the net effect considered by the model to be exerted by these two simultaneously changing production factors.

Due to the methods employed in defining this critical modification process, serious scrutiny should ensue when data permit. Obviously, theoretical appeal does not guarantee validity.

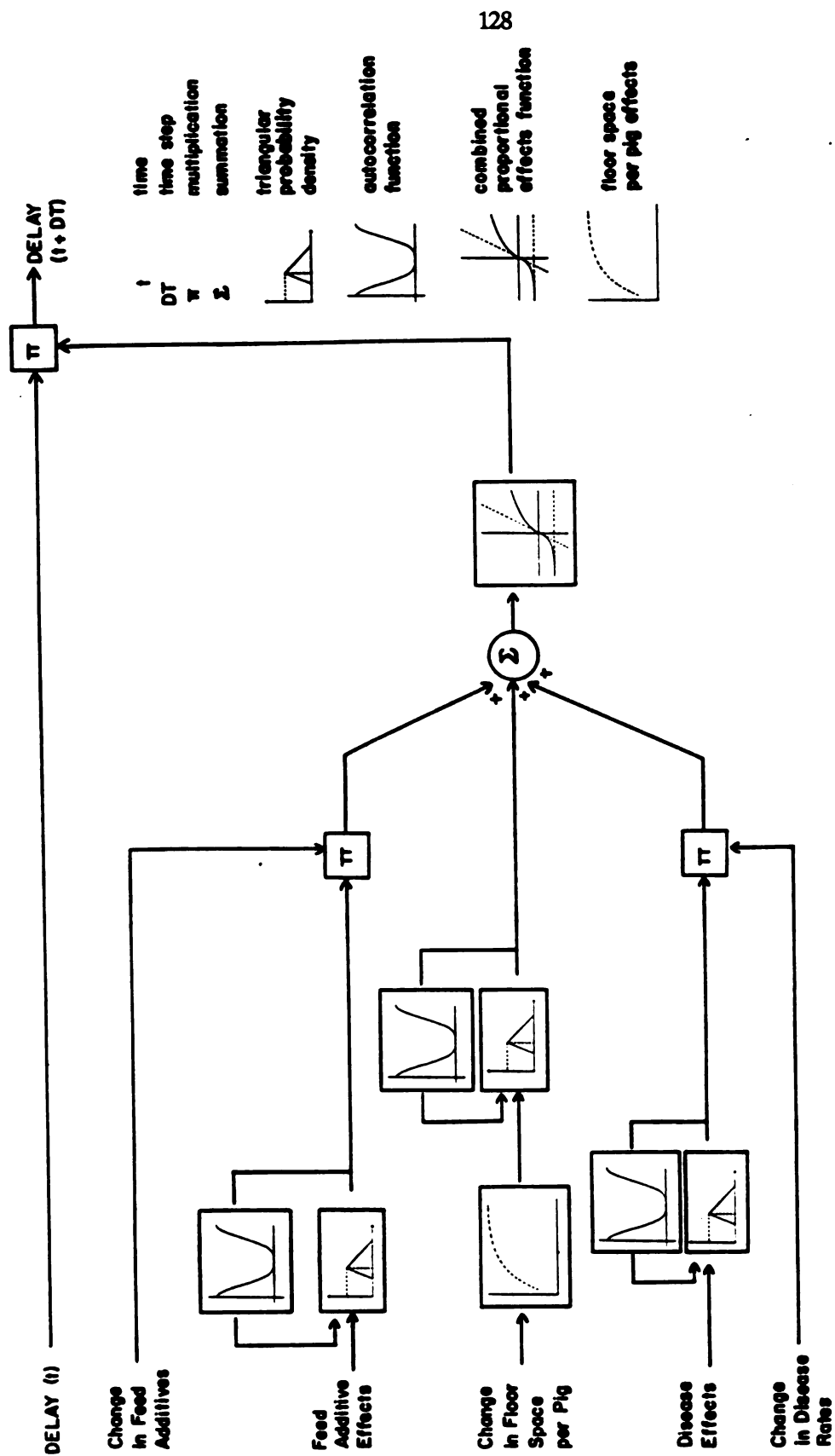


Figure 4.7. Schematic representation of DELAY modification, Michigan State University SHIMS project

Alpha-beta Tracker

Simulation inherently involves projection. However, successful prediction of system performance and output often hinges on the availability of information regarding future values of certain underlying system variables (input levels and prices, output prices, disease rates, death rates, rate of feed consumption, etc.). Therefore, accurate simulation of system performance is frequently contingent upon the accuracy of previous forecasts for these system variables. However, completion of such forecasts is not a trivial task. The variables of interest are often difficult to observe reliably, which markedly complicates their prediction. In the absence of extensive sets of accurate data with which to formulate predictive statistical models for these system variables, certain projection techniques based on time series data are useful. Among these is the alpha-beta tracker (Manetsch, 1984).

An alpha-beta tracker predicts an unknown based solely on its current observed value, its current perceived rate of change, and its previously predicted value. The equations for the alpha-beta tracker are:

$$y(t) = y_p(t) + (\alpha * [u(t) - y_p(t)]) ,$$

$$dy(t) = dy(t-DT) + \frac{(\beta * [u(t) - y_p(t)])}{DT}$$

$$y_p(t+DT) = y(t) + (DT * dy(t)) ,$$

where $u(t)$ = measurement of the unknown from observation at time t ,

$y(t)$ = the estimate of the unknown at time t ,

$y_p(t)$ = prediction of the unknown at time t based on observations through time $(t-DT)$,

$dy(t)$ = estimated rate of change of the unknown at time t ,

$y_p(t+DT)$ = prediction of the unknown at time $(t+DT)$ based on observations through time t ,

and α, β = design parameters which tailor the alpha-beta tracker's performance to the particular system being modeled.

Notice that, in the first equation, the alpha-beta tracker "corrects" its own previous prediction based on an observation, $u(t)$, assumed to contain measurement error. For the current model, those variables forecast using an alpha-beta tracker are listed in Table 4.4. For illustrative purposes, the variables are organized in Table 4.4 according to general type. However, each of the 38 variables contained in the table were individually projected with its own alpha-beta tracker. Use of the alpha-beta trackers in relation to the rest of the model appears in Figures 4.1 and 4.2.

Table 4.4. Variable series projected with the alpha-beta tracker

Disease Rates	Non-feed Cash Expenses
Mild pneumonia	Repairs and maintenance
Moderate pneumonia	Veterinary care and drugs
Severe pneumonia	Labor
Mild ascariasis	Supplies
Moderate ascariasis	Fuel
Severe ascariasis	Electricity
Mild mange	Telephone
Moderate mange	Trucking
Severe mange	Marketing
Mild atrophic rhinitis	Insurance
Moderate atrophic rhinitis	Interest
Severe atrophic rhinitis	Taxes
Nasal septum deviation	Replacement females
Pleuritis	Replacement boars
Pericarditis	Other cash expenses
Pig Deaths	Feed Consumption
Finisher	Finisher
Grower	Grower
Nursery	Nursery
Marketing Measures	
Market hog weight	
Market hog price	

Optimization

As discussed in Chapter 2, the capacity for optimization is often desired for use with simulation because of its contribution to the model's applicability. Also, optimization can be useful in defining system parameters, as will be discussed later. For this modeling exercise, the optimization technique employed was the COMPLEX routine

of Box (Kuester and Mize, 1973). Basically, COMPLEX involves a non-gradient search algorithm. The user-defined objective function is optimized over the variables of concern by starting with a "best guess" at the true optimum and then randomly generating an entire set of alternative "possible" optima. This set must contain at least one more possible optimum than the number of variables included in the search. Once generated, these points are treated as vertices of a multidimensional geometric figure (or "complex"), whose centroid is subsequently calculated. Corresponding values of the objective function are calculated for each of the vertices and for the centroid.

Starting from the vertex with the worst objective function value and proceeding through the centroid, COMPLEX establishes a search direction. After moving a user-controlled distance in this direction, a new point is defined and evaluated for its corresponding objective function value. If this value is an improvement over that of the original worst vertex, the new point is substituted for the old worst vertex in the multidimensional figure. On the other hand, if the objective function value at the new point is not as good as that of the original worst vertex, COMPLEX moves back toward the centroid. The distance of this movement is also user-controlled and again, a "new" point is defined where the objective function value is evaluated and compared to that of the original worst vertex.

This process continues either until a "better" point is discovered, or until a user-defined criterion for maximum number of unsuccessful improvement attempts is exceeded, whereby the search is terminated short of the optimum. Barring such premature termination, inferior vertices are progressively replaced. An acceptable neighborhood and value for the optimum is achieved when the objective function values of an acceptable number of "new" vertices are within a prescribed amount of absolute objective function value variation. These search parameters are also user-defined.

COMPLEX is relatively efficient in moving to the neighborhood of the optimum. It is also capable of optimizing virtually any objective function, constrained or

unconstrained, and linear or non-linear. For these reasons, it provided a very good optimization routine for the current work.

Income Over Variable Costs

Finally, it is important to consider the methods used for financial calculations. Because fixed costs, assets, and liabilities were not included in the database, financial analysis was restricted to estimation of *Income Over Variable Costs*, as presented in Figure 4.2. Though certain aspects of a thorough financial analysis are precluded as a result, most short-term health management alternatives do not entail major changes in fixed costs, assets, or liabilities. If particular situations should arise where these factors are indeed critical to the analysis, the current model will supply the needed information on the changing variable factors to a somewhat broader analysis conducted after the model projections have been obtained.

In the current model, revenues are projected by combining the projections for hog marketings with those for market weights and market prices. Both feeder pigs and market hogs are included (see Figure 4.2), but the required information on numbers and prices for feeder pigs needs to be specifically entered (these are not projected). As a result, expected income was estimated as:

$$TPR_{Q+1} = (PMHS_{Q+1} * PMHP_{Q+1} * PMHW_{Q+1}) + (PFPS_{Q+1} * PFPP_{Q+1})$$

where TPR_{Q+1} = total projected revenue,

$PMHS_{Q+1}$ = projected market hog sales (from physical production model),

$PMHP_{Q+1}$ = projected market hog price (from alpha-beta tracker),

$PMHW_{Q+1}$ = projected market hog weight (from alpha-beta tracker),

$PFPS_{Q+1}$ = projected feeder pig sales (as entered by user),

and $PFPP_{Q+1}$ = projected feeder pig price (as entered by user).

All variable costs were formulated on a "per pig-day" basis, where input rates were obtained from the physical production model (*PIG DAYS* from Figures 4.1 and 4.2). Non-feed, variable input prices (*NON-FEED CASH EXPENSES* from Figure 4.2) were

projected with the alpha-beta tracker, but feed prices required input by the user. The feed prices entered were the total costs per pound for each of the nursery, grower, or finisher rations. Since only one price per ration was considered, it became a "blend" price which combined purchased and raised feeds. This approach was taken to preclude the need for distinguishing between home-raised and purchased feeds. Doing so also avoided the need to explicitly address appropriate transfer pricing techniques for feeds (between crop and livestock enterprises) in the model. Thus, total expected variable costs were estimated as:

$$\begin{aligned} \text{TPVC}_{Q+1} = & (\text{PNPD}_{Q+1} * \text{PNFPP}_{Q+1} * \text{PNFCPD}_{Q+1}) + (\text{PGPD}_{Q+1} * \\ & \text{PGFPP}_{Q+1} * \text{PGFCPD}_{Q+1}) + (\text{PFPD}_{Q+1} * \text{PFFPP}_{Q+1} * \\ & \text{PFFCPD}_{Q+1}) + (\text{PTPD}_{Q+1} * \sum_n \text{PNFVCPD}_{Q+1}) \end{aligned}$$

where TPVC_{Q+1} = total projected variable costs,

PNPD_{Q+1} = projected nursery pig-days (from physical production model),

PNFPP_{Q+1} = projected nursery feed price per pound (as entered by user),

PNFCPD_{Q+1} = projected nursery feed consumption per pig-day (from alpha-beta tracker),

PGPD_{Q+1} = projected grower pig-days (from physical production model),

PGFPP_{Q+1} = projected grower feed price per pound (as entered by user),

PGFCPD_{Q+1} = projected grower feed consumption per pig-day (from alpha-beta tracker),

PFPD_{Q+1} = projected finisher pig-days (from physical production model),

PFFPP_{Q+1} = projected finisher feed price per pound (as entered by user),

PFFCPD_{Q+1} = projected finisher feed consumption per pig-day (from alpha-beta tracker),

PTPD_{Q+1} = projected total pig-days (from physical production model),

PNFVCPD_{Q+1} = projected non-feed variable costs per pig-day (from alpha-beta tracker),

and $n = 15$, the number of different non-feed expense categories (from Table 4.4).

Finally, the computation of *INCOME OVER VARIABLE COSTS* proceeded as follows:

$$\text{PIOVC}_{Q+1} = \text{TPR}_{Q+1} - \text{TPVC}_{Q+1}$$

where PIOVC_{Q+1} = projected income over variable costs and other variables were as previously defined.

PARAMETER ESTIMATION

By its nature, systems modeling involves prediction of state changes for a given system over time. Initial state and system inputs provide the bases for change and system outputs are consequential. The rates of change for these state and input variables are referred to as *system parameters*. How successful the model is at projection is determined by the degree to which the model's system parameter values represent actual rates of change for the system being modeled. Therefore, definition of system parameters is an extremely critical step in the modeling process.

Various techniques are used to discover system parameters, depending on system characteristics and available modeling resources. These techniques range in degree of sophistication from simple use of expert opinion, to statistical estimation, to "reverse optimization" (which minimizes the difference between model projections and observed system performance). Those model parameters whose estimation was critical to the current work were *DELAY*, disease effects, feed additive effects, space effects, feed efficiency, and the alpha-beta tracker parameters.

Initial DELAY

Using only aggregate population data makes it difficult to accurately calculate a mean time spent in the production system (or days to market) for growing hogs. This is especially true if a relatively short time period is considered and if pigs entering and leaving the system are grouped. Thus, even though the SHIMS database specifically addresses physical production, the system parameter *DELAY* was difficult to estimate.

Because *DELAY* is expected to vary both across farms and over time, expert opinion and statistical estimation were not practical. For these reasons, "reverse optimization" using COMPLEX was employed. Such optimization is referred to as "reverse" since observed system performance was used to estimate system parameters through optimization rather than optimizing projected system performance based on observed system parameters.

In this case, optimization involved discovery of the mean *DELAY* which would minimize the sum of squared differences between observed and predicted values for ending inventory and total hogs marketed over individual 3-month periods. A modified version of the system model described earlier in this chapter was used for projecting pig-days. Changes to the model entailed removal of delay modifications and elimination of random variation while using observed values for input levels, specific days of input, and specific days of output. A unique search was conducted for each farm for every quarter. And each search involved a single variable: the mean *DELAY* for that particular three month period. The *DELAY* value resulting from optimization in any given quarter provided initial input for the *DELMOD* subroutine when the following quarter was simulated.

Disease Effects

Numerous accounts of the effects of disease on hog production exist in the literature. Commonly included in these is consideration of the production diseases included in the SHIMS database. Nearly all of these report decreased growth rates associated with disease. Though authors generally agree that this is the type of production effect that disease imparts, considerable disagreement exists regarding the absolute magnitudes of those effects. When individual diseases are considered, it is found that very limited information is available on the relative production effects according to severity of affliction.

For example, Lindqvist (1974) reported that hogs with pneumonic lesions at slaughter exhibited lower average daily gain (ADG) over the nursery, grower, and finisher phases than hogs without lesions. The mean differences observed were decreases of 6.2% and 0.2% for hogs with severe and mild lesions, respectively. However, the maximum difference in ADG was observed to be 26% and 9.6% lower for hogs with severe and mild lesions, respectively. In hogs with pleuritic lesions, the mean difference recorded was a 5.0% depression associated with pleuritis, with the worst being 19.5% lower. Severe ascarid-related liver scarring was associated with a mean ADG depression of 4.3% across several groups, while the maximum depression was 13.9%. And mildly ascarid-scarred livers accompanied hogs with a mean decrease of 1.2% in ADG, while the maximum decrease encountered was 7.74%.

Hale, *et al.* (1985) reported a decreased ADG in grower and finisher hogs of 9.2% associated with experimental infection with ascariasis. In contrast, Flesja, *et al.* (1984) concluded that evidence of ascariasis at slaughter could not be associated with any detectable performance difference. However, they did conclude that decreased ADGs in nursery, grower, and finisher pigs of 9.2%, 4.4%, and 1.6% were associated with presence of atrophic rhinitis, severe pneumonia, and moderate pneumonia at slaughter, respectively.

Finally, Straw and Ralston (1987) also reported decreased ADG associated with disease present at slaughter. For nursery, grower, and finisher hogs, the suggested decreases to be 3 to 26%, 7.6 to 12.5%, and 4.5% for pneumonia, mange, and ascariasis, respectively. With atrophic rhinitis, they documented decreased of 0 to 9% and 10% for grower/finisher and nursery pigs, respectively.

Because of the described state of current knowledge, the characteristics of the SHIMS database, and the design objectives of the current modeling exercise, estimation of disease effect parameters presented some potential problems. To facilitate *DELAY* modification, the effect of disease on growth rate was of particular interest. However,

insufficient data existed in the pilot phase of the SHIMS project to allow statistical estimation of parameters. While such estimation should be considered as a high priority for future efforts, it was necessary to use a combination of the above published reports and expert opinion (Thacker, 1987) to provide the needed values for the current modeling exercise. Summaries of these appear by production phase in Tables 4.5, 4.6, and 4.7. Notice that parameter presentation is readily amenable to the format required for the triangular probability density functions discussed earlier. Also, recall that even though these diseases affect production in all three production phases, diagnosis occurs only at slaughter.

Table 4.5. Proportional effects of SHIMS disease categories on finisher average daily gain (negative values indicate a depression of growth rate)

	Low	Mode	High
Severe pneumonia	-0.044	-0.122	-0.26
Moderate pneumonia	-0.021	-0.044	-0.126
Mild pneumonia	0.0	-0.021	-0.044
Severe ascariasis	-0.043	-0.091	-0.139
Moderate ascariasis	-0.024	-0.05	-0.077
Mild ascariasis	0.0	-0.012	-0.05
Severe mange	-0.076	-0.125	-0.206
Moderate mange	-0.046	-0.076	-0.125
Mild mange	0.0	-0.046	-0.076
Severe atrophic rhinitis	-0.059	-0.09	-0.138
Moderate atrophic rhinitis	-0.027	-0.059	-0.09
Mild atrophic rhinitis	0.0	-0.027	-0.059
Pleuritis	0.0	-0.05	-0.195
Pericarditis	0.0	-0.05	-0.195
Nasal septum deviation	0.0	-0.059	-0.138

Numbers in Tables 4.5, 4.6, and 4.7 correspond to expected individual pig proportional effects on average daily gain, or $\text{PrEff}_{\text{ADG}}$ as discussed in the section on delay modification, associated with an increased frequency of disease. If disease rates decrease, the following transformation is necessary to maintain the format of proportional change from a known starting point:

$$ADG(HD) = (1 + \text{PrEff}_{ADG}(IDR)) * ADG(LD) ,$$

$$\text{so } ADG(LD) = ADG(HD) * \frac{1}{(1 + \text{PrEff}_{ADG}(IDR))} ,$$

where $ADG(HD)$ = average daily gain with "high" disease rate,

$ADG(LD)$ = average daily gain with "low" disease rate,

and $\text{PrEff}_{ADG}(IDR)$ = the proportional effect on average daily gain of increasing the disease rate (ie. the values in Tables 4.5, 4.6, and 4.7).

Therefore, if the system is moving from "high" to "low" disease, the proportional effect of the change on average daily gain, now defined as $\text{PrEff}_{ADG}(DDR)$, is obtained as follows:

$$(1 + \text{PrEff}_{ADG}(DDR)) = \frac{1}{(1 + \text{PrEff}_{ADG}(IDR))}$$

$$\text{or } \text{PrEff}_{ADG}(DDR) = \frac{1}{(1 + \text{PrEff}_{ADG}(IDR))} - 1 .$$

Table 4.6. Proportional effects of SHIMS disease categories on grower average daily gain (negative values indicate a depression of growth rate)

	Low	Mode	High
Severe pneumonia	-0.044	-0.122	-0.26
Moderate pneumonia	-0.021	-0.044	-0.126
Mild pneumonia	0.0	-0.016	-0.044
Severe ascariasis	-0.043	-0.091	-0.139
Moderate ascariasis	-0.024	-0.05	-0.077
Mild ascariasis	0.0	-0.012	-0.05
Severe mange	-0.076	-0.125	-0.206
Moderate mange	-0.046	-0.076	-0.125
Mild mange	0.0	-0.046	-0.076
Severe atrophic rhinitis	-0.06	-0.092	-0.141
Moderate atrophic rhinitis	-0.028	-0.06	-0.092
Mild atrophic rhinitis	0.0	-0.028	-0.06
Pleuritis	0.0	-0.05	-0.195
Pericarditis	0.0	-0.05	-0.195
Nasal septum deviation	0.0	-0.06	-0.141

Table 4.7. Proportional effects of SHIMS disease categories on nursery average daily gain (negative values indicate depression of growth rate)

	Low	Mode	High
Severe pneumonia	-0.044	-0.122	-0.26
Moderate pneumonia	-0.021	-0.044	-0.126
Mild pneumonia	0.0	-0.016	-0.044
Severe ascariasis	-0.043	-0.091	-0.139
Moderate ascariasis	-0.024	-0.05	-0.077
Mild ascariasis	0.0	-0.012	-0.05
Severe mange	-0.076	-0.125	-0.206
Moderate mange	-0.046	-0.076	-0.125
Mild mange	0.0	-0.046	-0.076
Severe atrophic rhinitis	-0.03	-0.065	-0.10
Moderate atrophic rhinitis	-0.03	-0.065	-0.10
Mild atrophic rhinitis	0.0	-0.03	-0.065
Pleuritis	0.0	-0.05	-0.195
Pericarditis	0.0	-0.05	-0.195
Nasal septum deviation	0.0	-0.065	-0.153

As a closing comment on disease effects, it is important to understand how the observations of disease rates obtained four times annually were adapted to the one day time-step framework of the analytical model. Basically, the approach was simple linear interpolation, where the daily changes in disease rates for the three month period being simulated were all equal proportions of the total. Specifically, they were calculated as:

$$\text{DDR} = \frac{(\text{DRP}_{Q+1} - \text{DRO}_Q)}{\text{NDAYS}}$$

where DDR = daily change in disease rate,

DRP_{Q+1} = projected disease prevalence rate that will be observed at next quarter's slaughter health check,

DRO_Q = disease prevalence rate observed at the current quarter's slaughter health check,

and NDAYS = total number of days in the quarter being simulated.

Thus, as suggested, all simulated days for a given quarter involve the same complement of disease rate changes.

Feed Additive Effects

Similar to the situation with disease effects, the literature contains numerous reports regarding some feed additive effects of interest for the current model, but scant information on others. These effects have generally been reported as a "growth promotion" effect, without regard for possible effects on disease or death rates. For example, Stahly, *et al.* (1980) reported an increase in ADG in nursery pigs of 17 to 22% associated with introduction of antibiotics into the feed, and an improvement of 22% corresponding to addition of copper. In contrast, Ribeiro de Lima, *et al.* (1981) contended the associated increases in ADG were only 3.4 to 4.2% for antibiotics and 4% for copper in the nursery. Powley, *et al.* (1981) documented increases in ADG with antibiotic feeding of 4% in the finisher, 4 to 14% in the grower, and 14% in the nursery.

Biehl, *et al.* (1985) reported that increases in ADG of 10.2% and 7.6% were seen with use of antibiotics and carbadox, respectively, in the nursery. Similarly, an NCR-89 (1984) committee documented an increase of 13.2% in ADG with use of antibiotics and sulfas in the nursery. In the grower and finisher, the increased ADG associated with antibiotic feeding was reported to be 15% by NCR-89 (1986) and no effect was observed by Moser, *et al.* (1985).

Finally, Root and Mahan (1982) found that ADG was improved in the nursery by 10% and 3% associated with use of carbadox and copper, respectively. Similarly, Zimmerman, *et al.* (1982) documented increases of 0 to 25% and 0 to 5% for use of carbadox in the grower and finisher, respectively. They also found that feeding of pyrantel had no effect in the grower, but increased ADG by 31% in finisher pigs.

Again, effect on growth rate was of primary interest, but the relative data shortage necessitated the selective blending of these published accounts with expert opinion (Thacker, 1987) into the desired lowest–most likely–highest format. Coefficients appear in Tables 4.8, 4.9 and 4.10 as they are contained in the model for increases in feed additives. Once more, these are individual pig effects, such as $\text{PrEff}_{\text{ADG}}$, and

Table 4.8. Proportional effects of SHIMS feed additive categories on finisher average daily gain (positive values indicate enhancement of growth rate)

	Low	Mode	High
Antibiotics	0.0	+0.028	+0.056
Carbadox	0.0	+0.025	+0.05
Anthelmintics	0.0	+0.025	+0.05
Copper	0.0	+0.01	+0.02
Sulfa	0.0	+0.028	+0.056

Table 4.9. Proportional effects of SHIMS feed additive categories on grower average daily gain (positive values indicate enhancement of growth rate)

	Low	Mode	High
Antibiotics	+0.015	+0.076	+0.14
Carbadox	0.0	+0.113	+0.25
Anthelmintics	0.0	+0.11	+0.31
Copper	0.0	+0.01	+0.02
Sulfa	+0.015	+0.076	+0.14

Table 4.10. Proportional effects of SHIMS feed additive categories on nursery average daily gain (positive values indicate enhancement of growth rate)

	Low	Mode	High
Antibiotics	+0.034	+0.125	+0.22
Carbadox	+0.024	+0.088	+0.155
Anthelmintics	0.0	+0.08	+0.31
Copper	+0.03	+0.097	+0.22
Sulfa	+0.034	+0.125	+0.22

transformation must occur to preserve the proportional-effect basis when feed additives are decreased.

Finally, recall from previous discussion that feed additives are generally administered to the entire population, and as such the model implements their overall effects according to:

$$DTW(t+DT) = DTW(t) * (1 + PrEff_{DTW}) .$$

Also, the effect that results only happens once, at the time of the management change (addition or removal of feed additives). However, the question arose regarding whether or not the alteration of performance was instantaneous. As with other aspects of the current model, published reports in this regard were not found, and again expert opinion was incorporated (Thacker, 1987). Consequently, the model implemented the production effects of feed additive changes over a three day period. Because the basic modification was multiplicative, each of the three days involved the following adaptation of the above equation:

$$DTW(t+DT) = DTW(t) * (1 + PrEff_{DTW})^{1/3} .$$

Space Effects

As with disease and feed additives, published accounts of the effect of available floor space per pig on production vary considerably. For instance, Lindvall (1981) reported that decreasing available floor space in the nursery from 0.25 to 0.17 m²/pig resulted in a decrease of 8% in ADG, but changing from 0.25 to 0.13 m²/pig brought about a 20% ADG decrease. Also in the nursery, NCR-89 (1984) found an increase of 10.6% in ADG when available floor space per pig was increased from 0.14 to 0.23 m².

In the grower, Moser, *et al.* (1985) observed a decrease in ADG of 6.2% when floor space per pig was decreased from 0.37 to 0.28 m². Also, they observed a decrease of 7% when decreasing per pig floor space from 0.74 to 0.56 m². NCR-89 (1986) recorded a decrease of 5.7% in ADG when space per pig went from 0.46 to 0.32 m² in the grower, while a decrease of 2.9% was observed in the finisher with a reduction in space per pig

from 0.74 to 0.56 m². Finally, Randolph, *et al.* (1981) reported a diminished ADG of 7% associated with space per pig of 0.33 m² as compared to 0.60 m² in the grower and finisher.

Combining these mixed reports with the need for an adjustment approach resulted in the mathematical relationships defined for the *FINISHER*, *GROWER*, and *NURSERY* which appear in Figures 4.8, 4.9, and 4.10, respectively. These relationships were defined using the relative space effects on average daily gain contained in the literature. For instance, Lindvall (1981) reported that a change in available *NURSERY* floor space from 0.25 to 0.17 m²/pig was associated with a decrease of 8% in average daily gain. It is this 8% change that is important from Figure 4.10, and not the absolute percentage effects on growth rate that appear on the vertical axis. For fitting the curves, a non-linear regression technique (linearization) available with PlotIT^o was used.

Therefore, when reviewing Figures 4.8, 4.9, and 4.10, it is critical to remember the adjustment approach, so that only changes in growth rate which result from changes in available floor space are considered. Also, the proportional effects contained in the figures correspond to decreases in available floor space per pig. For example, Figure 4.10 indicates that the expected relative change in growth rate associated with decreasing the available *NURSERY* floor space from 0.3 to 0.25 m²/pig is:

$$\begin{aligned} f(0.25) - f(0.3) &= -0.11463080 - (-0.07850064) \\ &= -0.03613, \end{aligned}$$

or about a 3.6% decrease in average daily gain. If, on the other hand, the floor space increased from 0.25 to 0.3 m²/pig, transformation of the above result yields:

$$\begin{aligned} \text{PrEff}_{\text{ADG}} &= \frac{1}{(1 - 0.03613)} - 1 \\ &= 0.03748, \end{aligned}$$

or about a 3.7% improvement in average daily gain.

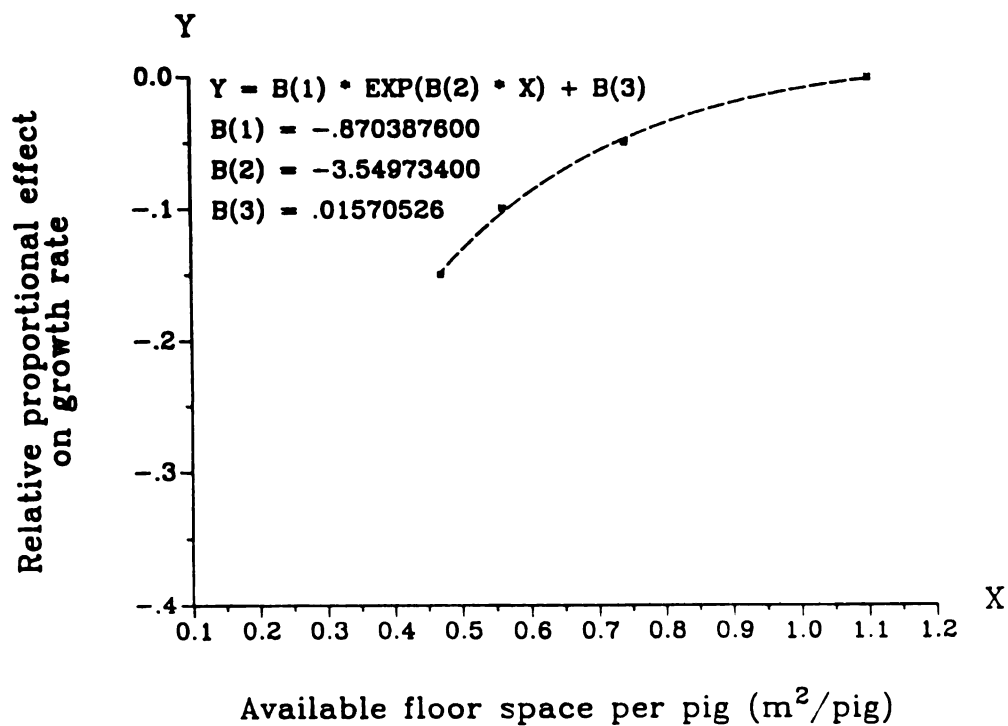


Figure 4.8. Effects of available floor space per pig on growth rate—finisher phase

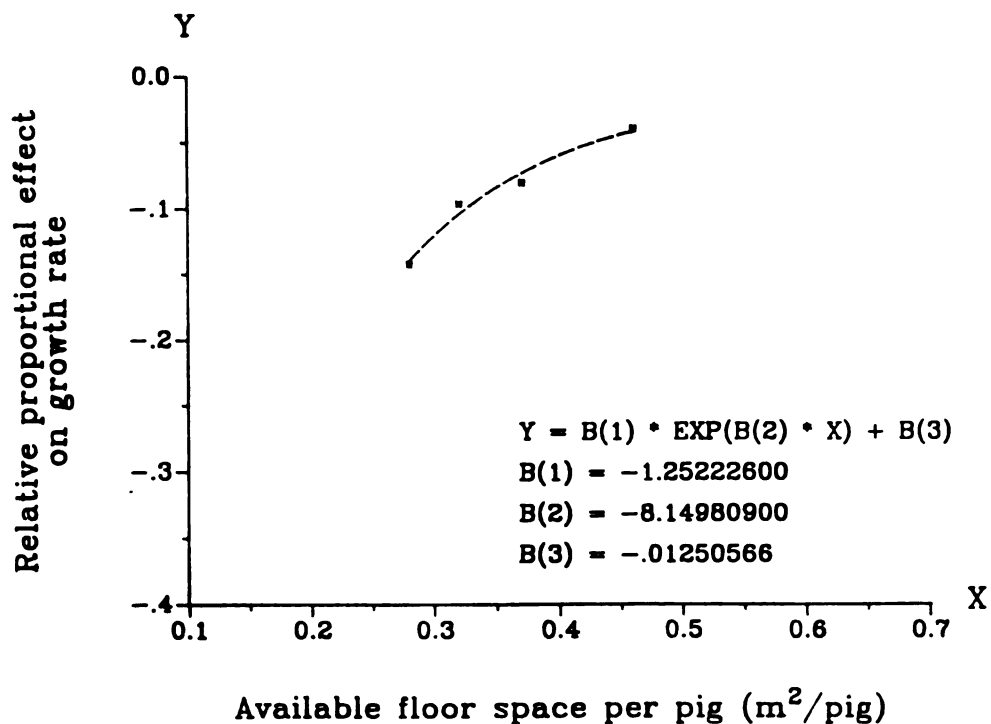


Figure 4.9. Effects of available floor space per pig on growth rate—grower phase

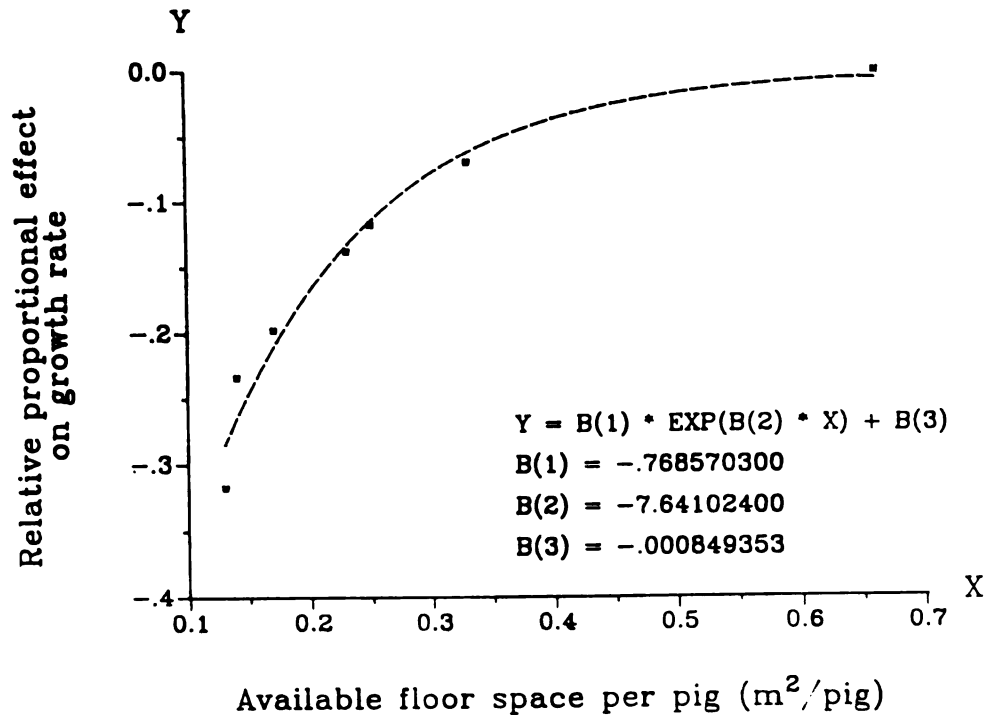


Figure 4.10. Effects of available floor space per pig on growth rate—nursery phase

To accommodate the triangular distribution format, a potential range of values needed identified. When the equations appearing in Figures 4.8, 4.9, and 4.10 were estimated, the maximum proportional residuals observed in any of the equations was -0.115 (or -11.5%) in the nursery. Thus, this proportional variation (± 0.115 or $\pm 11.5\%$) was established on the percentage growth rate changes.

Feed Efficiency

Conspicuous in its relative absence from the discussion to this point is the efficiency of feed utilization. Certainly the literature has afforded ample attention to factors that affect feed consumption and its conversion efficiency, and expert opinions abound on the subject. However, problems arise when observations of adjustment starting points are sought for modeling purposes. First, accurate measurement of feed usage is often difficult due to variation in feed delivery systems. The most difficult of these to precisely track involves attempts to estimate quantities of feed used as they are removed from home-produced inventories.

In addition, the conversion efficiency of feed to pork is directly dependent on both the quantity and quality of feed actually consumed. Even if total feed usage were accurately observable, the proportion of that total which is consumed versus wasted would probably still be indeterminable. Further, hog rations very frequently contain commercially prepared feedstuffs whose exact nutritional values are unknown. Even though feed tags may be available, the amount of information they contain is variable, and is frequently inadequate. For example, dietary energy levels are critical to nutritional evaluation. However, minimum legal requirements for feed tags include only protein, fat, fiber, and occasionally certain minerals (Boyd, 1988). As such, information on the energy content of a commercially prepared feed might easily be lacking. Situations such as this often preclude the thorough nutritional evaluation which must precede analysis of feed conversion efficiency, and appropriate modeling.

In lieu of automated data collection on feed usage/consumption and extensive nutritional evaluation of feeds being fed, an alternative approach needed developed for the current modeling exercise. As discussed in the previous chapter, the SHIMS database attempts to capture the total amount of feed used over individual three-month periods according to ration. When this is combined with the total number of pig-days for the same time period (as observed with the aid of COMPLEX in the process of *DELAY* optimization), a mean amount of feed used per pig-day can be calculated. Trends in feed usage per pig-day are projected with the alpha-beta tracker (see Table 4.4). Combination of such projections with simulation of changes in the resident hog population permits prediction of feed usage.

Limited as such in calculation capabilities, the effects of disease, feed additives, and available floor space on overall efficiency of feed conversion are necessarily restricted in the current model. Alterations in the amount of feed required per pound of pork produced are accomplished by changing the total number of days required to achieve market weight (*DELMOD*). Biologically, this corresponds to an increase in the nutrition required for maintenance relative to that needed for growth.

Alpha-beta Tracker

The final parameters which were estimated were the α and β values for the alpha-beta trackers. As with previously discussed aspects of the current model, the values of α and β for the alpha-beta trackers needed to be determined based on characteristics of the system being modeled. Ideally, the parameters α and β should be discovered by an optimization routine focused on the modeler's objectives (Manetsch, 1984). For current purposes, the objective was to predict system variable values as accurately as possible. Unique values for α and β were selected for each of the 38 system variable series being forecast (see Table 4.4). Thus, each series had its own alpha-beta tracker. To encourage accuracy, the sum of the squared differences between projected and observed variable values was minimized over the entire current range of each data series. As such, α and β were re-estimated for each data series following each quarterly observation using COMPLEX as the optimization routine. These updated α and β values were then used for projection into the following quarter.

More directly, the sequence of activity for the alpha-beta tracker in *each* of the 38 data series was:

1. predict variable value with alpha-beta tracker for the approaching time period ($t+DT$),
2. observe variable value once ($t+DT$) is attained,
3. re-estimate α and β over entire variable series through present using COMPLEX, and
4. repeat steps 1 through 3 for subsequent time periods.

Initial values of $y_p(t)$ and $dy(t-DT)$ were assumed to be zero.

To enhance the quality of prediction with the alpha-beta tracker, minimum variance on $y(t)$ and $dy(t)$ was sought. According to Manetsch (1984), this minimum

variance condition is referred to as *critical damping*, and is achieved by employing the following identity:

$$\alpha = (2 * \beta^{0.5}) - \beta$$

Thus, the COMPLEX needed only solve for β .

DISCUSSION

In evaluating the economic analysis provided by the systems model and its associated computerized simulation, it is critical to recall that, at present, this is exclusively a research model. As such, attention should center on the techniques and parameters employed. Though thorough discussion is premature at this point, some potentially critical issues related to these techniques and parameters will be forwarded. Bringing these areas to light will prevent them from being overlooked in later discussion, and should accommodate their consideration during the remainder of the exercise.

System Definition

The *NURSERY*, *GROWER*, and *FINISHER* phases of hog production provide a seemingly discrete and easily defined system for modeling purposes. Exclusion of other aspects of production from the model greatly facilitated the modeling process. However, consideration of hog production and health management from weaning to market may also require additional information from other production phases before thorough economic analysis can occur. For example, perhaps preweaning history has a critical impact on how disease affects production in a given herd. This history might include factors such as pig health management, pig nutrition, lactating sow nutrition, lactating sow health management, gestating sow nutrition, etc. Further, even though an adjustment approach is employed, it may become evident that environmental factors in addition to available floor space warrant consideration when predicting hog

performance. Because the systems approach is expressly iterative, factors such as these should be considered even when evaluating results from initial applications.

Techniques Employed

Assuming an adequate system definition, the systems modeling and computer simulation techniques employed should also be continually scrutinized. For instance, even though the alpha-beta tracker can be successful in predicting state variables for some systems (Manetsch, 1984), it may be necessary to use more traditional epidemiological models to adequately predict disease and death rates. This might be especially true when the model is predicting changes in disease and death rates associated with particular management changes. Since the alpha-beta tracker relies heavily on time trends, the effects of abrupt management changes, which may well represent turning points in production, might be more adequately modeled with an epidemiologic model incorporating appropriate risk factors. Further, the economic effects of alternative health management strategies can presently be evaluated only if the corresponding disease and death rates are known; the model cannot be expected to predict these rates (or, for that matter, evaluate the associated economics) without an epidemiologic model.

In similar fashion, the methods of parameter estimation deserve attention. Use of COMPLEX to estimate mean *DELAY*s is somewhat innovative. If successful, the approach offers a substantial contribution to the information procurement process for hog producers. However, its performance needs to be scrutinized to assure its applicability. Likewise, expert opinion and literature reports on the performance effects of changing production factors should be rigorously examined. These production modifications are critical to the model's performance.

Along with the review of alpha-beta trackers for prediction, the use of discrete delays, distributed delays, and triangular probability density functions to represent a dynamic hog population should be closely followed. For instance, the aggregate, (population) modeling techniques offer much in the way of depicting a true herd

management approach and also afford remarkable computational efficiency. However, alternative methods that consider the hog population as a group of discrete individuals, each possessing prescribed probabilities of disease, death, slow growth, and accelerated growth may, in fact, provide better overall system representation.

Again, these areas provide examples of the type of perpetual re-evaluation characteristic of the systems approach. Suggestions are made at this point to stimulate on-going critical review.

Data

Because this exercise involves both an analytical model and an information management system, perpetual review should also embrace the database and all of its various features. Specific mention here serves only as a reminder that a good analytical model might well go unrecognized for want of good data to drive it. In light of some of the preliminary results and sample size calculations presented in Chapter 3, this comment might be especially relevant for the current research.

Validation

Solutions to the uncertainties posed above can only be achieved through model validation. This process should involve two steps. First, the model should be developed on a small group of farms. For the current research, this group consisted of the SHIMS pilot producers. This phase of validation involved mostly subjective comparison of model predictions to corresponding system observations. Results of this process involving the SHIMS producers will be discussed in Chapter 5.

Once initial fine-tuning is complete, an expanded group of farms should be employed. The size of this group should ideally follow the sample size estimations made in Chapter 3, and selection should be according to appropriate random procedures to prevent bias. Sampling at slaughter, if continued, should also follow the guidelines discussed in Chapter 3. Provided successful expansion, predictions from the model can be statistically compared to subsequent observations to furnish a more rigorous, objective validation. Further discussion of validation is deferred to Chapter 6.

SUMMARY

Chapter 4 has presented the analytical model portion of a decision support system for production and health management of growing/finishing hogs. Both mathematical modeling and computer simulation techniques have been addressed. Preliminary discussion has also occurred with the intent of stimulating perpetual critical evaluation. Chapter 5 considers the results of initial model applications.

CHAPTER 5

RESULTS OF DECISION SUPPORT SYSTEM APPLICATION

INTRODUCTION

The two preceding chapters respectively described the development of an information management system and an analytical model focused on swine production and health management. Together, these tools were intended to provide health management decision support for growing and finishing pigs. This chapter presents the results obtained from initial joint application of the information management system and analytical model. A subsequent chapter will discuss these results in an assessment of the ultimate applicability of the techniques employed for on-farm decision support.

INFORMATION MANAGEMENT SYSTEM

As discussed in Chapter 3, the information management system designed for this research was implemented as a pilot project involving six commercial hog producers in Michigan from spring 1986 to winter 1988. Several notable strengths and weaknesses were also pointed out. Among the strengths was the structured combination of data on both physical and financial production in a single database. At the same time, the shortcomings arose primarily from the types and amounts of data collected on these different areas of production. While the system was not sufficiently broad to provide comprehensive coverage of *all* aspects of production, it often requested considerably more data than was strictly necessary to address the issue of health management in the growing and finishing pigs. As a result, both the quantity and quality of data provided

by pilot participants experienced serious dilution. Discussion of the dilution's severity follows.

Data Quantity

An overview of the data actually received from the SHIMS pilot producers appears in Table 5.1. From this it can be seen that of the possible forty-eight "producer-quarters" (one producer's data during one of the eight annual quarters covered by the project's data collection), only fourteen were completely achieved. As such, these fourteen producer-quarters provided the only *complete* SHIMS farm management reports of the pilot phase, and also provided the only basis for thorough review of the corresponding analytical model. However, twelve of the remaining thirty-four producer-quarters lacked only data on feed usage. Though absence of feed usage information precluded complete financial analysis, the physical production aspects of both the SHIMS farm management report and the analytical research model were still feasible. Thus, a total of twenty-six producer-quarters were available for analysis of physical production.

On evaluation of Table 5.1, the most immediately obvious feature is the lack of data for Producer 6. In short, even though most of the requested data were already being maintained by this producer, the perceived benefits of providing the data to MSU personnel were obviously less than the perceived cost, in terms of effort required. This may have been related to the willingness of MSU to continue providing slaughter health checks even without receiving the desired, on-farm data in hopes of eventual historical reconstruction. A similar situation occurred with Producer 1, from whom on-farm data were received only after project completion. As Table 5.1 reveals, historical reconstruction for Producer 1 was not entirely successful.

These data collection problems occurred in spite of repeated inquiries by SHIMS personnel at MSU. However, in attempting to maintain an atmosphere of cooperation, these inquiries were generally made through a positive approach, and were never pressuring.

Table 5.1 Data received from SHIMS producers, spring 1986 through winter 1988

Producer number	Data class	Quarter							
		Sp 1986	Su 1986	F 1986	W 1987	Sp 1987	Su 1987	F 1987	W 1988
1	SHC	X	X	X	X	X	X	X	X
	PDAT	O	O	O	O	O	O	O	O
	CEXP	X	X	X	X	X	X	X	X
	FU	X	X	X	X	X	X	X	X
2	SHC	X	X	X	X	X	X	X	X
	PDAT	X	X	X	X	X	X	X	X
	CEXP	X	X	X	X	X	X	X	X
	FU	-	X	X	X	X	X	X	X
3	SHC	X	X	X	X	X	X	X	X
	PDAT	X	X	X	X	X	X	X	X
	CEXP	X	X	X	X	X	X	X	X
	FU	O	-	-	-	-	-	-	-
4	SHC	X	X	X	X	X	X	X	X
	PDAT	O	X	X	X	X	X	X	X
	CEXP	X	X	X	X	X	X	X	X
	FU	O	O	O	O	O	O	O	O
5	SHC	X	X	X	X	X	X	X	X
	PDAT	X	X	X	X	X	X	X	O
	CEXP	X	X	X	X	X	X	X	X
	FU	X	X	X	X	X	X	X	-
6	SHC	X	X	X	X	X	X	X	X
	PDAT	O	-	-	-	-	-	-	-
	CEXP	O	-	-	-	-	-	-	-
	FU	O	-	-	-	-	-	-	-

SHC = Slaughter health check data
 PDAT = Data on pig inventories and flows
 CEXP = Cash production expense data
 FU = Feed usage data
 X = Complete data
 O = Incomplete data
 - = No data

Further examination of Table 5.1 reveals evidence that the SHIMS data class most difficult to achieve was feed usage. Only two of the six pilot producers were able (or willing) to provide the requested data on the quantity of feeds being fed. Producer 4 was able to provide amounts (physical quantities) of feed ingredients as they were purchased, but the rations in use were not sufficiently unique to allow adequate estimation of quantities fed. Producer 3 maintained batch information initially, but batch sizes were not judged to be sufficiently uniform (in the absence of individual batch-weights) to provide reliable information.

Following feed usage data in lack of successful achievement was physical production data. As with feed use, physical production data were often provided in an incomplete fashion. The characteristics of "incompleteness" involved insufficient data related to either pig inventories or pig flows, or both. For example, Producer 1 routinely maintained sufficient data on marketings and inventories, but failed to maintain weaning data. Other individual producer-quarters selectively lacked complete data as exceptions, rather than as routine.

Finally, the most success was achieved in collecting financial production data. These data were generally adapted from existing financial record systems, and were usually provided in those formats. As such, financial records probably required the least amount of extra producer effort.

Data Quality

Though, as discussed, complete data were obtained for fourteen producer-quarters, and sufficient physical production data were procured for an additional twelve producer-quarters, several questions regarding the quality of the data received have surfaced. Primarily, these relate to frequent inconsistency between pig inventory and pig flow data, and to inherent data "lumpiness."

During the course of the pilot project, quarterly pig inventory data were requested (as discussed in Chapter 3) from participating producers. The original intent of researchers was that these inventories be obtained through actual herd counts on or

near the recommended dates. In actuality, and despite repeated encouragements, real quarterly counts were performed only by Producer 4. Inventory data from remaining producers (if provided) were achieved through either linear interpolation between actual annual counts, or through "appropriately" adjusting occasional counted inventories in light of known pig flows (weanings, marketings, deaths, etc.). For some management purposes, these "inventory" methods may provide sufficient accuracy; however, as will be discussed later in this chapter, the data which result from such techniques are too inconsistent to form a solid systems modeling and computer simulation base.

Another potential source of inconsistency in the SHIMS database was the inherent "lumpiness" of the data. Lumpiness arose from the non-continuous nature of most management processes immediately peripheral to actual physical production. These included feed procurement (which occurred in "batches"), marketings (which occurred according to a non-continuous, predetermined schedule), weanings (which also took place according to schedule), and the incurring of other various cash expenses (such as annual property taxes, biannual interest installments, and fuel procurement). If reliable information regarding the actual input/output rates involved were available, effective analysis would have been virtually unimpeded (though somewhat complicated) by lumpiness. However, since the lumpy data were the sole source of input/output rates for the SHIMS database, the corresponding analysis must be interpreted very carefully. For clarification, several examples follow.

Several particular problems regarding input/output lumpiness have become evident in the SHIMS database. First, though absolute *a priori* information was not available on SHIMS input/output rates, at least the expected schedules for activities such as weaning and marketing were known. In this case, inconsistency has arisen when predetermined schedules appear not to be followed. The most prominent example of this was provided by Producer 3. Ordinarily, this producer followed a weekly marketing schedule, except (according to the database) during December, when virtually no hogs were marketed, and January, when a veritable flood of hogs was marketed during the

first week. Most likely, this "phenomenon" was related to income tax management strategies. Following this marked marketing increase, seemingly "ordinary" marketing ensued. In this case, comparison of expected (based on pig flow data) January 1 inventory with an actual count might have revealed lack of consistency. Comparing these data to model projections would also likely reveal substantial differences between observed and projected values. However, as has been suggested, these differences were related (at least in part) to circumstances distinctly apart from poor model performance.

The second major source of data inconsistency resulted from aggregation of lumps into "super-lumps." This process occurred most commonly with Producer 4, who ordinarily weaned and marketed pigs at weekly intervals, but aggregated weanings data into sow-group summaries (usually involving weanings that occurred over periods of four weeks). Further, marketings were aggregated into monthly summaries. As a result, the mean amount of time that pigs required to reach market weight as calculated from the "super-lump" data may have been inconsistent with that calculated from actual data on weanings and marketings. Also, weanings for a given sow-group were recorded on the last day that weanings from the particular group occurred. If, by circumstance, the last weaning for a given sow-group occurred during the first week of a month, the recorded data artificially overestimated weanings for that month, while underestimating weanings during the previous month. As a result, pig-flow inventory expectations for the beginning of the month were often inconsistent with counted inventories. Again, model performance must be judged accordingly.

Production involving such markedly uneven flows of inputs and outputs can be handled through several alternative approaches. First, as briefly discussed, additional data can be collected on the actual rates which occur by explicitly focusing on smaller time periods. Secondly, an extended history of production can be evaluated to "smooth" the rates of use over a longer period of time. Finally, the time horizon of the analysis can be extended. As implied with the previous suggestions, the detrimental effects of lumpiness are diminished as the total amount of time being considered lengthens.

As suggested, one of the major areas of inconsistency arising from the data problems discussed was between expected pig inventories (based on pig flow and beginning inventory calculations), and data actually obtained regarding observed inventories. When each of the twenty-six SHIMS producer-quarters with sufficient physical production data were evaluated for such a lack of consistence, the following calculations were employed:

$$\begin{aligned} \text{Expected Ending Inventory} &= \text{Beginning Inventory} - \text{Total Exits} + \text{Total Entries} \\ \text{Proportional Data Inconsistency} &= \frac{|\text{Expected Ending Inventory} - \text{Observed Inventory}|}{\text{Observed Inventory}} \end{aligned}$$

Over the twenty-six producer-quarters, it was found that the mean proportional data inconsistency in physical production, calculated as above, was 0.08385. These errors ranged from a minimum of 0.00 to a maximum of 0.35. However, at least one participant (Producer 5) was known to calculate the inventory "observations," (between annual counted "observations") using an approach similar to that presented above for "Expected Ending Inventory." Also, it is interesting to note that one of these "observations" for Producer 5 provided the minimum observed proportional data inconsistency (0.00). Therefore, it is difficult to know just how accurately the actual data inconsistency is captured by the calculated mean data inconsistency.

The probable importance of these findings will be addressed in the following chapter. However, it should be recognized at this point that substantial doubt has been cast on the quality of the physical production data contained in the twenty-six SHIMS producer-quarters. Evaluation of the subsequent analytical model application should bear this fact in mind.

THE ANALYTICAL MODEL

When considering initial application results from the analytical model described in Chapter 4, two general areas warrant attention: the estimation of model parameters and the actual implementation of the model for purposes of simulation. Since the relative success achieved with simulation was directly dependent upon the quality of coefficients (or parameters) employed by the underlying model, the results of parameter estimation will be discussed first.

Parameter Estimation

From Chapter 4, recall that several groups of system parameters needed to be quantified. Of these, the proportional growth rate effects of subclinical diseases, available floor space, and presence of feed additives were obtained from the literature. On the other hand, the current growth rate (as represented by *Initial DELAY* in Figure 4.1), the current rate of feed utilization, and the alpha-beta tracker parameters were estimated from the database by producer-quarter. The results of these estimations follow.

DELAY. As presented in Chapter 4, the mean amount of time pigs spent in the finisher phase was estimated with the assistance of the COMPLEX optimization routine by producer-quarter. Results then provided input for simulation in the form of *Initial DELAY*. For producers with sufficient physical production data to allow such estimation, a summary of the results appear in Table 5.2. When the prescribed lengths of nursery and grower phases were included, the total length of the post-weaning period could be estimated. A summary of these appears in Table 5.3.

While the results presented in Tables 5.2 and 5.3 may seem reasonable, some important concerns warrant mention. First, when using COMPLEX for parameter estimation, it is quite possible that the system as defined might have contained insufficient information to produce a "well-behaved" surface for optimization. This condition might have corresponded to either a highly irregular or nearly flat surface.

Table 5.2. Estimated length of finisher phase for SHIMS producers, spring 1986 through winter 1988

Producer Number	Length of finisher phase (days)		
	Mean	Low	High
2	107.52	83.73	115.35
3	116.40	98.76	141.36
4	80.65	68.17	105.92
5	91.47	82.34	102.57

Both of these situations signify a weak functional relationship for optimization and both can make identification of an unique optimum very difficult. When estimating the *DELAYS*, however, this did *not* occur. Repeated solution of individual producer-quarters consistently produced virtually identical results.

Table 5.3. Estimated total length of post weaning period for SHIMS producers, spring 1986 through winter 1988

Producer Number	Length of post weaning period (days)		
	Mean	Low	High
2	165.52	146.73	178.35
3	207.40	189.76	232.36
4	164.65	152.17	189.92
5	167.47	158.34	178.57

Another optimization concern relates back to the earlier data quality discussion. Since the estimation process rested on pig flow and pig inventory data, the quality of these was critical. Thus, the preceding discussion regarding data inconsistencies is especially pertinent. Finally, though the values resulting from the estimation process seem reasonable, they must be viewed cautiously until the technique can be validated

through concurrent, on-farm observation of the *DELAY* experienced by pigs in corresponding systems.

Feed Use. When the optimal *DELAY* was discovered for a given producer-quarter, the estimated number of pig-days associated with that optimum was also recorded by production phase. Thus, each *DELAY* also provided an estimate of the number of nursery, grower, and finisher pig-days. Combining these figures with data on the total amount of feed(s) by ration provided estimates, by phase, of the amount of feed used per pig per day during individual producer-quarters. Since, as presented, feed usage data were only obtained from fourteen producer-quarters, the scope of this estimation was limited. Results appear in Table 5.4, where it can readily be seen that lumpiness is a primary concern, and that fundamental data quality may also be suspect, especially in the spring quarter of 1986 for Producer 5. It is interesting to note that this was also the producer-quarter with the maximum proportional data inconsistency (0.35) related to pigs in the system.

Table 5.4. Estimated feed use per pig-day for SHIMS producers, spring 1986 through winter 1988

Producer Number	Quarter	Production Phase		
		Nursery	Grower	Finisher
		(pounds feed/pig-day)		
2	Su 1986	1853	1858	4.228
	F 1986	1841	1627	4.700
	W 1987	2369	1582	5.708
	Sp 1987	1897	1646	5.577
	Su 1987	1790	2377	5.170
	F 1987	2101	2439	7.563
	W 1988	1110	1091	3.285
5	Sp 1986	1.794	23.310	17.618
	Su 1986	1.891	4.855	3.513
	F 1986	3.770	7.177	2.769
	W 1987	4.068	13.384	0.300
	Sp 1987	2.624	5.262	2.904
	Su 1987	3.580	9.293	1.078
	F 1987	2.940	10.435	0.769

Because of the method used to estimate feed use per pig-day, widely divergent results could be related to either problems with hog population or feed use data. Though a definitive explanation cannot be offered, it is felt that the remarkable results obtained for Producer 5 in spring 1986 were related to errors associated with initiation of data collection. Beyond this, the fluctuations seen with this producer can probably be attributed to a combination of lumpy feed use data and the calculation (as opposed to counting) of pig inventories.

As discussed previously, lumpiness can be appropriately taken into consideration provided fundamental data quality is adequate. However, the degree of success that this approach achieved in *accurately* estimating feed use per pig-day hinged critically on not only the quality of feed use data, but also on the caliber of pig inventory and pig flow data. Further, the estimated number of pig-days rested on the suitability of the COMPLEX optimization routine as well. Thus, again, some of the results (though limited) seem feasible, but confidence cannot be established in the absence of model validation.

Alpha-beta Tracker. Returning again to Chapter 4, recall that a projection technique (called the alpha-beta tracker) was used for projection of certain data series that were required for simulation. Estimation of the parameters (α and β) involved the use of the COMPLEX optimization routine in an attempt to minimize the error of prediction. Unique parameter values were estimated for each of the thirty-nine data series, and for each producer-quarter. As presented in Chapter 4, critical damping required that α be a function of β , and therefore only β values were estimated through optimization. Summarization of the β values for the thirty-nine data series and twenty-six producer-quarters appears in Table 5.5.

Some of the variability present in the β values may have resulted from under-identification. Unlike the optimizations to discover *DELAY*, repeated β value estimation for a given data series and producer-quarter did not always yield the same output. This

Table 5.5. Summary of beta coefficients for SHIMS pilot producer alpha-beta trackers, spring 1986 through winter 1988

Data series	Mean	Standard deviation
Disease prevalence rates		
Severe pneumonia	1.1318	0.4249
Moderate pneumonia	0.9735	0.1412
Mild pneumonia	0.9984	0.0053
Severe ascariasis	1.2091	0.6785
Moderate ascariasis	1.0934	0.6797
Mild ascariasis	0.9883	0.0902
Severe mange	1.6897	1.0805
Moderate mange	1.2111	0.6155
Mild mange	1.0255	0.2138
Severe atrophic rhinitis	1.1522	0.6707
Moderate atrophic rhinitis	1.0898	0.4700
Mild atrophic rhinitis	0.9974	0.0118
Pleuritis	0.9784	0.3056
Pericarditis	0.8920	0.3636
Nasal septum deviation	1.0443	0.2690
Non-feed cash expenses		
Purchased feed	1.0032	0.0088
Repair and maintenance	0.9555	0.1182
Veterinary care and drugs	0.9047	0.2007
Labor	0.9810	0.0606
Supplies	0.8626	0.1705
Fuel	0.8089	0.1950
Electricity	0.9509	0.1142
Telephone	0.8502	0.6799
Trucking	1.3343	0.9654
Marketing	1.0962	0.7131
Insurance	0.8099	0.4046
Interest	1.2884	0.7664
Taxes	1.3303	0.9438
Replacement females	1.9292	1.2134
Replacement boars	2.3262	1.2353
Other	0.8893	0.1536
Pig deaths		
Finisher	0.9922	0.0546
Grower	0.9978	0.0201
Nursery	0.9956	0.0205
Marketing measures		
Market hog weight	0.9988	0.0090
Market hog price	1.0017	0.0083
Feed use		
Finisher	0.9993	0.0053
Grower	0.9961	0.0054
Nursery	0.9977	0.0069

was noticed to be especially true when the producer-quarter involved was early in the project. Further, it is interesting to note that many of the mean β values were very close to 1.0. Reviewing the alpha-beta tracker equations presented in Chapter 4 reveals that if $\beta = 1.0$, the critical damping condition provides that $\alpha = 1.0$. As a result, $y(k) = u(k)$, which implies a lack of systematic observational error. When coupled with the apparent occurrence of multiple optima, this lack of systematic error suggests that the optimization surfaces involved may have indeed been highly irregular. As discussed previously, this would indicate the presence of a weak functional relationship. For the alpha-beta tracker, this would suggest a weak relationship between successive observations of the variables being projected.

Simulation Output and Evaluation

To facilitate evaluation of analytical model output, a format was needed which presented the results of projection in a thorough, clear, and concise manner. Toward that end, the report presented in Table 5.6 was developed. As is evident, the format developed addressed both physical and financial production, and contained information on both the projected expectations and their variations. Also, the sources of data used for simulation were included. Because the validity of the model had not been firmly established, these reports were not provided to SHIMS pilot producers.

Before presenting the results attained from simulations performed with the analytical model, it is necessary to explain the various scenarios evaluated. As is the case in actual production, an unlimited number of simulation scenarios were possible. Because primary objectives for this research centered on evaluating the usefulness of this modeling approach in providing decision support for animal health management, the scenarios examined attempted to silhouette major modeling techniques and the effects of subclinical disease. Also in light of the objectives, all scenarios used actual observations for pig weanings and feeder pig sales to preclude projection errors arising from these sources.

Table 56. Sample output from SHIMS computer simulation model

SHIMS SIMULATION OUTPUT				
Physical and Financial Performance				
Producer: XXXXXX		Number of runs: 200		Projected Quarter: 4/87
1. Data Sources				
Expense rates, market weights and market prices market Feed usage Disease and death rates DELAY			actual observation actual observation actual observation model projection	
	<u>Mean</u>	<u>Standard Deviation</u>	<u>Low</u>	<u>High</u>
2. Ending Inventories				
Finisher	2,485.00	55.00	2,386.00	2,581.00
Grower	706.00	*	*	*
Nursery	940.00	*	*	*
3. Average DELAY (days)	103.78	2.78	98.92	108.77
4. Ending DELAY (days)	102.26	4.52	93.02	112.83
5. Weanings	2,639.00	*	*	*
6. Death Losses				
Finisher	34.00	*	*	*
Grower	12.00	*	*	*
Nursery	48.00	*	*	*
7. Marketings				
Market hogs	1,978.00	55.00	1,881.00	2,078.00
Feeder pigs	100.00	*	*	*
8. Feed consumption (tons)				
Finisher	837.00	8.00	821.00	852.00
Grower	71.00	*	*	*
Nursery	87.00	*	*	*
Total	994.00	8.00	979.00	1,010.00

Table 5.6 (cont'd).

	<u>Mean</u>	<u>Standard Deviation</u>	<u>Low</u>	<u>High</u>
9. Revenue				
Market hogs (price = \$43.65/cwt) (weight = 333.64 lbs/head)	\$288,026.13	\$7,988.68	\$273,981.56	\$302,558.53
Feeder pigs (price = \$156.66/cwt) (weight = 29.00 lbs/head)	4,543.14	*	*	*
Total	\$292,569.25	\$7,988.68	\$278,524.69	\$307,101.66
10. Feed Expense				
Finisher (price = \$0.05/lb)	\$92,063.55	\$917.70	\$90,363.02	\$93,768.24
Grower (price = \$0.07 per pound)	9,936.80	*	*	*
Nursery (price = \$0.10 per pound)	18,176.10	*	*	*
Total	\$120,176.45	\$917.70	\$11,845.91	\$121,881.13
11. Non-feed Cash Expense				
Repair and maintenance	\$10,114.19	\$ 61.65	\$ 9,999.94	\$10,228.71
Veterinary care and drugs	1,884.63	11.49	1,863.34	1,905.97
Labor	21,484.79	130.97	21,242.11	21,728.07
Supplies	1,256.42	7.66	1,242.23	1,270.65
Fuel	2,198.74	13.40	2,173.90	2,223.63
Electricity	7,601.35	46.34	7,515.48	7,687.42
Telephone	0.00	0.00	0.00	0.00
Trucking	125.64	0.77	124.22	127.06
Marketing	2,638.48	16.08	2,608.69	2,668.36
Insurance	2,261.56	13.79	2,236.01	2,287.17
Interest	5,088.50	31.02	5,031.03	5,146.12
Taxes	691.03	4.21	683.23	698.86
Replacement females	0.00	0.00	0.00	0.00
Replacement boars	0.00	0.00	0.00	0.00
Other cash expense	11,621.89	70.84	11,490.62	11,753.49
Total	\$66,967.23	\$408.22	\$66,210.78	\$67,725.52
12. Income Over Variable Costs	\$105,425.58	\$8,051.58	\$88,918.04	\$122,353.04

The following conventions have been used to help maintain clarity in discussion: variable values from the base producer-quarter for simulation will be subscripted Q , while those from the projected producer-quarter will be subscripted $Q+1$. Thus, model inputs for pig weanings and feeder pig sales were observed values of PIGSWEANED_{Q+1} and FPIGSOLD_{Q+1} , respectively, rather than projected values. Also, to achieve simulation, a complete producer quarter of data was required for model initialization, thereby providing a basis for projection. As a result, the first complete quarter of data for each producer served only the initialization purpose, and could not be projected. Thus, only twenty-two of the twenty-six producer-quarters with complete physical production data were candidates for projection and subsequent model evaluation.

Because the model was stochastic in its modifications of *DELAY*, a Monte Carlo approach was employed for all projections involving *DELAY* alteration; each Monte Carlo involved 200 runs under identical conditions (except for the random variation). As a consequence, results of these analyses were obtained in the form of probability distributions, where results for scenarios not involving *DELAY* modification were single point estimates. For purposes of subjective comparison, total hogs marketed and mean *DELAY* by producer-quarter have been chosen as the criteria for assessing simulation performance regarding physical production. To facilitate such assessment, appropriate observed values of total hogs marketed and mean *DELAY* are presented by producer-quarter in all presentations of simulation results. Marketing observations were obtained from the SHIMS database, while *DELAY* observations were obtained from COMPLEX optimization as discussed in Chapter 4.

Though subjective comparisons can be insightful, techniques for objectively reviewing the accuracy of a model's predictions provide a more consistent, reliable means of evaluation. Due to the questionable validity of *DELAY* observations using COMPLEX (at least at this point), and in an attempt to maintain as much objectivity

as possible, only projected vs. observed marketings were included in such evaluations for this model. Also, because herd size and methods of data collection varied considerably between individual SHIMS pilot producers, objective evaluation of the model's accuracy was undertaken producer-by-producer; no attempt was made to compare the model's predictive power between producers.

For current purposes, two methods were used to evaluate the model's predictive power: mean absolute prediction error and Theil's u_2 statistic (Leuthold, 1975). Mean absolute prediction error was chosen because, for evaluating a model predicting numbers of hogs sold, it provides a practical, intuitively appealing measure of performance. This is especially true when the mean absolute prediction error is compared to the mean number of hogs a given producer markets per quarter, thereby defining the mean proportional difference between predictions and observations. The method of calculation follows:

$$\text{MAE} = \frac{\sum |P_Q - A_Q|}{N}$$

where MAE = mean absolute prediction error,

P_Q = model prediction of total hogs marketed for producer-quarter Q
(mean prediction of stochastic),

A_Q = observation of total hogs marketed for producer-quarter Q,

and N = total number of producer quarters involved in the evaluation.

Recall that producer was held constant for all such calculations and that observations of total hogs marketed for individual producer-quarters are summarized in each table containing simulation results to facilitate comparisons.

As discussed by Leuthold (1975), Theil's u_2 statistic provides a suitable approach to evaluating the predictive performance of a model relative to that of other models. Comparison to a naive, no-change model is implicit in the calculation, while explicit comparison to other model formulations is also possible. For comparison to the no-change model, Theil's u_2 statistic assumes the null hypothesis of no-change in system performance. The calculation involved is:

$$u_2 = \frac{(\sum [(P_Q - P_{Q-1}) - (A_Q - A_{Q-1})]^2)^{0.5}}{(\sum (A_Q - A_{Q-1})^2)^{0.5}}$$

where u_2 = Theil's u_2 statistic,
 P_Q = model prediction of total hogs marketed for producer-quarter Q
(mean prediction if stochastic),
 P_{Q-1} = model prediction of total hogs marketed for producer-quarter Q-1
(mean prediction if stochastic),
 A_Q = observation of total hogs marketed for producer-quarter Q,
 A_{Q-1} = observation of total hogs marketed for producer-quarter Q-1,
and N = total number of producer-quarters involved in the evaluation.

Again, recall that producer was always held constant, and observations of total hogs marketed by producer-quarter are summarized in each table of results.

From this equation, it can be derived that a model which predicts perfectly would yield $u_2 = 0$, while the naive model yields $u_2 = 1.0$. Thus, values of $1.0 < u_2 < \infty$ indicate prediction less accurate than the naive model, while $0 < u_2 < 1.0$ signify predictions better than assuming no change. Finally, if $u_2 = 0.5$, for example, the error of prediction is 50% that of the no change model. These evaluations were performed for all of the following simulation scenarios.

Evaluation of Data Quality

ANALYSIS I. To establish a baseline for model performance, the first simulation scenario involved projection using the observed mean $DELAY_{Q+1}$ for the producer-quarter being simulated, and without imposing any *DELAY* modification. This simulation addressed the question, "If the future performance of the system is known, how well will the model predict?" While this scenario may seem trivial at first, it provided both a better understanding of existing problems with data quality and a basis for relative comparisons between scenarios. Projections involving *DELAY* modifications should not be expected to outdistance projections using "known" performance criteria.

Results of these simulations appear in Table 5.7, and evaluation of their accuracy is presented in Table 5.8.

Because all variable values employed in the first scenario were system observations, inaccuracy in the predictions obtained must be attributed to problems with data quality. Though Theil's u_2 statistics indicate a substantial improvement over the naive model (as well it should), it is quite disconcerting to note that for Producer 3, the model failed to explain even half of the change between successive producer-quarters. However, this finding is not too surprising when considering the previous discussions on data quality. Recall that Producer 3 substantially altered ordinary marketing patterns for apparent tax management purposes. As discussed, this was expected to impart the appearance of a deleterious effect on model performance.

ANALYSIS 2. The next scenario examined the ability of the model to predict if the current $DELAY_Q$ observation was used for projection without modification. In effect, the question was asked, "If current performance is known, but information regarding the upcoming quarter's performance is completely lacking, how well does the model predict?" Results of these simulations provided a basis for evaluating the *DELAY* modification process. Outcomes are presented in Tables 5.9 and 5.10.

With the exception of Producer 3, this scenario, as expected, failed to predict as accurately as that using all known parameters (ANALYSIS 1). For Producer 3, the improvement in accuracy was quite small, and should be attributed to the combined effects of data quality peculiarities (recall previous discussion) and chance. Prediction was least effective for Producer 5. This may have been related to the fact that this producer was known to calculate inventories, as previously discussed. Also, as the smallest producer in the pilot group, lumpiness in weanings and marketings was considered to be a very real problem, especially because projected marketing schedules were not rigorously followed. As with the tax management of Producer 3, this "irregular lumpiness" in marketings may have contributed to an appearance of questionable model

Table 5.7. Simulation projections based on unmodified DELAY_{Q+1} for SHIMS producers, summer 1986 through winter 1988 (ANALYSIS 1)

Producer Number	Quarter	Observed Total Hogs Marketed	Projected Total Hogs Marketed _{Q+1}
2	Su 1986	2013	1997
	F 1986	2032	2112
	W 1987	2155	1956
	Sp 1987	2117	2059
	Su 1987	1873	2147
	F 1987	2419	2359
	W 1988	2284	2360
	Mean	2128	2141
3	Su 1986	1222	1131
	F 1986	801	1202
	W 1987	1742	1428
	Sp 1987	1084	1148
	Su 1987	983	1024
	F 1987	1006	1454
	W 1988	1633	1266
	Mean	1210	1236
4	F 1986	4833	4025
	W 1987	4041	3828
	Sp 1987	3994	4132
	Su 1987	3607	3846
	F 1987	4388	4547
	W 1988	3728	3612
	Mean	4098	3998
5	Su 1986	401	344
	F 1986	434	505
	W 1987	499	454
	Sp 1987	331	364
	Su 1987	443	426
	F 1987	443	381
	Mean	425	412

Table 5.8 Accuracy of simulation projections based on unmodified $DELAY_{Q+1}$ for SHIMS producers, summer 1986 through winter 1988 (ANALYSIS 1)

Producer Number	Mean Absolute Error	Theil's u_2 Statistic
2	109.00	0.25085
3	246.57	0.63845
4	278.00	0.19209
5	47.50	0.42753

performance. Considering the entire group of producers, accuracy of prediction was diminished, but the model still predicted considerably better than the naive model, as evidenced by Theil's u_2 statistics.

Evaluation of Systems Model

ANALYSIS 3. Next, simulation was focused on the basic ability of the model to predict system performance with "perfect" information on disease rates and pig deaths. For this approach, the hypothetical question being addressed was, "If perfect information regarding future pig deaths and prevalence of subclinical disease at slaughter were possible, how well would the model predict system performance?" To facilitate the analysis, the desired perfect information was emulated by using actual observations for the simulated period regarding the diseases (DIS_{Q+1}) and deaths (DTH_{Q+1}) of interest, and then allowing the model to start with $DELAY_Q$ and adjust accordingly. For evaluation of model performance, projected total hog marketings ($THOGSMKT_{Q+1}$) and mean $DELAY_{Q+1}$ were again compared to respective observations by individual producer-quarters. These appear in Tables 5.11, 5.12, and 5.13. Since this scenario involved $DELAY$ modification, Monte Carlo analysis was performed as is reflected by the inclusion of both mean values and variability estimates in Tables 5.11 and 5.12.

General evaluation of these results would intuitively indicate a reasonable amount of precision, but perhaps questionable accuracy. When compared to the mean

Table 59. Simulation projections based on unmodified $DELAY_Q$ for SHIMS producers, summer 1986 through winter 1988 (ANALYSIS 2)

Producer Number	Quarter	Observed Total Hogs Marketed	Projected Total Hogs Marketed _{Q+1}
2	Su 1986	2013	1944
	F 1986	2032	1893
	W 1987	2155	2085
	Sp 1987	2117	2029
	Su 1987	1873	2087
	F 1987	2419	2060
	W 1988	2284	2195
	Mean	2128	2042
3	Su 1986	1222	1393
	F 1986	801	1110
	W 1987	1742	1188
	Sp 1987	1084	1426
	Su 1987	983	1169
	F 1987	1006	1008
	W 1988	1633	1444
	Mean	1210	1248
4	F 1986	4833	3121
	W 1987	4041	3353
	Sp 1987	3994	4222
	Su 1987	3607	4398
	F 1987	4388	4090
	W 1988	3728	3855
	Mean	4098	3840
5	Su 1986	401	249
	F 1986	434	524
	W 1987	499	378
	Sp 1987	331	368
	Su 1987	443	476
	F 1987	443	319
	Mean	425	386

Table 5.10. Accuracy of simulation projections based on unmodified $DELAY_Q$ for SHIMS producers, summer 1986 through winter 1988 (ANALYSIS 2)

Producer Number	Mean Absolute Projection Error	Theil's u_2 Statistic
2	146.86	0.30163
3	250.43	0.60963
4	641.50	0.47850
5	92.83	0.83285

observed marketings, the mean absolute projection error is seen to range from 9% to 21% across producers. Further, when compared to the results of ANALYSIS 2, the modification of *DELAY* using known disease rates and pig deaths is seen to offer little in the way of improved predictive ability. In fact, predictions for three of the four producers were slightly *less* accurate than those of ANALYSIS 2. Potential reasons for the relatively poorer prediction for Producer 5 were discussed under ANALYSIS 2. Despite the decreased accuracy obtained, Theil's u_2 statistics still indicate that the model predicted substantially better than the naive, no-change model for all producers. This finding remains encouraging when considered in light of existing problems with data quality. Further discussion on the usefulness of disease and death information is deferred to Chapter 6.

ANALYSIS 4. Though ANALYSIS 3 has cast some doubt on the contribution offered to simulation by disease and death information, it was deemed worthwhile to evaluate the model's performance if only current and past disease and death information were used. Therefore, ANALYSIS 4 sought to evaluate the predictive power of the model when using alpha-beta tracker projected disease prevalence rates at slaughter and pig deaths. Using earlier notation, both DIS_{Q+1} and DTH_{Q+1} were used to modify $DELAY_Q$, except that the values of DIS_{Q+1} and DTH_{Q+1} were not observed for this analysis; they were projected with the alpha-beta tracker. Also following earlier format, the question being asked in this case was, "How well does the model project if it relies

Table 5.11. Monte Carlo projections of total hogs marketed based on modification of $DELAY_Q$ using observed disease rates (DIS_{Q+1}) and pig deaths (DTH_{Q+1}) for SHIMS producers, summer 1986 through winter 1988 (ANALYSIS 3)

Producer Number	Quarter	Observed Total Hogs Marketed	Projected Total Hogs Marketed _{Q+1}	
			Mean	SD
2	Su 1986	2013	1865	55
	F 1986	2032	1817	51
	W 1987	2155	2016	57
	Sp 1987	2117	1891	55
	Su 1987	1873	1972	56
	F 1987	2419	1978	55
	W 1988	2284	2206	71
	Mean	2128	1964	
3	Su 1986	1222	1460	69
	F 1986	801	1121	57
	W 1987	1742	1211	60
	Sp 1987	1084	1427	71
	Su 1987	983	1153	57
	F 1987	1006	941	45
	W 1988	1633	1628	72
	Mean	1210	1277	
4	F 1986	4833	3129	48
	W 1987	4041	3283	38
	Sp 1987	3994	4254	56
	Su 1987	3607	4636	49
	F 1987	4388	4170	63
	W 1988	3728	3721	36
	Mean	4098	3866	
5	Su 1986	401	234	4
	F 1986	434	539	13
	W 1987	499	373	12
	Sp 1987	331	331	5
	Su 1987	443	473	22
	F 1987	443	315	13
	Mean	425	378	

SD = standard deviation

Table 5.12. Monte Carlo mean DELAY projections based on modification of $DELAY_Q$ using observed disease rates (DIS_{Q+1}) and pig deaths (DTH_{Q+1}) for SHIMS producers, summer 1986 through winter 1988 (ANALYSIS 3)

Producer Number	Quarter	Observed Mean DELAY	Projected Mean $DELAY_{Q+1}$	
			Mean	SE
2	Su 1986	108.86	116.81	3.47
	F 1986	97.78	113.58	3.14
	W 1987	103.98	101.18	2.75
	Sp 1987	102.50	111.75	3.22
	Su 1987	99.67	108.62	3.08
	F 1987	87.29	103.78	2.78
	W 1988	80.23	86.94	3.19
Mean		97.19	106.09	
3	Su 1986	126.24	96.80	5.11
	F 1986	116.43	125.48	6.48
	W 1987	96.66	114.75	5.68
	Sp 1987	120.70	96.91	5.21
	Su 1987	137.86	122.97	6.14
	F 1987	95.26	149.17	7.36
	W 1988	108.60	88.32	4.34
Mean		114.54	113.49	
4	F 1986	78.45	102.27	1.53
	W 1987	64.67	80.45	1.24
	Sp 1987	67.33	63.83	1.64
	Su 1987	80.09	63.28	1.05
	F 1987	70.69	78.64	1.25
	W 1988	76.36	73.40	0.84
Mean		72.93	76.98	
5	Su 1986	74.80	99.77	2.01
	F 1986	88.71	66.70	4.12
	W 1987	72.84	89.97	3.81
	Sp 1987	76.30	85.64	1.02
	Su 1987	89.45	76.87	3.75
	F 1987	78.61	91.23	3.32
Mean		80.12	85.03	

SE = standard error

Table 5.13. Accuracy of Monte Carlo projections based on modification of $DELAY_Q$ using observed disease rates (DIS_{Q+1}) and pig deaths (DTH_{Q+1}) for SHIMS producers, summer 1986 through winter 1988 (ANALYSIS 3)

Producer Number	Mean Absolute Projection Error	Theil's u_2 Statistic
2	192.29	0.31395
3	238.86	0.58890
4	661.83	0.51266
5	92.67	0.87485

on the alpha-beta tracker to predict disease rates and pig deaths?" Again, *DELAY* modification was stochastic, so Monte Carlo analysis was performed; results appear in Tables 5.14, 5.15, and 5.16.

Before discussing the relative quality of the projections obtained with ANALYSIS 4, it will be helpful to assess the quality of data prediction provided by the alpha-beta tracker. To facilitate this evaluation, the mean absolute deviation and Theil's u_2 statistic were calculated for each data series projected with the alpha-beta tracker across all producer-quarters. Here, predictions were evaluated across producers, because data collection was felt to be more consistent for these series. Financial data, as mentioned earlier, was the class most likely to be successfully collected across producers. Further, data on disease rates were collected consistently, since they were all achieved by MSU personnel. Review of these predictions' accuracy is presented in Table 5.17.

In general, the alpha-beta tracker didn't predict very well in this application. The absolute errors for disease prevalence rates ranged from about 0.015 (1.5%), which might be acceptable under certain circumstances, to over 0.26 (26%), which would virtually never be acceptable. Further, examination of Theil's u_2 statistics indicate that *none* of the disease prevalence rates were predicted better than would be provided with the naive model. Similar results, with a few exceptions, were obtained for the remaining data series projected. The apparent perfect prediction for replacement female and replacement boar expenses was related to the fact that none of the SHIMS producers

Table 514. Monte Carlo projections of total hogs marketed based on modification of $DELAY_Q$ using disease rates (DIS_{Q+1}) and pig deaths (DTH_{Q+1}) as projected with the alpha-beta tracker for SHIMS producers, summer 1986 through winter 1988 (ANALYSIS 4)

Producer Number	Quarter	Observed Total Hogs Marketed	Projected Total Hogs Marketed _{Q+1}	
			Mean	SD
2	Su 1986	2013	1808	50
	F 1986	2032	1742	48
	W 1987	2155	1997	55
	Sp 1987	2117	1912	56
	Su 1987	1873	1924	55
	F 1987	2419	1936	52
	W 1988	2284	2222	69
	Mean	2128	1934	
3	Su 1986	1222	1227	59
	F 1986	801	1077	54
	W 1987	1742	1170	57
	Sp 1987	1084	1472	71
	Su 1987	983	1097	52
	F 1987	1006	996	49
	W 1988	1633	1455	72
	Mean	1210	1213	
4	F 1986	4833	2844	42
	W 1987	4041	3196	37
	Sp 1987	3994	4365	60
	Su 1987	3607	4235	51
	F 1987	4388	4233	58
	W 1988	3728	3861	36
	Mean	4098	3789	
5	Su 1986	401	206	4
	F 1986	434	533	11
	W 1987	499	367	12
	Sp 1987	331	345	4
	Su 1987	443	446	12
	F 1987	443	300	10
	Mean	425	366	

SD = standard deviation

Table 5.15. Monte Carlo mean DELAY projections based on modification of DELAY_Q using disease rates (DIS_{Q+1}) and pig deaths (DTH_{Q+1}) as projected with the alpha-beta tracker for SHIMS producers, summer 1986 through winter 1988 (ANALYSIS 4)

Producer Number	Quarter	Observed Mean DELAY	Projected Mean DELAY _{Q+1}	
			Mean	SE
2	Su 1986	108.86	120.30	3.37
	F 1986	97.78	118.72	3.28
	W 1987	103.98	102.62	2.72
	Sp 1987	102.50	109.93	3.20
	Su 1987	99.67	111.44	3.18
	F 1987	87.29	105.99	2.80
	W 1988	80.23	86.06	3.04
Mean		97.19	107.87	
3	Su 1986	126.24	115.52	6.00
	F 1986	116.43	129.97	6.56
	W 1987	96.66	119.18	5.87
	Sp 1987	120.70	94.10	4.91
	Su 1987	137.86	126.07	6.16
	F 1987	95.26	143.89	7.24
	W 1988	108.60	93.94	4.83
Mean		114.54	117.52	
4	F 1986	78.45	113.47	1.72
	W 1987	64.67	80.67	1.27
	Sp 1987	67.33	61.79	1.57
	Su 1987	80.09	70.88	1.15
	F 1987	70.69	76.99	1.14
	W 1988	76.36	71.02	0.81
Mean		72.93	79.14	
5	Su 1986	74.80	118.13	2.40
	F 1986	88.71	67.11	4.18
	W 1987	72.84	92.39	3.96
	Sp 1987	76.30	83.35	0.96
	Su 1987	89.45	81.44	4.22
	F 1987	78.61	95.75	3.11
Mean		80.12	89.70	

SE = standard error

Table 5.16. Accuracy of Monte Carlo projections based on modification of $DELAY_Q$ using disease rates (DIS_{Q+1}) and pig deaths (DTH_{Q+1}) as projected with the alpha-beta tracker for SHIMS producers, summer 1986 through winter 1988 (ANALYSIS 4)

Producer Number	Mean Absolute Projection Error	Theil's u_2 Statistic
2	207.71	0.31558
3	220.43	0.63900
4	687.67	0.47707
5	97.67	0.91526

reported any expenses of these type over the entire project. More than likely, the failure of the technique can be related to data features such as the lumpiness discussed previously. Also, suggestive evidence was presented earlier in this chapter which indicated a somewhat weak functional relationship between successive observations of these variables. As such, their prediction based solely on time series (as occurs with the alpha-beta tracker) cannot be expected to be overly successful. Again, further discussion is deferred to Chapter 6.

In light of the lack of acceptable alpha-beta tracker performance, simulations using data generated as such must be judged accordingly. Therefore, when returning to Table 5.16, it is not surprising that ANALYSIS 4 did not predict as well, in general, as did ANALYSIS 3. The main features of this comparison which bear mention are: the model still predicted better than the assumption of no change, and even though ANALYSIS 4 employed erroneous values for diseases and deaths, the resulting predictions were not much worse (relatively) than those obtained using observed data values.

ANALYSIS 5. The next scenario was designed to confirm that the simulated production and financial effects of disease and deaths were logically consistent. For this purpose, the question was posed, "How well does the model predict if all future disease rates and pig deaths are assumed to be zero, and how do these results compare to those

Table 5.17. Accuracy of alpha-beta tracker data projections for SHIMS producers, summer 1986 through winter 1988

Data series	Mean Absolute Projection Error	Theil's u_2 statistic
Disease prevalence rates		
Severe pneumonia	0.09902	1.50495
Moderate pneumonia	0.06658	1.07781
Mild pneumonia	0.26509	1.85416
Severe ascariasis	0.04358	4.26044
Moderate ascariasis	0.03088	3.13665
Mild ascariasis	0.14974	2.23406
Severe mange	0.01563	2.57282
Moderate mange	0.03813	2.85471
Mild mange	0.11472	1.15947
Severe atrophic rhinitis	0.05667	1.99550
Moderate atrophic rhinitis	0.09330	1.57539
Mild atrophic rhinitis	0.19767	1.37230
Pleuritis	0.02061	1.85534
Pericarditis	0.01493	2.84161
Nasal septum deviation	0.16887	1.75063
Non-feed cash expenses		
Purchased feed	139.65982	3.74579
Repair and maintenance	8.05562	0.51958
Veterinary care and drugs	10.74076	4.53317
Labor	18.90576	1.10040
Supplies	0.74190	0.78411
Fuel	0.75999	1.24105
Electricity	2.20451	0.54742
Telephone	0.22312	1.17656
Trucking	1.71265	0.80918
Marketing	0.84006	0.75166
Insurance	0.46450	1.12158
Interest	12.58992	1.11823
Taxes	0.79011	1.77069
Replacement females	0.00000	0.00000
Replacement boars	0.00000	0.00000
Other	7.12753	5.91861
Pig deaths		
Finisher	28.56425	1.01909
Grower	13.38520	1.07151
Nursery	39.52869	0.90890
Marketing measures		
Market hog weight	38.30460	1.00215
Market hog price	20.23995	1.30397
Feed use		
Finisher	41.40473	0.41854
Grower	19.04404	0.57089
Nursery	7.06406	3.33092

obtained from simulations involving actual disease observations?" Using the established notation, again both DIS_{Q+1} and DTH_{Q+1} were used to modify $DELAY_Q$, but this time the values of DIS_{Q+1} and DTH_{Q+1} were assumed to be zero. Monte Carlo results were summarized in Tables 5.18 and 5.19. However, in this case, the output of ANALYSIS 3 (see Tables 5.11 and 5.12) were included for purposes of comparison. Recall that ANALYSIS 3 modified $DELAY_Q$ using observed values of disease and death data.

Without exception, ANALYSIS 5 predicted an increase and the total number of hogs marketed and a decrease in mean $DELAY$ when compared to ANALYSIS 3. This is exactly as would be anticipated if the presence of diseases and deaths have the expected deleterious impact on production. It is interesting to note that, while the variability in mean $DELAY$ generally decreased with such decreasing disease rates and pig deaths, the variability in total hogs marketed actually increased somewhat. It is felt that this increase was mostly the result of the increased number of marketings, since the coefficients of variation were only mildly affected.

As a matter of interest, the question may be posed, "In a financial sense, how much would it be worth to the producer if zero disease prevalence rates and pig deaths could be achieved?" Because only Producers 2 and 5 provided data regarding feed use, the ability to address this question was somewhat limited for the current SHIMS producers. However, the estimation procedure for income over variable costs (IOVC) as presented in Chapter 4 was applied to the results of ANALYSIS 5 for these two producers. Recall that non-feed, variable costs were formulated on a "per pig-day" basis, where input rates were obtained from the database. Product prices and market weights were also obtained from actual observations. For this analysis, the following feed prices were employed (prices represent a blend of purchased and home-raised feed prices):

finisher = \$0.055 per pound
grower = \$0.07 per pound
nursery = \$0.105 per pound .

Table 5.18 Monte Carlo projections of total hogs marketed based on modification of $DELAY_Q$ using disease rates (DIS_{Q+1}) and pig deaths (DTH_{Q+1}) of zero for SHIMS producers, summer 1986 through winter 1988 (ANALYSIS 5)

Producer Number	Quarter	Projected Total Hogs Marketed $DIS_{Q+1}, DTH_{Q+1} > 0$		Projected Total Hogs Marketed $DIS_{Q+1}, DTH_{Q+1} = 0$	
		Mean	SD	Mean	SD
2	Su 1986	1865	55	1957	60
	F 1986	1817	51	1891	53
	W 1987	2016	57	2100	57
	Sp 1987	1891	55	2004	64
	Su 1987	1972	56	2083	63
	F 1987	1978	55	2063	61
	W 1988	2206	71	2309	78
Mean		1964		2058	
3	Su 1986	1460	69	1682	72
	F 1986	1121	57	1281	66
	W 1987	1211	60	1359	71
	Sp 1987	1427	71	1638	73
	Su 1987	1153	57	1313	68
	F 1987	941	45	1099	56
	W 1988	1628	72	1836	69
Mean		1277		1458	
4	F 1986	3129	48	3596	58
	W 1987	3283	38	3637	41
	Sp 1987	4254	56	4709	34
	Su 1987	4636	49	5102	57
	F 1987	4170	63	4705	56
	W 1988	3721	36	4333	32
Mean		3866		4347	
5	Su 1986	234	4	252	5
	F 1986	539	13	566	31
	W 1987	373	12	391	13
	Sp 1987	331	5	365	2
	Su 1987	473	22	550	41
Mean		378		409	

SD = standard deviation

Table 5.19. Monte Carlo mean DELAY projections based on modification of DELAY_Q using disease rates (DIS_{Q+1}) and pig deaths (DTH_{Q+1}) of zero for SHIMS producers, summer 1986 through winter 1988 (ANALYSIS 5)

Producer Number	Quarter	Projected Mean DELAY _{Q+1} DIS _{Q+1} , DTH _{Q+1} > 0		Projected Mean DELAY _{Q+1} DIS _{Q+1} , DTH _{Q+1} = 0	
		Mean	SE	Mean	SE
2	Su 1986	116.81	3.47	111.59	3.41
	F 1986	113.58	3.14	109.41	2.99
	W 1987	101.18	2.75	98.06	2.54
	Sp 1987	111.75	3.22	106.25	3.34
	Su 1987	108.62	3.08	103.63	3.08
	F 1987	103.78	2.78	100.35	2.83
	W 1988	86.94	3.19	83.26	3.16
Mean		106.09		101.79	
3	Su 1986	96.80	5.11	86.20	4.45
	F 1986	125.48	6.48	113.25	5.75
	W 1987	114.75	5.68	105.97	5.42
	Sp 1987	96.91	5.21	87.62	4.51
	Su 1987	122.97	6.14	110.24	5.70
	F 1987	149.17	7.36	130.14	6.70
	W 1988	88.32	4.34	76.29	4.05
Mean		113.49		101.39	
4	F 1986	102.27	1.53	91.13	1.39
	W 1987	80.45	1.24	71.77	1.10
	Sp 1987	63.83	1.64	54.86	1.39
	Su 1987	63.28	1.05	56.71	0.94
	F 1987	78.64	1.25	70.23	1.08
	W 1988	73.40	0.84	63.37	0.69
Mean		76.98		68.01	
5	Su 1986	99.77	2.01	92.46	1.93
	F 1986	66.70	4.12	63.18	3.85
	W 1987	89.97	3.81	84.66	3.57
	Sp 1987	85.64	1.02	77.52	1.03
	Su 1987	76.87	3.75	70.62	3.36
	F 1987	91.23	3.32	87.05	3.10
Mean		85.03		79.25	

SE = standard error

Since these prices were not included in the SHIMS database, they were (approximately) reconstructed for the simulated period with the assistance of the Mason Elevator Company, of Mason, Michigan.

When the expected IOVC results of ANALYSIS 5 are compared to those of ANALYSIS 3 for Producers 2 and 5, the difference offers an answer to the question regarding the financial value of disease- and death-free production. Results of this comparison are presented in Table 520. As might be expected based on the projected improvements in physical production in the absence of disease, financial production also improved in the absence of disease. Without exception, projected IOVC was higher with ANALYSIS 5 than with ANALYSIS 3. However, it should be noted that the cost of disease eradication was not assessed in this analysis. The maximum amount the producers should be willing to pay for one quarter of these lower disease rates, provided accurate projections, is the difference between the IOVC of ANALYSIS 5 and that of ANALYSIS 3. Of course, this also assumes that disease eradication is technically feasible. Once more, further discussion will occur in Chapter 6.

Demonstration of Decision Support Capabilities

ANALYSIS 6. The final simulation scenario to be presented was designed to display the analytical model's capability for evaluating very specific changes in production circumstances. To provide illustration, the hypothetical situation was constructed where a producer desired to assess the production and financial effects of making environmental changes to help alleviate respiratory disease. Following these changes, the producer expected all pneumonia prevalence rates at slaughter in the upcoming quarter to be 50% of the levels they would have achieved without the environmental changes. In addition, all atrophic rhinitis rates were expected to be at 90% of the no-change levels. No effects on death rates were assumed. The question is posed, "What physical and financial production performance can be expected if the outlined environmental changes are made?"

Table 520. Projected income over variable costs (IOVC) with and without diseases (DIS_{Q+1}) and pig deaths (DTH_{Q+1}) for SHIMS producers, summer 1986 through winter 1988 (ANALYSIS 5)

Producer Number	Quarter	Projected IOVC					
		$DIS_{Q+1}, DTH_{Q+1} > 0$			$DIS_{Q+1}, DTH_{Q+1} = 0$		
		Mean	SD	CV	Mean	SD	CV
2	F 1986	\$ 103,102	\$ 5942	0.0576	\$ 111,634	\$ 6163	0.0552
	W 1987	94,396	6315	0.0669	103,137	6330	0.0614
	Sp 1987	112,814	6820	0.0605	127,288	8020	0.0630
	Su 1987	91,519	6959	0.0760	105,161	7803	0.0742
	F 1987	105,426	8052	0.0764	117,098	8976	0.0767
	W 1988	108,651	6687	0.0615	118,279	7409	0.0626
5	Su 1986	8930	460	0.0515	10,807	537	0.0497
	F 1986	53,083	1871	0.0352	57,060	4410	0.0773
	W 1987	29,008	1456	0.0502	31,122	1546	0.0497
	Sp 1987	8078	463	0.0573	10,997	194	0.0176
	Su 1987	74,465	4277	0.0574	88,974	7881	0.0886
	F 1987	1116	1317	1.1801	2668	1520	0.5697

SD = standard deviation
CV = coefficient of variation

Based on previous data quantity and quality discussions associated with specific producers in the SHIMS pilot group, Producer 2 alone was chosen for this analysis. Feed prices used were the same as in ANALYSIS 5. Since the current model evaluates only on the basis of a three month time horizon, each quarter simulated for this scenario must be considered an independent attempt to answer the producer's question; prolonged disease rate changes are not assumed. Results are presented in Tables 521, 522, and 523. For comparison purposes, both projections achieved with the actually observed disease rates and pig deaths and those attained using disease rates and pig deaths of zero have been included.

As the results show, the model's logical consistency remained unscathed; performance for ANALYSIS 6 fell between the observed disease scenario (ANALYSIS 3) and the not disease, no death scenario (ANALYSIS 5). As a matter of interest, the mean difference in IOVC for a three month period which was associated with making

Table 521. Monte Carlo projections of total hogs marketed based on modification of $DELAY_Q$ using specifically modified pneumonia and atrophic rhinitis prevalence rates for SHIMS producers, summer 1986 through winter 1988 (ANALYSIS 6)

Producer Number	Quarter	Projected Total Hogs Marketed $_{Q+1}$ $DIS_{Q+1} = \text{Obs.}$ $DTH_{Q+1} = \text{Obs.}$		Projected Total Hogs Marketed $_{Q+1}$ $Pn_{Q+1} = 0.5 * \text{Obs.}$ $AR_{Q+1} = 0.9 * \text{Obs.}$	
		Mean	SD	Mean	SD
2	Su 1986	1865	55	1889	57
	F 1986	1817	51	1836	48
	W 1987	2016	57	2039	58
	Sp 1987	1891	55	1917	57
	Su 1987	1972	56	2005	60
	F 1987	1978	55	2008	56
	W 1988	2206	71	2239	68
	Mean	1964		1990	

SD = standard deviation
Pn = pneumonia prevalence rates
AR = atrophic rhinitis prevalence rates
Obs. = observed rates

Table 522. Monte Carlo mean $DELAY$ projections based on modification of $DELAY_Q$ using specifically modified pneumonia and atrophic rhinitis prevalence rates for SHIMS producers, summer 1986 through winter 1988 (ANALYSIS 6)

Producer Number	Quarter	Projected Mean $DIS_{Q+1} = \text{Obs.}$ $DTH_{Q+1} = \text{Obs.}$		Projected Mean $Pn_{Q+1} = 0.5 * \text{Obs.}$ $AR_{Q+1} = 0.9 * \text{Obs.}$	
		Mean	SE	Mean	SE
2	Su 1986	116.81	3.47	115.31	3.50
	F 1986	113.58	3.14	112.41	2.92
	W 1987	101.18	2.75	100.08	2.72
	Sp 1987	111.75	3.22	110.22	3.24
	Su 1987	108.62	3.08	106.84	3.16
	F 1987	103.78	2.78	102.27	2.74
	W 1988	86.94	3.19	85.51	2.96
	Mean	106.09		104.66	

SE = standard error
Pn = pneumonia prevalence rates
AR = atrophic rhinitis prevalence rates
Obs. = observed rates

Table 5.23. Projected income over variable costs (IOVC) with observed diseases (DIS_{Q+1}) and pig deaths (DTH_{Q+1}) compared to specifically modified pneumonia and atrophic rhinitis prevalence rates for SHIMS producers, summer 1986 through winter 1988 (ANALYSIS 6)

Producer Number	Quarter	Projected IOVC					
		$DIS_{Q+1} = \text{Obs.}$ $DTH_{Q+1} = \text{Obs.}$			$Pn_{Q+1} = 0.5 * \text{Obs.}$ $AR_{Q+1} = 0.9 * \text{Obs.}$		
		Mean	SD	CV	Mean	SD	CV
2	F 1986	\$ 103,102	\$ 5942	0.0576	\$ 105,419	\$ 5597	0.0531
	W 1987	94,396	6315	0.0669	97,199	6404	0.0659
	Sp 1987	112,814	6820	0.0605	116,278	7096	0.0610
	Su 1987	91,519	6959	0.0760	95,929	7428	0.0774
	F 1987	105,426	8052	0.0764	110,275	8208	0.0744
	W 1988	108,651	6687	0.0615	112,110	6410	0.0572

SD = standard deviation
 CV = coefficient of variation
 Pn = pneumonia prevalence rates
 AR = atrophic rhinitis prevalence rates
 Obs. = observed rates

the proposed management changes was +\$3550. The cost to attain this would involve both the cost of SHIMS information (see Table 3.14) and the cost of any management change required to affect the improved disease rates.

This example displays both the flexibility of the model and its potential usefulness for assessing the financial aspects of proposed management changes. These results, in turn, could be used to help managers achieve their objectives more effectively. Provided the model can be validated to provide confidence in the results, decision makers should find these capabilities beneficial when faced with choices between management alternatives.

SUMMARY

This chapter has presented the initial application results for a decision support system developed to address health management issues in market hog production.

Several strengths and limitations have surfaced. Further discussion of these in relation to potential on-farm applicability and to recommendations for future system development will occur in Chapter 6.

CHAPTER 6

SUMMARY AND RECOMMENDATIONS

INTRODUCTION

In Chapter 1, the role of the production economist was described as one "... of facilitating choice in production patterns and resource use so that the ends or objectives of farmers and consumers can be attained" (Heady, 1952). Chapter 2 followed by reviewing historical approaches of production economists to this task. Then, Chapters 3, 4, and 5 described the methods used for this purpose by the SHIMS research project and the associated initial results. In short, much discussion regarding information management systems, analytical models, and decision support systems has ensued, both in general and in specific reference to the current project's strengths and limitations. This chapter will summarize the current research in light of its stated goals and will focus discussion on the potential applicability of the decision support system to actual production situations. The structured approach for review presented in Chapter 2 will again be employed. Recommendations will then be made toward future enhancements.

INFORMATION MANAGEMENT SYSTEM

In Chapter 2, the discussion of information management systems involved two major considerations: data collection and data processing. These aspects of the SHIMS project will be reviewed individually. Both developments during the pilot phase and the potential for actual implementation to support real-time production decisions will be discussed.

Data collection

The first data collection question posed in Chapter 2 was, "What to collect?" As alluded to briefly in Chapter 3, the SHIMS accumulation of physical production, animal health, and financial production data in a single database is somewhat unique when information management systems for market hog production are considered. The pilot project was successful in integrating health data collected at slaughter with both physical input/output data and revenue/expense data collected on-farm. As such, the resulting database would provide a single, comprehensive basis for evaluating the economics of health management in market hog production for research purposes. Similarly, the database would provide adequate support for real-time decisions regarding choices between alternative health management strategies for these livestock. Though the scope of the pilot information management system was somewhat limited (because only growing/finishing pigs were considered), a very useful prototype was provided for future expansion. These expansions might include other diseases and/or phases involved in market hog production, or adaptation to non-porcine livestock species.

The second database question posed in Chapter 2 was, "How to collect?" Most noteworthy when considering the SHIMS project in this regard was the method of slaughter health check developed. High speed techniques for pathology evaluation and observation recording were employed, making it possible to collect the desired animal health data at slaughter. While this approach is certainly not unique to SHIMS, the combination of these capabilities with marketing coordination allowed data collection to proceed without disrupting the usual marketing patterns of participating producers. This feature is especially critical if representative samples are to be achieved at slaughter and if the system is eventually intended to be employed in real-time decision support for commercial production of hogs. The major constraint in performing slaughter health checks was the limited availability of university human and capital resources.

Because of the large amount of travel required to follow Michigan hogs through normal marketing channels, provision of this data collection could easily become financially and physically prohibitive for a limited-resource research project. However, once the value of this data and its associated information has been more adequately documented, producers should theoretically be willing to pay for the service in pursuit of the accompanying decision support. Further, since some benefits may also accrue to consumers and non-participating producers (as discussed in Chapter 3), government or other groups (such as consumer organizations) may also become interested in providing long-term assistance.

The final data collection issue posed in Chapter 2 was that of the motivation of people involved. Because of the SHIMS research interests, the motivation for slaughter health checks was surely adequate. However, pilot producers were motivated in their data collection only by the value individually ascribed to the combination of management information received and interaction with university personnel. As mentioned in Chapter 5, this motivation was apparently adequate for all but one of the pilot producers. Since a more convincing documentation of associated benefits is now possible using pilot project results and the analytical model developed, producer motivations should be improved for future endeavors. As discussed, eventual applications in real-time hog production will be similarly motivated by the perceived value of the resulting information.

Data processing

Following the lead of Chapter 2, the first data processing issue to be addressed for the current information management system will be output destination/format. Judging from positive comments received from producers, the content and format of both the slaughter health check and farm management reports were adequate. In general, as discussed in Chapter 3, producers were eager to receive reports containing information on their own production characteristics. Again, the farm management report successfully consolidated information on physical production (inputs, outputs, and

animal health) with financial production information (revenues and expenses). Not only was current information provided, but also historical performance was included to facilitate subjective evaluation of production trends. In addition, summary information from other producers was furnished, providing individuals a basis on which to assess relative performance (see Appendix D).

Finally, perhaps the most noteworthy output destination/format issue for the current information management system was the foundation it provided for the attending analytical model. As will be discussed in the following section, this unique feature afforded both generality and precision to the model. Further, such use of the information management system helped glean as much information from the database as was technically possible. The quality of diagnostic, prescriptive, and predictive information (Harsh, et al, 1981) was thereby greatly enhanced.

The next concern of data processing involved the actual events of entry, processing, and storage. As presented in Chapter 2, SHIMS used a mainframe computer database manager. While research was facilitated as a result, the exclusive future use of a mainframe may hamper the applicability of the system for actual, on-farm problem solving. For this reason, the parallel development of a similar information management system for the microcomputer (as discussed in Chapter 3) is encouraging. Success in this development is critically hinged on ease-of-use, but when achieved the entire information management system will be much closer to actual problem solving situations. This should greatly enhance the usefulness of the system, since reports will be available virtually as soon as the data are entered. Also, potential data inconsistencies should be detected sooner and more reliably.

Finally, the motivations of the people involved in entry/processing will also be enhanced by a completely on-farm system. Producers who use the system will have their financial well-being at least partially related to the caliber of the associated data entry/processing effort. This situation should provide more than adequate motivation.

ANALYTICAL MODEL

As when considering the information management system, the framework for review established in Chapter 2 will be followed in reviewing the current analytical model. In that approach, the following attributes were addressed: resolution, realism, generality, precision, and applicability.

At this point, it is critical to remember that the ultimate judgement of a particular model's attributes is somewhat subjective. Further, as presented in Chapter 2, such assessments rest on system and problem characteristics, modeler's objectives, and available modeling resources. With the current research, the modeler's objectives were to use the modeling approach to build a decision support system for livestock health management. However, because the analytical model will require validation before its overall performance can be objectively evaluated, the existence of somewhat limited modeling resources has hindered thorough assessment. As a result, complete objective judgement of the relative adequacy of each of the five attributes listed is not possible at this point, and the following sections will review the attributes of the analytical model somewhat subjectively, without always judging their adequacy. Also, full compliance with data collection procedures will be assumed for purpose of model discussions. Finally, the potential usefulness of the model in actual problem solving situations will be discussed, since herein lies its contribution to the discipline of economics.

In Chapter 2, a distinction was drawn between analytical production models and analytical decision models. To briefly summarize, production models provide technological expectations for use in decision models, where the production plan is formulated in light of decision maker objectives. As it currently stands, the analytical model associated with the SHIMS project contains both production and decision components. However, the model's primary focus is provision of technological expectations. The corresponding decision model is largely *passive*, in that expected financial outcome is provided for prescribed production tactics, but an *active*,

recommended production plan is not generated. Both production and decision models will be considered in the following discussion.

Resolution

For the current production model, biological resolution was achieved through inclusion of such factors as specific disease conditions present at slaughter, available floor space by production phase, death rates, and rate of feed use. Further, assuming no abrupt changes, the effects of genetics, nutrition, and other environmental factors on production were captured implicitly through observation of current production performance from the database. For financial resolution, the model has appropriately included sales of both feeder pigs and market hogs. In addition, variable expenses were addressed according to fourteen separate classifications (see Appendix A–Production Expenses). As a result of these factors, the amount of resolution in the production model was quite substantial.

When considering the decision model, the passive approach allows decision makers to pursue their own personal objectives, regardless of their exact nature, because specific production recommendations are not forwarded. Decision makers using the model must actively infuse preferences into the choice between various production alternatives based on the projected outcomes. This method avoids the imposition of any specified objectives which are assumed to be universally applicable, a problem often encountered in the literature review of Chapter 2.

Realism

As discussed in Chapter 2, the virtues of resolution are often limited in the absence of realistic representation of the interrelationships present. Realism was attained in the current production model through an adjustment approach using various systems modeling and computer simulation techniques.

Overall, the adjustment approach employed is intuitively appealing. Logically, it seems realistic to ascertain the current status of production for use as a basis to predict future system performance. Further, the physical production model was

stochastic and autocorrelated. Production was modified according to a "tempered" combination of the effects of disease conditions, feed additive use, and available floor space which followed a natural logarithm-based function. Not only did this modification contain autocorrelated stochasticity, but it was also dynamic. As discussed in Chapter 4, the time-step of one day closely approximated the continuous time situation, thereby allowing changes to occur on a continuous basis. Consequently, today's performance was always stochastically modified according to changing system circumstances (diseases, deaths, available floor space, and feed additive use), while retaining a relationship with yesterday's performance. Finally, the model represented the hog population as a single dynamic unit, rather than as a large group of dynamic individuals. Since this technique concurrently maintained a distribution of individual traits (such as growth and death rates), the usual approach of producers to managing groups of growing hogs was captured.

As with the review of resolution, the amount of realism in the decision model was *implicitly* substantial due to its passive approach. In addition, the output from Monte Carlo analyses included both the mean projected outcomes and their variances. An illustration of the output produced from one such analysis was presented in Table 5.6. These features should allow future decision makers to evaluate projections based on criteria such as certainty equivalent income, first degree stochastic dominance, second degree stochastic dominance, etc. Further, trade-offs between multiple decision maker objectives can be evaluated through appropriate "What if?" scenario analysis. Again, the lack of specific recommendations avoids the possibility of imposing non-representative decision maker objectives.

Generality and precision

Though generality and precision represent distinctly different concepts, they will be reviewed together for the current production model since both were achieved through a single mechanism: use of individual-farm data. This feature is perhaps one of the model's greatest assets. In one sense, the approach was broadly generic, since it could

be applied to virtually any confinement, hog-growing system with an adequate record system. On the other hand, it became very specifically tailored to individual farms once data from that farm were entered.

One of the most commonly expressed concerns in the literature review of Chapter 2 was one of statistically estimated functions lacking validity outside their particular experimental population/sample. Integration of the analytical model with an information management system as accomplished by the current research completely avoided this potential problem.

For the current production model, precision and generality refer to how well performance was predicted for selected individual producers and for a group of producers, respectively. In spite of some questionable data quality, the current model was shown in Chapter 5 to consistently predict better than the naive, no-change model for all individuals providing data in the pilot group. Thus, the eventual precision and generality for real-time decision support should be very good.

As with resolution and realism, the generality and precision of the decision model were determined by the absence of active recommendations. As such, the model should perform equally as well across a group of decision makers as it does for the individuals involved.

Applicability

The final model attribute for review is applicability. The paramount concern in this regard must be related to eventual use of the analytical model for actual support of production decisions. For these purposes, the model's applicability should be very good. Just as the potential for evaluating the importance of both the presence and severity of disease was exhibited by ANALYSIS 6 in Chapter 5, similar sensitivity analyses could be accomplished for available floor space and feed additive use. These analyses can be very specific. For example, the effects of changing a single disease in one phase of production can be accomplished as easily as evaluating the effects of decreasing the entire available floor space or removal of certain feed additives. Further,

the resulting outputs contain the expected outcomes and their variances for both physical production and the associated financial circumstances (income over variable costs). The resulting information should be extremely useful for producers.

For example, if Producer 2 reviewed ANALYSIS 6 for fall quarter 1986, the results would be seen to indicate that, on average, up to \$2317 could be spent to decrease pneumonia prevalence rates by 50% and atrophic rhinitis prevalence rates by 10% for one three month period (see Table 5.23). However, the output generated also indicates that when the variability in production is considered, the probability distributions of these two management options exhibit considerable overlap. In fact, because the difference between the means is only about one half of one standard deviation, the distributions are statistically indistinguishable.

Thus, the decision maker is faced with a *possibility* of improved income over variable costs, but certainly without guarantees. The decision regarding whether or not to invest in the proposed management changes would depend critically on both the cost involved and the associated epidemiological probability of achieving the described decrease in disease rates. If, for instance, the effect could also be achieved through use of antibiotics in the feed, perhaps an added benefit may be achieved, making the alternative seem more desirable. Or, if the disease rates remained low for an extended time period, the analysis would change. As discussed, similar analyses could be readily performed for other diseases, available floor space, and/or the use of feed additives.

Finally, the computer technology involved warrants explicit mention. Implementation of the model on a microcomputer greatly enhances applicability. The limits on "What if?" analyses are imposed only by the user's interests and the availability of time. Computerized implementation expedites the mere calculation involved. Eventually, having such capacity entirely on-farm will make turn around time virtually non-existent while providing excellent accessibility for purposes of user interaction. With recent advances in microcomputer technology, the potential only stands to improve.

CONCLUSIONS AND RECOMMENDATIONS

As stated in Chapter 1, the goal of this research was to construct a prototype decision support system for livestock production using growing pigs as an analytical framework, placing emphasis on animal health management. This has been accomplished. A multidisciplinary approach has been used to successfully integrate information management, systems modeling, and computer simulation techniques. The research has received the guidance of academia, industry, and government. From academia, both extension and research interests were involved across the disciplines of agricultural economics, operations research (including systems science), veterinary medicine, epidemiology, and animal science. Interaction with the hog producing industry has actively included slaughter, marketing, producer, and veterinary input. And involvement of both state and federal governments has been achieved through the Michigan Department of Agriculture; the United States Department of Agriculture (USDA), Economic Research Service; USDA, Food Safety and Inspection Service (FSIS); USDA, Extension; and (to a lesser extent) USDA, Animal and Plant Health Inspection Service. The resulting decision support system holds much potential, both for actual implementation in the future and as a prototype for development of similar systems to address other livestock production problems.

However, to fully capitalize on the present accomplishments, validation of the system using an expanded sample of farms will be necessary. Though certain information regarding hog performance may be attainable from various ongoing and future experimental trials, the mission of the production economist should be to facilitate choice in actual production situations. Since experimental trials often (usually) involve control of certain aspects of production that may exhibit considerable variation during commercial production, the resulting information may be of limited value for current purposes. Specifically, environments are frequently controlled, as are disease conditions and nutritional variation, in an attempt to silhouette the aspects of production which interest the investigator(s) involved. Nevertheless, environment, disease, and

nutrition vary simultaneously in the course of ordinary commercial production. This normal (albeit complicated) situation will provide a much more useful basis for validation of the current decision support system.

Therefore, an expanded sample of commercial farms is recommended. This expansion should build on current findings through incorporation of the accompanying recommendations. For the information management system, these recommendations are summarized and enumerated below.

1. To maximize inferential capabilities the expanded sample of producers should be selected according to appropriate random procedures, and should include a sample of about 80 herds (as discussed in Chapter 3).
2. Also according to sample size calculations from Chapter 3, frequency of slaughter health check should be tailored to individual farm sizes and marketing characteristics. In general, this will involve more slaughter health checks than the rate of four per year as occurred during the pilot project. According to herd size and desired confidence, recommendations for the pilot group ranged from 8 to 53 slaughter health checks per year.
3. Related to the frequency of slaughter health checks and the increased sample size, it will be necessary to garner substantial extramural support for conducting future slaughter health checks. Such support could be financial, allowing hired slaughter health checks, or in the form of labor contributions. A good potential candidate as a source of potential labor support is USDA-FSIS based on their interest and active participation in the pilot project.
4. On-farm data not immediately critical for evaluating the economics of health management for growing pigs should not be collected. These data include factors such as reproductive management, farrowing rates, and preweaned pig deaths.

5. **Explicit information on pig flows should be collected. If strict all-in-all-out management is followed, pig flow schedules will be adequate. If not, numbers of pigs being moved and dates of movement will be required.**
6. **Along with the pig flow data mentioned, structured subsampling should occur involving individual pig identification. This will facilitate observation of average transit times, thereby allowing evaluation of COMPLEX optimization as a method to estimate *DELAY*.**
7. **Where possible and practical, lumpiness of data should be minimized. Though complete elimination of lumps in favor of flow rates cannot be expected, data aggregation into "super-lumps" should be strictly avoided.**
8. **Pig inventory data need to be counted rather than calculated.**
9. **Formats for provision of data should be limited to a select, standardized few. While the importance of flexibility is recognized, careful selection of those few standard formats which will be accepted should easily accommodate most producers.**
10. **Methods of collecting feed use data should be reviewed in an effort to increase producer compliance. For this purpose, the advisory input of producers will be extremely important.**
11. **Advice of producers will also be useful in determining appropriate methods to assure adequate producer motivation. Ultimately, the economic benefits which accrue to the producer by virtue of participation should become more evident, but strong documentation of these benefits will necessarily be delayed until after system validation. In the interim, potential motivation techniques such as payment for participation and/or periodic collection assistance through occasional farm visits should be considered.**
12. **Methods of capturing substantial management changes need to be developed. These might involve periodic surveys and/or farm visits.**

13. Regarding the farm management reports, periodic summaries involving all participating producers should be considered. These should contain the production value ranges which interested the pilot producers.
14. Producer requests and/or comments should be periodically elicited. This elicitation should be explicit, rather than a standing offer to receive comments, and focus should be maintained on data collection techniques and output content/format.
15. To enhance system function, electronic communication between the database and analytical model should be developed. Because of the expanded sample size, this will probably require conversion of the analytical model to mainframe computer compatibility, thereby allowing the research aspects of system development to be completed.

Once the sample size has been appropriately expanded and data collection (reflecting the recommended changes) has been implemented, system validation should proceed. Again, several specific recommendations can be made based on experiences to this point. As before, these will be enumerated.

1. Using the subsample data with pigs individually identified, the use of COMPLEX optimization for observation of system performance should be evaluated. This step is extremely critical, since the entire model rests on modifications made to the initial *DELAY*. If COMPLEX is found to be inappropriate, an alternative method of observing current system performance needs to be discerned to allow success with the remainder of the validation process.
2. Certain specific modeling techniques need to be heavily scrutinized. Primary concern centers on the methods used to modify *DELAY*, including:
 - a. the effects of changes in disease rates, available floor space, and feed additive use as obtained from the literature;

- b. the use of logarithm functions to "temper" the combined effects of simultaneous change in several production factors; and
 - c. the function used to achieve autocorrelation.
- 3. If model predictions of system performance are found to be inadequate after the evaluations suggested under 1 and 2, priority areas for further modeling efforts include environment, nutrition (especially feed efficiency), and clinical diseases. If warranted, attempts might be made in these areas to increase the resolution and realism of the model. This, in turn, may require modifications of the database to include features such as subsampling. For example, pigs in the system at various phases may be subsampled for purposes of laboratory health evaluation. Similarly, hogs at slaughter may require subsampling and subsequent laboratory testing. Feeds may require subsampling to fully ascertain nutritional parameters. And environments may need subsampled to help define the micro-environments of growing pigs.
- 4. If alpha-beta tracker performance for disease rate prediction is found to be inadequate on the expanded sample (as it was in the pilot sample), development of a more traditional epidemiological model should be considered. Relative expenditure of resources in this regard should be based on the results of economic sensitivity analysis to the diseases contained in the model. In addition to strong environmental considerations, heavy emphasis should be placed on discerning the relationships between feed additives and disease rates as well as disease rates and pig deaths.
- 5. To enhance the ability of the model to support rigorous economic analyses, reliable sources of market information for future periods should be utilized. Independent marketing models should be strongly considered, and could conceivably be integrated electronically in the long run.

6. Pending the outcome of analyses such as suggested, further changes to the database and/or analytical model may be recommended. These potential avenues for change should virtually never be discounted entirely, since the modeling process is truly iterative, as was displayed in Figure 2.1
7. As a final research note, it will be extremely important to use the model for rigorous assessment of the economics associated with various management options. Of primary interest in this regard will be diseases and the use of feed additives. Such information will be very useful to:
 - a. government for regulatory activities,
 - b. academia for teaching and further research, and
 - c. producers for management.

Following the structured validation process, the decision support system should be ready for development of an appropriate user interface to facilitate implementation by individual producers. Also, complete conversion to the microcomputer may be desirable.

SUMMARY

The goal of this research was to construct a prototype decision support system for livestock production, focusing on animal health management. Through application of some innovative techniques, this has been successfully accomplished. The system developed has shown much promise by combining individual farm production data with an original analytical model. Modeling techniques from systems science have been adapted for current purposes, and computerized implementation has facilitated analysis of the complex relationships involved in production. Though the accomplishments have been substantial, full realization of the benefits associated with the current effort will only be achieved when the system is validated and trial implementation occurs.

Whatever developments ensue, however, the pilot SHIMS project has provided an invaluable experience in multidisciplinary research. Because the problems associated

with "...facilitating choice in production patterns..." (Heady, 1952) seldom fall discretely within the boundaries of *any* single academic discipline, this experience has provided an important example of broadening the approach of the production economist. Fostering and expanding such efforts should yield substantial social benefits, since doing so will widen the economist's repertoire. If more choices are adequately facilitated as a result, the well-being of society will ultimately be improved.

APPENDICES

APPENDIX A

APPENDIX A

SWINE HEALTH INFORMATION MANAGEMENT SYSTEM INITIAL VISIT FORM GENERAL INFORMATION

Date: _____

Farm Code: _____

Farm Name: _____

Telephone: ()-____-_____

Owner's Name: _____

Address: _____

Production Type (check all that apply)

_____ Farrow-to-finish
_____ Finish only

_____ Feeder pig producer
_____ Seed stock producer

Other Livestock (respond appropriately)

Average No. on Hand

Dairy cattle	_____
Beef cattle	_____
Sheep	_____
Goats	_____
Horses	_____
Veal	_____
Poultry	_____

Crops raised (check all that apply and respond appropriately)

	Cash Crop	Livestock Feed	Acres
Corn grain	_____	_____	_____
Corn silage	_____	_____	_____
Oats	_____	_____	_____
Barley	_____	_____	_____
Wheat	_____	_____	_____
Soybeans	_____	_____	_____
Hay	_____	_____	_____

SHIMS
General Information
Page 2

Health Management Practices

Veterinary service is used _____ times/year.

When used, the purpose is:

(check all that apply)

- _____ to investigate disease problems
 _____ to treat sick pigs
 _____ to do herd work
 _____ veterinary service is contracted

Traffic Control (check all that apply):

- _____ shower in/out
 _____ boots required
 _____ coveralls required
 _____ truck traffic control
 _____ foot baths

Incoming Stock Management (check all that apply):

- _____ isolation from other animals
 _____ blood test before arrival
 _____ blood test after arrival
 _____ automatically treated for disease on arrival
 _____ automatically vaccinated for disease on arrival
 _____ live animals are not purchased

Breeding Herd Management

	Always	Sometimes	Never		
Pen mate	1	2	3	4	5
Hand mate	1	2	3	4	5
Artificial insemination	1	2	3	4	5
Breed on first heat post-weaning	1	2	3	4	5
Pregnancy test	1	2	3	4	5
Group farrowing	1	2	3	4	5
21 day heat checks	1	2	3	4	5

Age of gilts at breeding _____ months

Weight of gilts at breeding _____

Genetics

Source of Replacements:

	Purchased	Raised
Gilts	_____	_____
Boars	_____	_____

SHIMS
General Information
Page 3

Predominant Breeds Involved: (check all that apply)

	<u>Maternal Sires</u>	<u>Terminal Sires</u>
Hamp	_____	_____
Duroc	_____	_____
York	_____	_____
Ch.White	_____	_____
Landrace	_____	_____
Lg.White	_____	_____

Frequency of boar purchase _____ times/year.
 Age of boars at purchase _____ months
 Weight of boars at purchase _____

Source of boars: (check all that apply)

Breeding company _____
 Commercial producer(s) _____
 Purebred breeder(s) _____

Feed Handling

Feed Analysis Frequency: _____ times/year

Mixer type (check all that apply):

_____ Portable grinder-mixer with scales
 _____ Portable grinder-mixer without scales
 _____ Volumetric mixer
 _____ Stationary vertical mixer
 _____ Stationary horizontal mixer

Pig Management

Age at weaning _____
 Weight at weaning _____
 Age at castration _____
 Age at tail docking _____
 Age at teeth clipping _____

Provision of supplemental milk: (check one)

_____ Starting at day 1 post-farrowing
 _____ Starting at day 7 post-farrowing
 _____ Starting at day 14 post-farrowing
 _____ Starting at day 21 post-farrowing

Provision of creep feed: (check one)

_____ Starting at day 1 post-farrowing
 _____ Starting at day 7 post-farrowing
 _____ Starting at day 14 post-farrowing
 _____ Starting at day 21 post-farrowing

RATION USAGE

Page 4

[illegible]

MASTER PREPARED FEEDS LIST

Date: _____
Farm Code: _____
Page 5

Prepared Feed	:	:	Percent	:	Percent	
Number (PF #)	:	Description	:	Crude Protein	:	Fat

[illegible]

HEALTH MANAGEMENT PRACTICES

Date: _____

Farm Code: _____

DISEASE (see disease code list)	:	:	:	:	:	:	:
PRODUCT (see product code list)	:	:	:	:	:	:	:
ROUTE	:	:	:	:	:	:	:
1. water	:	:	:	:	:	:	:
2. feed	:	:	:	:	:	:	:
3. injectable	:	:	:	:	:	:	:
DOSAGE mg/ton (feed products only)	:	:	:	:	:	:	:
PRODUCTION PHASE (use inventory codes from below)	:	:	:	:	:	:	:
FREQUENCY	:	:	:	:	:	:	:
1. as needed	:	:	:	:	:	:	:
2. continuous	:	:	:	:	:	:	:
DURATION Number of treatment days (0 = continuous)	:	:	:	:	:	:	:
PURPOSE	:	:	:	:	:	:	:
1. growth promotion	:	:	:	:	:	:	:
2. disease prevention	:	:	:	:	:	:	:
3. disease treatment	:	:	:	:	:	:	:

1. Gestating females	7. Preweaned pigs
2. Lactating females	8. Prenursery weaned pigs
3. Open sows	9. Nursery pigs
4. Cull sows	10. Grower pigs
5. Open gilts	11. Finisher pigs
6. Boars	

SHIMS HEALTH MANAGEMENT PRODUCT LIST

I. Vaccines

<u>Code</u>	<u>Product</u>	<u>Code</u>	<u>Product</u>
1	Bordetella bronchiseptica	10	Pseudorabies
2	Clostridium perfringens	11	Rotavirus
3	E. coli	12	Salmonella
4	Erysipelas		Streptococcus
5	Haemophilus parasuis	13	suis II
6	Haemophilus pleuropneumonia	14	other
7	Leptospirosis	15	Swine dysentery
8	Parvovirus	16	T.G.E.
9	Pasteurella multocida		

II. Drugs

<u>Code</u>	<u>Product</u>	<u>Code</u>	<u>Product</u>
16	Amprolium	43	Permethrin (Ectaban, Permaban, Permectrin)
17	Apramycin (Apralan)	44	Piperazine
18	B. M. D.	45	Probiotic
19	Carbadox	46	Prolate
20	Ciodrin	47	Prostaglandin
21	Decoquinat	48	Pyrantel tartarate (Banminth)
22	Dichlorvos (Atyard)	49	Rabon
23	Electrolytes	50	Ronnel
24	Erythromycin	51	Selenium
25	Fenbendazole (Safeguard)	52	Spectinomycin
26	Fenthion (Tigumon)	53	Sulfachlorpyridazine
27	Fenvalerate (Ectrin)	54	Sulfamerazine
28	Flavomycin	55	Sulfamethazine
29	Gentamycin (Gentocin)	56	Sulfathiazole
30	Hygromycin		Tetracycline
31	Iron	57	Chlortetracycline
32	Ivermectin	58	Oxytetracycline
33	L-S 50	59	LA-200
34	Levamisole	60	Thiabendazole
35	Lincomycin	61	Tiamulin
36	Lindane	62	Triple sulfa
37	Malathion	63	Tylosin (Tylan)
38	Neomycin	64	Virginiamycin
39	Oxytocin	65	Vitamin A
	Penicillin	66	Vitamin D
40	Benzathine (Flocillin)	67	Vitamin E
41	Pen/Strep		
42	Procaine Pen G		

HISTORICAL DISEASE PROBLEMS

Date: _____
 Farm Code: _____

+ - - - - - +

PROBLEM CODES

1. = Not a problem
2. = Problem within the last year
3. = Problem over 1 year ago
4. = Both 2 and 3

+ - - - - - +

DISEASE	PROBLEM CODE	DISEASE	PROBLEM CODE
Abscessation	_____	Nutr. deficiency	_____
Anemia	_____	vit E/selenium	_____
Arthritis	_____	other	_____
Atrophic rhinitis	_____	Osteochondrosis	_____
Cannibalism	_____	P.S.S.	_____
Clostr. perfringens	_____	Parvovirus	_____
Coccidiosis	_____	Pneumonia	_____
Deformed	_____	mycoplasma	_____
Diarrhea	_____	pasteurella	_____
preweaning	_____	Poor milking	_____
postweaning	_____	Prolapses	_____
Downer sows	_____	rectal	_____
Dystocia	_____	vaginal	_____
E. coli	_____	Pseudorabies	_____
Edema disease	_____	Rectal stricture	_____
Enteric torsions	_____	Rotavirus	_____
Erysipelas	_____	Round worms	_____
Greasy pig disease	_____	Salmonellosis	_____
Haemophilus	_____	Shaker pigs	_____
parasuis	_____	Streptococcus	_____
pleuropneumonia	_____	suis (II)	_____
Hemorrhagic bowel	_____	other	_____
Hernia	_____	Swine dysentery	_____
scrotal	_____	Swine influenza	_____
umbilical	_____	T.G.E.	_____
Lameness	_____	Terminal ileitis	_____
Leptospirosis	_____	Tetanus	_____
Lice	_____	Toxicities	_____
Mange	_____	Ulcers	_____
Mastitis	_____	Urinary infection	_____
Metritis	_____	Vaginal discharge	_____
Mycotoxiosis	_____		

SHIMS DISEASE CODE LIST

<u>CODE</u>	<u>DISEASE</u>	<u>CODE</u>	<u>DISEASE</u>
1	Abscessation		Nutritional deficiency
2	Anemia	30	vit E/selenium
3	Arthritis	31	other
4	Atrophic rhinitis	32	Osteochondrosis
5	Cannibalism	33	P.S.S.
6	Clostridium perfringens	34	Parvovirus
7	Coccidiosis		Pneumonia
8	Deformed	35	mycoplasma
	Diarrhea	36	pasteurella
9	preweaning	37	Poor milking
10	postweaning		Prolapses
11	Downer sows	38	rectal
12	Dystocia	39	vaginal
13	E. coli	40	Pseudorabies
14	Edema disease	41	Rectal stricture
15	Enteric torsions	42	Rotavirus
16	Erysipelas	43	Round worms
17	Greasy pig disease	44	Salmonellosis
	Haemophilus	45	Shaker pigs
18	parasuis		Streptococcus
19	pleuropneumonia	46	suis (II)
20	Hemorrhagic bowel	47	other
	Hernia	48	Swine dysentery
21	scrotal	49	Swine influenza
22	umbilical	50	T.G.E.
23	Lameness	51	Terminal ileitis
24	Leptospirosis	52	Tetanus
25	Lice	53	Toxicities
26	Mange	54	Ulcers
27	Mastitis	55	Urinary infection
28	Metritis	56	Vaginal discharge
29	Mycotoxiosis		

FARROWING FACILITY FORM

DATE: _____
 FARM CODE: _____
 FACILITY NO: _____

Building Type (choose one)

1. Enclosed _____
2. M O F _____
3. Cargill _____
4. Pasture _____
5. Other _____

Ventilation Type (choose one)

1. Natural _____
2. Mechanical _____
3. Combination _____

Supplemental Heat (check all that apply)

1. Space heater unit _____
2. Floor heat _____
(hot water)
3. Hovers _____
4. Heat lamps _____
5. Heat pads _____

Percent Solid Floor _____Number of Crates _____Crate Width (choose one)

- 4 1/2 feet _____
- 5 feet _____
- Other _____

Solid Floor Type (check all that apply)

1. Dirt _____
2. Cement _____
3. Wood _____
4. None _____

Slotted Floor Type (check all that apply)

1. Cement _____
2. Plastic-coated _____
metal
3. Wire _____
4. T-bar _____
5. Other _____

Manure Handling (check all that apply)

1. Manual removal _____
2. Flush _____
3. Pit with plug _____
4. Pit w/o plug _____
5. Part of lagoon system _____
6. Scraper system _____

Sow Feeder Type (check all that apply)

1. Trough w/hopper _____
2. Trough w/o hopper _____
3. Floor _____

Creep Feeder Type (check all that apply)

1. Trough w/hopper _____
2. Trough w/o hopper _____
3. Floor _____

No. Waterers/Pen or Crate

- | | Sows | Pigs |
|-----------|-------|-------|
| 1. Nipple | _____ | _____ |
| 2. Cup | _____ | _____ |

All-in-all-out Management _____

BREEDING AND GESTATION FACILITY FORM

DATE: _____
 FARM CODE: _____
 FACILITY NO: _____

Building Type (choose one)

1. Enclosed
2. M O F
3. Cargill _____
4. Pasture _____
5. Other _____

Ventilation Type (choose one)

1. Natural
2. Mechanical _____
3. Combination _____

Supplemental Heat (check all that apply)

1. Space heater unit _____
2. Floor heat _____
(hot water)
3. Hovers _____
4. Heat lamps _____
5. Heat pads _____

Percent Solid Floor _____Number of Crates _____Solid Floor Type (check all that apply)

1. Dirt _____
2. Cement _____
3. Wood _____
4. None _____

Slotted Floor Type (check all that apply)

1. Cement _____
2. Plastic-coated
metal _____
3. Wire _____
4. T-bar _____
5. Other _____

Manure Handling (check all that apply)

1. Manual removal _____
2. Flush _____
3. Pit with plug _____
4. Pit w/o plug _____
5. Part of lagoon system _____
6. Scraper system _____

Feeder Type (check all that apply)

1. Trough w/hopper
Width/pen _____
2. Trough w/o hopper
Width/pen _____
3. Floor _____

No. Waterers/pen or crate

1. Nipple _____
2. Cup _____

All-in-all-out Management _____

PIG FACILITY FORM

DATE: _____
 FARM CODE: _____
 FACILITY NO: _____

Facility Use (choose one)

1. Hot nursery _____
2. Nursery _____
3. Grower _____
4. Finisher _____

Building Type (choose one)

1. Enclosed _____
2. M O F _____
3. Cargill _____
4. Pasture _____
5. Other _____

Ventilation Type (choose one)

1. Natural _____
2. Mechanical _____
3. Combination _____

Supplemental Heat (check all that apply)

1. Space heater unit _____
2. Floor heat _____
 (hot water)
3. Hovers _____
4. Heat lamps _____
5. Heat pads _____

Percent Solid Floor _____

Solid Floor Type (check all that apply)

1. Dirt _____
2. Cement _____
3. Wood _____
4. None _____

Slotted Floor Type (check all that apply)

1. Cement _____
2. Plastic-coated metal _____
3. Wire (non-deck) _____
4. Wire decks _____
5. T-bar _____
6. Other _____

Manure Handling (check all that apply)

1. Manual removal _____
2. Flush _____
3. Pit with plug _____
4. Pit w/o plug _____
5. Part of lagoon _____
6. Scraper system _____

Feeder Type (respond to all that apply)

1. Fenceline/Bain-bridge (no.) _____
 No. holes/feeder _____
 Hole width (in.) _____
2. Round trough with water (no.) _____
 Diameter (ft.) _____
3. Round trough w/o water (no.) _____
 Diameter (ft.) _____
4. Straight trough w/hopper (no.) _____
 Length (ft.) _____
5. Straight trough w/o hopper (no.) _____
 Length (ft.) _____
6. Round feeder w/holes (no.) _____
 No. holes/feeder _____
 Hole width (in.) _____
7. Drop system _____
8. Other _____

Total Waterers by Type

1. Nipple _____
2. Cup _____
3. Tank _____
4. Other _____

All-in-all-out Management _____

PEN SIZE FORM

DATE: _____

FARM CODE: _____

[illegible]

BREEDING AND GESTATION OBSERVATIONS

DATE: _____

OBSERVED BY: _____

FARM CODE: _____

(+ = Adequate; - = Needs Attention)

	+	-	<u>Comments</u>
Room temperature (°F)	_____	_____	_____
Moisture	_____	_____	_____
Gases	_____	_____	_____
Fan condition	_____	_____	_____
Inlet condition	_____	_____	_____
Heat source	_____	_____	_____
Cleanliness	_____	_____	_____
Waterers	_____	_____	_____
Feeder management	_____	_____	_____
Light	_____	_____	_____
Floor	_____	_____	_____
Body condition	_____	_____	_____
Hair coats	_____	_____	_____
Mange	_____	_____	_____
Thin sows	_____	_____	_____
Discharges	_____	_____	_____
Lameness	_____	_____	_____
Feet	_____	_____	_____
Downers	_____	_____	_____
Testicle size	_____	_____	_____
Prolapses	_____	_____	_____
Pig temperament	_____	_____	_____
Scours	_____	_____	_____
Snouts	_____	_____	_____
Sneezing	_____	_____	_____
Eyes	_____	_____	_____
Coughing	_____	_____	_____
Vices	_____	_____	_____
Other	_____	_____	_____

Summary:

FARROWING OBSERVATIONS

DATE: _____

OBSERVED BY: _____

FARM CODE: _____

(+ = Adequate; - = Needs attention)

	+	-	<u>Comments</u>
Room temperature (°F)	_____	_____	_____
Moisture	_____	_____	_____
Gases	_____	_____	_____
Fan condition	_____	_____	_____
Inlet condition	_____	_____	_____
Heat source	_____	_____	_____
Cleanliness	_____	_____	_____
Waterers	_____	_____	_____
Feeder management	_____	_____	_____
Sow appetite	_____	_____	_____
Creep management	_____	_____	_____
Creep feed management	_____	_____	_____
Floor	_____	_____	_____
Sow haircoat	_____	_____	_____
Underlines	_____	_____	_____
Sow temperament	_____	_____	_____
Discharges	_____	_____	_____
Feet	_____	_____	_____
Shoulder ulcers	_____	_____	_____
Pig haircoat	_____	_____	_____
Pig hydration	_____	_____	_____
Pig temperament	_____	_____	_____
Pig fill	_____	_____	_____
Estimated pig gain	_____	_____	_____
Scours	_____	_____	_____
Sneezing	_____	_____	_____
Coughing	_____	_____	_____
Arthritis	_____	_____	_____
Navel ill	_____	_____	_____
Teeth clipped	_____	_____	_____
Lacerations/abrasions	_____	_____	_____
Teat/vulva necrosis	_____	_____	_____
Anemia	_____	_____	_____
Other	_____	_____	_____

Summary:

GROWER OBSERVATIONS

DATE: _____

OBSERVED BY: _____

FARM CODE: _____

(+ = Adequate; - = Needs attention)

	+	-	<u>Comments</u>
Room temperature (°F)	_____	_____	_____
Moisture	_____	_____	_____
Gases	_____	_____	_____
Fan condition	_____	_____	_____
Inlet condition	_____	_____	_____
Heat source	_____	_____	_____
Cleanliness	_____	_____	_____
Waterers	_____	_____	_____
Feeder management	_____	_____	_____
Sort	_____	_____	_____
Pen uniformity	_____	_____	_____
Average number pigs per pen	_____	_____	_____
Feed texture	_____	_____	_____
Fill	_____	_____	_____
Hydration	_____	_____	_____
Hair coat	_____	_____	_____
Skin condition	_____	_____	_____
Scours	_____	_____	_____
Sneezing	_____	_____	_____
Tearing	_____	_____	_____
Snouts	_____	_____	_____
Coughing	_____	_____	_____
Labored breathing	_____	_____	_____
Lameness	_____	_____	_____
Eyes	_____	_____	_____
Anemia	_____	_____	_____
Prolapses	_____	_____	_____
Vices	_____	_____	_____
Other	_____	_____	_____

Summary:

NURSERY OBSERVATIONS

DATE: _____	OBSERVED BY: _____	
FARM CODE: _____	(+ - Adequate; - = Needs attention)	
	+ -	<u>Comments</u>
Room temperature (°F)	_____	_____
Moisture	_____	_____
Gases	_____	_____
Fan condition	_____	_____
Inlet condition	_____	_____
Heat source	_____	_____
Cleanliness	_____	_____
Waterers	_____	_____
Feeder management	_____	_____
Sort	_____	_____
Pen uniformity	_____	_____
Average number pigs per pen	_____	_____
Feed texture	_____	_____
Fill	_____	_____
Hydration	_____	_____
Hair coat	_____	_____
Skin condition	_____	_____
Scours	_____	_____
Sneezing	_____	_____
Tearing	_____	_____
Snouts	_____	_____
Coughing	_____	_____
Labored breathing	_____	_____
Lameness	_____	_____
Eyes	_____	_____
Anemia	_____	_____
Prolapses	_____	_____
Vices	_____	_____
Other	_____	_____
<u>Summary:</u>		

FINISHER OBSERVATIONS

DATE: _____

OBSERVED BY: _____

FARM CODE: _____

(+ = Adequate; - = Needs attention)

	+	-	<u>Comments</u>
Room temperature (°F)	_____	_____	_____
Moisture	_____	_____	_____
Gases	_____	_____	_____
Fan condition	_____	_____	_____
Inlet condition	_____	_____	_____
Heat source	_____	_____	_____
Cleanliness	_____	_____	_____
Waterers	_____	_____	_____
Feeder management	_____	_____	_____
Sort	_____	_____	_____
Pen uniformity	_____	_____	_____
Average number pigs per pen	_____	_____	_____
Feed texture	_____	_____	_____
Fill	_____	_____	_____
Hydration	_____	_____	_____
Hair coat	_____	_____	_____
Skin condition	_____	_____	_____
Scours	_____	_____	_____
Sneezing	_____	_____	_____
Tearing	_____	_____	_____
Snouts	_____	_____	_____
Coughing	_____	_____	_____
Labored breathing	_____	_____	_____
Lameness	_____	_____	_____
Eyes	_____	_____	_____
Anemia	_____	_____	_____
Prolapses	_____	_____	_____
Vices	_____	_____	_____
Other	_____	_____	_____

Summary:

Farm: _____

SHIMS FARROWING RECORD

[illegible]

Farm: _____

SHIMS FARROWING ROOM MORTALITY

No. Pre-Weaned Pig Deaths

[illegible]

Farm: _____

SHIMS POST-WEANING MORTALITY

Phase Codes	
12 = Pre-Nursery	Weaned Pigs
13 = Nursery Pigs	
14 = Grower Pigs	
15 = Finisher Pigs	

Key to Death Reason Codes	
1 = Pneumonia	7 = Cannibalism
2 = Scours	8 = Sudden Death
3 = Lameness	9 = Starvation
4 = Injury	10 = Other Conditions
5 = Abscess	or Reasons
6 = Chronic Poor Doer	11 = Unknown Reasons

[illegible]

Key to Removal Reason Codes

7 = Sudden Death
8 = Depopulate/Test and Remove
9 = Poor performance of offspring
10 = Financial
11 = Other Conditions or Reasons
12 = Unknown Reasons

[illegible]

Key to Swine Class Codes

1 = Feeder Pigs	6 = Boars for Replacement
2 = Market Hogs	7 = Open Gilts for Replacement
3 = Underweight Market Hogs	8 = Bred Gilts for Replacement
4 = Cull Sows	9 = Homeused
5 = Cull Boars	

[illegible]

Farm: _____

SHIMS ANIMAL PURCHASES

Key to Swine Class Codes

1 = Feeder Pigs

7 = Open Gilts for Replacement

6 = Boars for Replacement

8 = Bred Gilts for Replacement

[illegible]

Farm: _____

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SHIMS
INVENTORY

DATE _____
mm/dd/yy

	<u>HEAD</u>	<u>WEIGHT PER HEAD</u>
Gestating Females	_____	_____
Lactating Females	_____	_____
Open Sows	_____	_____
Cull Sows	_____	_____
Open Gilts	_____	_____
Boars	_____	_____
Pre-Weaned Pigs	_____	_____
Pre-Nursery Weaned Pigs	_____	_____
Nursery Pigs (less than 50 lbs)	_____	_____
Grower Pigs (50-125 lbs)	_____	_____
Finisher Pigs (125 lbs.-market weight)	_____	_____

Farm Code: _____

1. Purchased feed	8. Telephone
2. Repairs and maintenance	9. Trucking
3. Vet. and drugs	10. Marketing
4. Labor	11. Insurance
5. Supplies	12. Interest
6. Fuel	13. Taxes
7. Electricity	14. Other

[illegible]

PRODUCTION EXPENSES
(Except Livestock Purchases)

Month: _____

Farm Code: _____

EXPENSE ITEM CODES

- | | |
|----------------------------|---------------|
| 1. Purchased feed | 8. Telephone |
| 2. Repairs and maintenance | 9. Trucking |
| 3. Vet. and drugs | 10. Marketing |
| 4. Labor | 11. Insurance |
| 5. Supplies | 12. Interest |
| 6. Fuel | 13. Taxes |
| 7. Electricity | 14. Other |

[illegible]

RATION CODES			
1 = Starter #1	7 = Grower #1	13 = Lactation #1	19 = Boar #1
2 = Starter #2	8 = Grower #2	14 = Lactation #2	20 = Boar #2
3 = Starter #3	9 = Grower #3	15 = Lactation #3	21 = Gilt #1
4 = Nursery #1	10 = Finisher #1	16 = Gestation #1	22 = Gilt #2
5 = Nursery #2	11 = Finisher #2	17 = Gestation #2	23 = Creep #1
6 = Nursery #3	12 = Finisher #3	18 = Gestation #3	24 = Creep #2

Record each batch mixed or delivered. Indicate any discarded or returned feed.

[illegible]

APPENDIX B

APPENDIX B **SLAUGHTER CHECK DATA**

DATE:_____ **OWNER:**_____ **NO. HOGS CHECKED:**_____

PLANT:_____ **INVESTIGATOR(S):**_____

<u>LINE</u> <u>ORDER</u>	<u>LUNGS</u>	<u>LIVER</u>	<u>COMM.</u>	<u>LINE</u> <u>ORDER</u>	<u>LUNGS</u>	<u>LIVER</u>	<u>COMM.</u>	<u>LINE</u> <u>ORDER</u>	<u>LUNGS</u>	<u>LIVER</u>	<u>COMM.</u>
1.	_____	_____	_____	36.	_____	_____	_____	71.	_____	_____	_____
2.	_____	_____	_____	37.	_____	_____	_____	72.	_____	_____	_____
3.	_____	_____	_____	38.	_____	_____	_____	73.	_____	_____	_____
4.	_____	_____	_____	39.	_____	_____	_____	74.	_____	_____	_____
5.	_____	_____	_____	40.	_____	_____	_____	75.	_____	_____	_____
6.	_____	_____	_____	41.	_____	_____	_____	76.	_____	_____	_____
7.	_____	_____	_____	42.	_____	_____	_____	77.	_____	_____	_____
8.	_____	_____	_____	43.	_____	_____	_____	78.	_____	_____	_____
9.	_____	_____	_____	44.	_____	_____	_____	79.	_____	_____	_____
10.	_____	_____	_____	45.	_____	_____	_____	80.	_____	_____	_____
11.	_____	_____	_____	46.	_____	_____	_____	81.	_____	_____	_____
12.	_____	_____	_____	47.	_____	_____	_____	82.	_____	_____	_____
13.	_____	_____	_____	48.	_____	_____	_____	83.	_____	_____	_____
14.	_____	_____	_____	49.	_____	_____	_____	84.	_____	_____	_____
15.	_____	_____	_____	50.	_____	_____	_____	85.	_____	_____	_____
16.	_____	_____	_____	51.	_____	_____	_____	86.	_____	_____	_____
17.	_____	_____	_____	52.	_____	_____	_____	87.	_____	_____	_____
18.	_____	_____	_____	53.	_____	_____	_____	88.	_____	_____	_____
19.	_____	_____	_____	54.	_____	_____	_____	89.	_____	_____	_____
20.	_____	_____	_____	55.	_____	_____	_____	90.	_____	_____	_____
21.	_____	_____	_____	56.	_____	_____	_____	91.	_____	_____	_____
22.	_____	_____	_____	57.	_____	_____	_____	92.	_____	_____	_____
23.	_____	_____	_____	58.	_____	_____	_____	93.	_____	_____	_____
24.	_____	_____	_____	59.	_____	_____	_____	94.	_____	_____	_____
25.	_____	_____	_____	60.	_____	_____	_____	95.	_____	_____	_____
26.	_____	_____	_____	61.	_____	_____	_____	96.	_____	_____	_____
27.	_____	_____	_____	62.	_____	_____	_____	97.	_____	_____	_____
28.	_____	_____	_____	63.	_____	_____	_____	98.	_____	_____	_____
29.	_____	_____	_____	64.	_____	_____	_____	99.	_____	_____	_____
30.	_____	_____	_____	65.	_____	_____	_____	100.	_____	_____	_____
31.	_____	_____	_____	66.	_____	_____	_____				
32.	_____	_____	_____	67.	_____	_____	_____				
33.	_____	_____	_____	68.	_____	_____	_____				
34.	_____	_____	_____	69.	_____	_____	_____				
35.	_____	_____	_____	70.	_____	_____	_____				

SLAUGHTER CHECK DATA

DATE: _____ OWNER: _____ NO. HOGS CHECKED: _____

PLANT: _____ INVESTIGATOR(S): _____

CATEGORY	SCORE	COUNT																				TOTALS
		1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	
MANGE	(0)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	_____
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	(1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	_____
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	(2)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	_____
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
	(3)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	_____
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

RHINITIS

SEPTAL DEVIATION

	SCORE	COUNT										TOTAL											TOTAL
		1	2	3	4	5	6	7	8	9	10		1	2	3	4	5	6	7	8	9	10	
(0)		0	0	0	0	0	0	0	0	0	0	_____	0	0	0	0	0	0	0	0	0	0	_____
		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	
(1)		0	0	0	0	0	0	0	0	0	0	_____	0	0	0	0	0	0	0	0	0	0	_____
		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	
(2)		0	0	0	0	0	0	0	0	0	0	_____	0	0	0	0	0	0	0	0	0	0	_____
		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	
(3)		0	0	0	0	0	0	0	0	0	0	_____	0	0	0	0	0	0	0	0	0	0	_____
		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	
		0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	

COMMENTS:

APPENDIX C

APPENDIX C

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File: C:\UTIL\WATNFB.PGM 02/10/1989 17:52 -- Page: 001

[illegible]

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File: C:\UTIL\MAINR.PGM

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ITEM F_FEEDERS AS 9 LIMITS=(0:1);
ITEM F_WATER1 AS 999 HEADING 'STRAT:TROUGH:W/ NOP';
ITEM F_WATER2 AS 99 LIMITS=(0:1);
ITEM F_WATER3 AS 99 HEADING 'STRAT:TROUGH:W/O NOP';
ITEM F_WATER4 AS 99 LIMITS=(0:1);
ITEM F_ALLINALL AS 9 HEADING 'FLOOR:FEEDER';
LIMITS=(0:1);
ITEM F_SOURCE1 AS 99 HEADING 'NIPPLE:N20 PER:PEN/SOUL';
ITEM F_SOURCE2 AS 99 HEADING 'NIPPLE:N20 PER:PEN/PIGS';
ITEM F_SOURCE3 AS 99 HEADING 'CUP:N20 PER:PEN/SOUL';
ITEM F_SOURCE4 AS 99 HEADING 'CUP:N20 PER:PEN/PIGS';
ITEM F_SOURCE5 AS 99 HEADING 'ALL-IN-ALL-OUT:MANAGE';
LIMITS=(0:1);

MASTER BREED INSERT=KEYED(BR_FARMCODE, NOTUNIQUE);
ITEM BR_FARMCODE MEMBER FARM FILE;
HEADING 'FARM:CODE';
ITEM BR_EVALDATE AS DATE HEADING 'DATE';
ITEM BR_FACILITYNO AS 99 HEADING 'FACILITY:NO';
ITEM BR_BUILDING AS 9 HEADING 'BUILDING:TYPE';
LIMITS=(1:5);
ITEM BR_VENT AS 9 HEADING 'VENTILATION';
LIMITS=(1:3);
ITEM BR_MEAT1 AS 9 HEADING 'SPACE:HEATER';
LIMITS=(0:1);
ITEM BR_MEAT2 AS 9 HEADING 'FLOOR:HEATER';
LIMITS=(0:1);
ITEM BR_MEAT3 AS 9 HEADING 'MOVERS';
LIMITS=(0:1);
ITEM BR_MEAT4 AS 9 HEADING 'HEAT:LAMPS';
LIMITS=(0:1);
ITEM BR_MEAT5 AS 9 HEADING 'HEAT:PADS';
LIMITS=(0:1);
ITEM BR_PCSD_FLOOR AS 999 HEADING 'X SOLID:FLOOR';
ITEM BR_MOORATES AS 99 HEADING 'NO. OF:CRATES';
ITEM BR_SO_DIRT AS 9 HEADING 'NO. OF:DIRT:FLOOR';
LIMITS=(0:1);
ITEM BR_SO_CEMENT AS 9 HEADING 'SOLID:CEMENT:FLOOR';
LIMITS=(0:1);
ITEM BR_SO_WOOD AS 9 HEADING 'SOLID:WOOD:FLOOR';
LIMITS=(0:1);
ITEM BR_SL_CEMENT AS 9 HEADING 'SLOTTED:CEMENT:FLOOR';
LIMITS=(0:1);
ITEM BR_SL_PLASTIC AS 9 HEADING 'SLOTTED:PLASTIC:METAL:FLOOR';
LIMITS=(0:1);
ITEM BR_SL_WIRE AS 9 HEADING 'SLOTTED:WIRE:FLOOR';
LIMITS=(0:1);
ITEM BR_SL_TBAR AS 9 HEADING 'TBAR';
LIMITS=(0:1);
ITEM BR_SL_OTHER AS 9 HEADING 'OTHER';
LIMITS=(0:1);
ITEM BR_MANURE1 AS 9 HEADING 'MANUAL:REMOVAL';
LIMITS=(0:1);
ITEM BR_MANURE2 AS 9 HEADING 'FLUSH';
LIMITS=(0:1);
ITEM BR_MANURE3 AS 9 HEADING 'PIT WITH:PLUG';
LIMITS=(0:1);
ITEM BR_MANURE4 AS 9 HEADING 'PIT W/O:PLUG';
LIMITS=(0:1);
ITEM BR_MANURE5 AS 9 HEADING 'LAGOON:SYSTEM';
LIMITS=(0:1);
ITEM BR_MANURE6 AS 9 HEADING 'SCRAPE:SYSTEM';
LIMITS=(0:1);
ITEM BR_FEEDER1 AS 9 HEADING 'STRAT:TROUGH:W/ NOP';
LIMITS=(0:1);

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File: C:\UTIL\MAINR.PGM

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ITEM F_FEEDERS AS 9 HEADING 'OTHER';
LIMITS=(0:1);
ITEM F_WATER1 AS 999 HEADING 'NIPPLE:WATERS';
ITEM F_WATER2 AS 99 HEADING 'CUP:WATERS';
ITEM F_WATER3 AS 99 HEADING 'TANK:WATERS';
ITEM F_WATER4 AS 99 HEADING 'OTHER:WATERS';
ITEM F_ALLINALL AS 9 HEADING 'ALL-IN-ALL-OUT:MANAGE';
LIMITS=(0:1);

MASTER FARM INSERT=KEYED(FV_FARMCODE, NOTUNIQUE);
ITEM FV_FARMCODE MEMBER FARM FILE;
HEADING 'FARM:CODE';
ITEM FV_EVALDATE AS DATE HEADING 'DATE';
ITEM FV_FACILITYNO AS 99 HEADING 'FACILITY:NO';
ITEM FV_BUILDING AS 9 HEADING 'BUILDING:TYPE';
LIMITS=(1:5);
ITEM FV_VENT AS 9 HEADING 'VENTILATION';
LIMITS=(1:3);
ITEM FV_MEAT1 AS 9 HEADING 'SPACE:HEATER';
LIMITS=(0:1);
ITEM FV_MEAT2 AS 9 HEADING 'FLOOR:HEATER';
LIMITS=(0:1);
ITEM FV_MEAT3 AS 9 HEADING 'MOVERS';
LIMITS=(0:1);
ITEM FV_MEAT4 AS 9 HEADING 'HEAT:LAMPS';
LIMITS=(0:1);
ITEM FV_MEAT5 AS 9 HEADING 'HEAT:PADS';
LIMITS=(0:1);
ITEM FV_PCSD_FLOOR AS 999 HEADING 'X SOLID:FLOOR';
ITEM FV_MOORATES AS 99 HEADING 'NO. OF:CRATES';
ITEM FV_CRATEWIDTH AS 999 HEADING 'CRATE:WIDTH';
LIMITS=(1:3);
ITEM FV_SO_DIRT AS 9 HEADING 'SOLID:DIRT:FLOOR';
LIMITS=(0:1);
ITEM FV_SO_CEMENT AS 9 HEADING 'SOLID:CEMENT:FLOOR';
LIMITS=(0:1);
ITEM FV_SO_WOOD AS 9 HEADING 'SOLID:WOOD:FLOOR';
LIMITS=(0:1);
ITEM FV_SL_CEMENT AS 9 HEADING 'SLOTTED:CEMENT:FLOOR';
LIMITS=(0:1);
ITEM FV_SL_PLASTIC AS 9 HEADING 'SLOTTED:PLASTIC:METAL:FLOOR';
LIMITS=(0:1);
ITEM FV_SL_WIRE AS 9 HEADING 'SLOTTED:WIRE:FLOOR';
LIMITS=(0:1);
ITEM FV_SL_TBAR AS 9 HEADING 'TBAR:FLOOR';
LIMITS=(0:1);
ITEM FV_SL_OTHER AS 9 HEADING 'OTHER:FLOOR';
LIMITS=(0:1);
ITEM FV_MANURE1 AS 9 HEADING 'MANUAL:REMOVAL';
LIMITS=(0:1);
ITEM FV_MANURE2 AS 9 HEADING 'FLUSH';
LIMITS=(0:1);
ITEM FV_MANURE3 AS 9 HEADING 'PIT WITH:PLUG';
LIMITS=(0:1);
ITEM FV_MANURE4 AS 9 HEADING 'PIT W/O:PLUG';
LIMITS=(0:1);
ITEM FV_MANURE5 AS 9 HEADING 'LAGOON:SYSTEM';
LIMITS=(0:1);
ITEM FV_MANURE6 AS 9 HEADING 'SCRAPE:SYSTEM';
LIMITS=(0:1);
ITEM FV_SOURCE1 AS 9 HEADING 'STRAT:TROUGH:W/ NOP';
LIMITS=(0:1);
ITEM FV_SOURCE2 AS 9 HEADING 'STRAT:TROUGH:W/O NOP';
LIMITS=(0:1);
ITEM FV_SOURCE3 AS 9 HEADING 'FLOOR:FEEDER';
LIMITS=(0:1);

```

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```

INV_N_OPENGILT + INV_N_BOAR +
INV_N_PREAM + INV_N_PREMURS +
INV_N_MURSERV + INV_N_GROVER +
INV_N_FINISH +
DEFINE INV_F_MUN AS 999,999 HEADING 'TOTAL FEMALE:NUMBER'
EXP = (INV_N_GESTFEN + INV_N_LACTFEN +
INV_N_OPENSOU + INV_N_CULLSOU +
INV_N_OPENGILT) ;
MASTER PMSIZE INSERT=KEYED(M_FARMCODE,NOTUNIQUE);
ITEM M_FARMCODE MEMBER'FARM FILE'
HEADING 'FARM:CODE';
ITEM M_ENTERDATE AS DATE HEADING 'DATE';
ITEM M_PHASE AS 99 HEADING 'PHASE:CODE';
ITEM M_MUMPS AS 99,999 HEADING 'NUMBER:PIGS';
ITEM M_REASON AS 99 HEADING 'DEATH:REASON';
ITEM M_AVEWEIGHT AS 99,999 HEADING 'AVERAGE:WEIGHT';
MASTER FARREC INSERT=KEYED(FR_FARMCODE,NOTUNIQUE);
ITEM FR_FARMCODE MEMBER'FARM FILE'
HEADING 'FARM:CODE';
ITEM FR_ENTERDATE AS DATE HEADING 'DATE';
ITEM FR_LITTERFAR AS 99,999 HEADING 'NUMBER:LITTERS';
ITEM FR_PIGSBOIN AS 99,999 HEADING 'PIGS:BOIN';
ITEM FR_PIGSLIVE AS 99,999 HEADING 'PIGS:LIVE:BOIN';
ITEM FR_MUMPS AS 99,999 HEADING 'NUMBER:MUMPS';
ITEM FR_PIGSDEATH AS 99,999 HEADING 'PIGS:DEATH';
ITEM FR_SOUSEANED AS 99,999 HEADING 'SOU:SEANED';
MASTER FARMHRT INSERT=KEYED(FM_FARMCODE,NOTUNIQUE);
ITEM FM_FARMCODE MEMBER'FARM FILE'
HEADING 'FARM:CODE';
ITEM FM_ENTERDATE AS DATE HEADING 'DATE';
ITEM FM_CRUSHED AS 99,999 HEADING 'CRUSHED';
ITEM FM_DEFORMED AS 99,999 HEADING 'DEFORMED';
ITEM FM_SCOURS AS 99,999 HEADING 'SCOURS';
ITEM FM_STARVED AS 99,999 HEADING 'STARVED';
ITEM FM_SUDEN AS 99,999 HEADING 'SUDDEN:DEATH';
ITEM FM_WEAK AS 99,999 HEADING 'WEAK';
ITEM FM_OTHEMORT AS 99,999 HEADING 'OTHER:MORTALITY';
ITEM FM_TOTMORT AS 99,999 HEADING 'TOTAL:MORTALITY';
EXP = (FM_CRUSHED + FM_DEFORMED + FM_SCOURS +
FM_STARVED + FM_SUDEN + FM_WEAK +
FM_OTHEMORT) ;
MASTER BREEDREN INSERT=KEYED(B_FARMCODE,NOTUNIQUE);
ITEM B_FARMCODE MEMBER'FARM FILE'
HEADING 'FARM:CODE';
ITEM B_DATE AS DATE HEADING 'DATE';
ITEM B_SEX AS 9 LIMIT=(1:2);
ITEM B_MUMPS AS 99,999 HEADING 'NO.:HEAD';
ITEM B_REMOVAL AS 9 HEADING 'TYPE OF:REMOVAL';
ITEM B_REASON AS 99 LIMIT=(1:2);
ITEM B_REASON AS 99 HEADING 'REMOVAL:REASON';
LIMIT=(1:12);
MASTER MARKETS INSERT=KEYED(M_FARMCODE,NOTUNIQUE);
ITEM M_FARMCODE MEMBER'FARM FILE'
HEADING 'FARM:CODE';
ITEM M_DATE AS DATE HEADING 'DATE';
ITEM M_SWINECODE AS 9 HEADING 'SWINE:CLASS:CODE';
ITEM M_MUMPS AS 99,999 HEADING 'NO.:HEAD';
ITEM M_TOTALGROSS AS 999,999 HEADING 'TOTAL:WEIGHT';
ITEM M_GROSSDOLL AS 999,999 HEADING 'GROSS:DOLLAR:RECEIPTS';
ITEM M_MARKETCOST AS 99,999 HEADING 'MARKETING:COSTS';

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```

HEADING 'WIDTH:PER PEN';
HEADING 'STRAT:ROUGH:W/O MOP'
LIMITS=(0:1);
HEADING 'WIDTH:PER PEN';
HEADING 'FLOOR:FEEDER'
LIMITS=(0:1);
HEADING 'B RATTLE:W/O:PER PEN';
HEADING 'B CUP:W/O:PER PEN';
HEADING 'ALL-IN-ALL:OUT:W/O:WAGE'
LIMITS=(0:1);
MASTER PENSIZE INSERT=KEYED(PEN_FARMCODE,NOTUNIQUE);
ITEM PEN_FARMCODE MEMBER'FARM FILE'
HEADING 'FARM:CODE';
ITEM PEN_EVALDATE AS DATE HEADING 'DATE';
ITEM PEN_FACILITYNO AS 99 HEADING 'FACILITY:NO';
ITEM PEN_USETYPE AS 99 HEADING 'USE:TYPE';
ITEM PEN_NO_PENS AS 99 HEADING 'NO. OF:PENS';
ITEM PEN_WIDTH AS 999,9 HEADING 'PEN:WIDTH';
ITEM PEN_LENGTH AS 999,9 HEADING 'PEN:LENGTH';
ITEM PEN_TOT_AREA AS 999,999 HEADING 'TOT:PER:AREA';
EXP=PEN_WIDTH*PEN_LENGTH*PEN_NO_PENS;
EXTRACT F_FACILUSE FROM:
FEEDING KEY'PEN_FARMCODE';
MASTER INVENTOR INSERT=KEYED(INV_FARMCODE,NOTUNIQUE);
ITEM INV_FARMCODE MEMBER'FARM FILE'
HEADING 'FARM:CODE';
ITEM INV_DATE AS DATE HEADING 'DATE';
ITEM INV_N_GESTFEN AS 99,999 HEADING 'NUMBER:GESTATING';
ITEM INV_N_LACTFEN AS 99,999 HEADING 'WEIGHT:GESTATING';
ITEM INV_N_OPENSOU AS 99,999 HEADING 'NUMBER:OPEN SOUS';
ITEM INV_N_OPENSOU AS 99,999 HEADING 'WEIGHT:OPEN SOUS';
ITEM INV_N_CULLSOU AS 99,999 HEADING 'NUMBER:CULL SOUS';
ITEM INV_N_OPENGILT AS 99,999 HEADING 'WEIGHT:CULL SOUS';
ITEM INV_N_OPENGILT AS 99,999 HEADING 'NUMBER:OPEN GILT';
ITEM INV_N_BOAR AS 99,999 HEADING 'WEIGHT:OPEN GILT';
ITEM INV_N_PREAM AS 99,999 HEADING 'NUMBER:BOARS';
ITEM INV_N_PREMURS AS 99,999 HEADING 'WEIGHT:BOARS';
ITEM INV_N_MURSERV AS 99,999 HEADING 'NUMBER:PRE WEAN';
ITEM INV_N_GROVER AS 99,999 HEADING 'WEIGHT:PRE WEAN';
ITEM INV_N_FINISH AS 99,999 HEADING 'NUMBER:PRE MURS';
ITEM INV_N_FINISH AS 99,999 HEADING 'WEIGHT:PRE MURS';
ITEM INV_N_FINISH AS 99,999 HEADING 'NUMBER:MURSERV';
ITEM INV_N_FINISH AS 99,999 HEADING 'WEIGHT:MURSERV';
ITEM INV_N_FINISH AS 99,999 HEADING 'NUMBER:GROVERS';
ITEM INV_N_FINISH AS 99,999 HEADING 'WEIGHT:GROVERS';
ITEM INV_N_FINISH AS 99,999 HEADING 'NUMBER:FINISHER';
ITEM INV_N_FINISH AS 99,999 HEADING 'WEIGHT:FINISHER';
ITEM INV_N_FINISH AS 99,999 HEADING 'TOTAL:WEIGHT';
EXP = ((INV_N_GESTFEN + INV_N_LACTFEN +
(INV_N_OPENSOU + INV_N_OPENSOU) +
(INV_N_OPENGILT + INV_N_OPENGILT) +
(INV_N_BOAR + INV_N_BOAR) +
(INV_N_PREAM + INV_N_PREAM) +
(INV_N_MURSERV + INV_N_MURSERV) +
(INV_N_GROVER + INV_N_GROVER) +
(INV_N_FINISH + INV_N_FINISH));
EXP = ((INV_N_GESTFEN + INV_N_LACTFEN +
INV_N_OPENSOU + INV_N_OPENSOU +
INV_N_OPENGILT + INV_N_OPENGILT +
INV_N_BOAR + INV_N_BOAR +
INV_N_PREAM + INV_N_PREAM +
INV_N_MURSERV + INV_N_MURSERV +
INV_N_GROVER + INV_N_GROVER +
INV_N_FINISH + INV_N_FINISH));
DEFINE INV_MUN AS 999,999 HEADING 'TOTAL:NUMBER'
EXP = (INV_N_GESTFEN + INV_N_LACTFEN +
INV_N_OPENSOU + INV_N_OPENSOU +
INV_N_OPENGILT + INV_N_OPENGILT +
INV_N_BOAR + INV_N_BOAR +
INV_N_PREAM + INV_N_PREAM +
INV_N_MURSERV + INV_N_MURSERV +
INV_N_GROVER + INV_N_GROVER +
INV_N_FINISH + INV_N_FINISH);

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[illegible]

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ITEM OD_ROOM_TEMP	AS 9	HEADING 'ROOM:TEMP'
		LIMITS=(0:1);
ITEM OD_MOISTURE	AS 9	HEADING 'MOISTURE'
		LIMITS=(0:1);
ITEM OD_GASES	AS 9	HEADING 'GASES'
		LIMITS=(0:1);
ITEM OD_FAR	AS 9	HEADING 'FAR:COND'
		LIMITS=(0:1);
ITEM OD_INLET	AS 9	HEADING 'INLET:COND.'
		LIMITS=(0:1);
ITEM OD_HEAT	AS 9	HEADING 'HEAT:SOURCE'
		LIMITS=(0:1);
ITEM OD_CLEAN	AS 9	HEADING 'CLEAN:L1:MESS'
		LIMITS=(0:1);
ITEM OD_WATER	AS 9	HEADING 'H2O:GTS'
		LIMITS=(0:1);
ITEM OD_FEED_MNG	AS 9	HEADING 'FEED:INMGHT'
		LIMITS=(0:1);
ITEM OD_SORT	AS 9	HEADING 'SORT'
		LIMITS=(0:1);
ITEM OD_PUMIF	AS 9	HEADING 'PEN:UNIF'
		LIMITS=(0:1);
ITEM OD_MO_PEN	AS 9	HEADING 'AVG #PIGS/PEN'
		LIMITS=(0:1);
ITEM OD_FEED	AS 9	HEADING 'FEED:TEXTURE'
		LIMITS=(0:1);
ITEM OD_FILL	AS 9	HEADING 'FILL'
		LIMITS=(0:1);
ITEM OD_HYDRA	AS 9	HEADING 'HYDRA:TION'
		LIMITS=(0:1);
ITEM OD_HAIR	AS 9	HEADING 'HAIR:COAT'
		LIMITS=(0:1);
ITEM OD_SKIN	AS 9	HEADING 'SKIN:COND'
		LIMITS=(0:1);
ITEM OD_SCOURS	AS 9	HEADING 'SCOURS'
		LIMITS=(0:1);
ITEM OD_SNEEZE	AS 9	HEADING 'SNEEZ:ING'
		LIMITS=(0:1);
ITEM OD_TEAR	AS 9	HEADING 'TEAR:ING'
		LIMITS=(0:1);
ITEM OD_SHOUTS	AS 9	HEADING 'SHOUTS'
		LIMITS=(0:1);
ITEM OD_COUGH	AS 9	HEADING 'COUGH'
		LIMITS=(0:1);
ITEM OD_BREATH	AS 9	HEADING 'LABORED:BREATH'
		LIMITS=(0:1);
ITEM OD_LANE	AS 9	HEADING 'LANE:MESS'
		LIMITS=(0:1);
ITEM OD_EYES	AS 9	HEADING 'EYES'
		LIMITS=(0:1);
ITEM OD_ANEMIA	AS 9	HEADING 'ANEMIA'
		LIMITS=(0:1);
ITEM OD_PROLAP	AS 9	HEADING 'PROLAPSES'
		LIMITS=(0:1);
ITEM OD_VOICE	AS 9	HEADING 'VOICES'
		LIMITS=(0:1);
ITEM OD_OTHER	AS 9	HEADING 'OTHER'
		LIMITS=(0:1);

MASTER FEED LIST INSERT=KEYED(FL_FARMCODE,NOTUNIQUE);
 ITEM FL_FARMCODE MEMBER 'FARM FILE';
 ITEM FL_DATE HEADING 'DATE';
 ITEM FL_FEED_NO AS DATE HEADING 'PREPARED:FEED NO.';
 ITEM FL_DESC AS A15 HEADING 'DESCRIP.';
 ITEM FL_PROTEIN AS 999 HEADING '% CRUDE:PROTEIN'

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ITEM OD_MEAT	AS 9	HEADING 'MEAT:SOURCE'
		LIMITS=(0:1);
ITEM OD_CLEAN	AS 9	HEADING 'CLEAN'
		LIMITS=(0:1);
ITEM OD_WATER	AS 9	HEADING 'H2O:GTS'
		LIMITS=(0:1);
ITEM OD_FEED_MNG	AS 9	HEADING 'FEED:INMGHT'
		LIMITS=(0:1);
ITEM OD_SOJ_APP	AS 9	HEADING 'SOJ:APPETITE'
		LIMITS=(0:1);
ITEM OD_CR_MNG	AS 9	HEADING 'CREEP:INMGHT'
		LIMITS=(0:1);
ITEM OD_CR_F_MNG	AS 9	HEADING 'CREEP:FEED:MNG.'
		LIMITS=(0:1);
ITEM OD_FLOOR	AS 9	HEADING 'FLOOR'
		LIMITS=(0:1);
ITEM OD_SHAIR	AS 9	HEADING 'SOJ:HAIR:COAT'
		LIMITS=(0:1);
ITEM OD_UNDER	AS 9	HEADING 'UNDER:LINES'
		LIMITS=(0:1);
ITEM OD_TEMPER	AS 9	HEADING 'SOJ:TEMPER'
		LIMITS=(0:1);
ITEM OD_DISCNG	AS 9	HEADING 'DISC:NG'
		LIMITS=(0:1);
ITEM OD_FEET	AS 9	HEADING 'FEET'
		LIMITS=(0:1);
ITEM OD_ULCER	AS 9	HEADING 'SHLDER:ULCERS'
		LIMITS=(0:1);
ITEM OD_PHAIR	AS 9	HEADING 'BIG:HAIR:COAT'
		LIMITS=(0:1);
ITEM OD_PHYDRA	AS 9	HEADING 'PIG:HYDRA:TION'
		LIMITS=(0:1);
ITEM OD_PTEMPER	AS 9	HEADING 'PIG:TEMPER'
		LIMITS=(0:1);
ITEM OD_PFILL	AS 9	HEADING 'PIG:FILL'
		LIMITS=(0:1);
ITEM OD_PGAIN	AS 9	HEADING 'EST.:PIG:GAIN'
		LIMITS=(0:1);
ITEM OD_SCOURS	AS 9	HEADING 'SCOURS'
		LIMITS=(0:1);
ITEM OD_SNEEZE	AS 9	HEADING 'SNEEZ:ING'
		LIMITS=(0:1);
ITEM OD_COUGH	AS 9	HEADING 'COUGH'
		LIMITS=(0:1);
ITEM OD_ARTH	AS 9	HEADING 'ARTHRITIS'
		LIMITS=(0:1);
ITEM OD_NAVEL	AS 9	HEADING 'NAVEL:ILL'
		LIMITS=(0:1);
ITEM OD_TEETH	AS 9	HEADING 'TEETH:CLIP'
		LIMITS=(0:1);
ITEM OD_LACER	AS 9	HEADING 'LACERA:ABRAS'
		LIMITS=(0:1);
ITEM OD_WECR	AS 9	HEADING 'TEAT:VULVA:WECR'
		LIMITS=(0:1);
ITEM OD_ANEMIA	AS 9	HEADING 'ANEMIA'
		LIMITS=(0:1);
ITEM OD_OTHER	AS 9	HEADING 'OTHER'
		LIMITS=(0:1);

MASTER OD_MGF INSERT=KEYED(OD_FARMCODE);
 ITEM OD_FARMCODE MEMBER 'FARM FILE';
 ITEM OD_DATE AS DATE HEADING 'DATE';
 ITEM OD_OBSERVE AS A10 HEADING 'OBSERVER';
 ITEM OD_TYPE AS 9 HEADING 'TYPE OF:OBSER';
 LIMITS=(1:3);


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ITEM FL_FAT      AS 999          LIMITS=(0:100);
                                HEADING 'X FAT';
                                LIMITS=(0:100);

MASTER BAT FORM INSERT=KEYED(RF_FARMCODE,NOTUNIQUE);
ITEM RF_FARMCODE      MEMBER 'FARM:CODE';
ITEM RF_DATE          AS DATE      HEADING 'DATE';
ITEM RF_FEED_NO       AS 9999      HEADING 'PREPARED:FEED NO.';
ITEM RF_CODE1         AS 99        HEADING 'RATION:CODE #';
                                LIMITS=(1:24);
ITEM RF_CODE2         AS 99        HEADING 'RATION:CODE #';
                                LIMITS=(1:24);
ITEM RF_CODE3         AS 99        HEADING 'RATION:CODE #';
                                LIMITS=(1:24);
ITEM RF_CODE4         AS 99        HEADING 'RATION:CODE #';
                                LIMITS=(1:24);
ITEM RF_CODE5         AS 99        HEADING 'RATION:CODE #';
                                LIMITS=(1:24);
ITEM RF_CODE6         AS 99        HEADING 'RATION:CODE #';
                                LIMITS=(1:24);
ITEM RF_CODE7         AS 99        HEADING 'RATION:CODE #';
                                LIMITS=(1:24);
ITEM RF_CODE8         AS 99        HEADING 'RATION:CODE #';
                                LIMITS=(1:24);
ITEM RF_CODE9         AS 99        HEADING 'RATION:CODE #';
                                LIMITS=(1:24);

MASTER RU USE INSERT=KEYED(RU_FARMCODE,NOTUNIQUE);
ITEM RU_FARMCODE      MEMBER 'FARM:CODE';
ITEM RU_DATE          AS DATE      HEADING 'DATE';
ITEM RU_FEED_NO       AS 9999      HEADING 'PREPARED:FEED NO.';
                                LIMITS=(1:24);
ITEM RU_SOURCE        AS 9         HEADING 'SOURCE';
                                LIMITS=(1:2);
ITEM RU_FORM          AS 9         HEADING 'FORM';
                                LIMITS=(1:2);
ITEM RU_AMOUNT        AS 9         HEADING 'AMOUNT';
                                LIMITS=(1:2);
ITEM RU_S_WGT         AS 9999      HEADING 'PIG START:WEIGHT';
ITEM RU_E_WGT         AS 9999      HEADING 'PIG END:WEIGHT';

MASTER HEALTH INSERT=KEYED(H_FARMCODE,NOTUNIQUE);
ITEM H_FARMCODE      MEMBER 'FARM:CODE';
ITEM H_DATE          AS DATE      HEADING 'DATE';
ITEM H_DISEASE        AS 99        HEADING 'DISEASE:CODE';
                                LIMITS=(1:56);
ITEM H_PROD           AS 99        HEADING 'PRODUCT';
                                LIMITS=(1:67);
ITEM H_ROUTE          AS 9         HEADING 'ROUTE';
                                LIMITS=(1:3);
ITEM H_DOSEAGE        AS 9999      HEADING 'DOSEAGE:MG/TON';
ITEM H_PROD_PHASE     AS 99        HEADING 'PRODUCTION:PHASE';
                                LIMITS=(1:11);
ITEM H_FREQ           AS 9         HEADING 'FREQUENCY';
                                LIMITS=(1:2);
ITEM H_DURATION       AS 9999      HEADING 'DURATION';
ITEM H_PURPOSE        AS 9         HEADING 'PURPOSE';
                                LIMITS=(1:3);

MASTER DISEASE INSERT=KEYED(D_FARMCODE,NOTUNIQUE);
ITEM D_FARMCODE      MEMBER 'FARM:CODE';
ITEM D_DATE          AS DATE      HEADING 'DATE';

```

```

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ITEM D_ACCESS        AS 9          HEADING 'ABSCCESS';
                                LIMITS=(1:4);
ITEM D_AMENIA        AS 9          HEADING 'AMENIA';
                                LIMITS=(1:4);
ITEM D_ARTH           AS 9          HEADING 'ARTHRITIS';
                                LIMITS=(1:4);
ITEM D_RHIN          AS 9          HEADING 'ATROPHIC:RHINITIS';
                                LIMITS=(1:4);
ITEM D_CANNIB        AS 9          HEADING 'CANNIBAL';
                                LIMITS=(1:4);
ITEM D_CPERF         AS 9          HEADING 'CLOST.:PERFRING.';
                                LIMITS=(1:4);
ITEM D_COCCID        AS 9          HEADING 'COCCID.';
                                LIMITS=(1:4);
ITEM D_DEFORM        AS 9          HEADING 'DEFORMED';
                                LIMITS=(1:4);
ITEM D_DIA_PREU      AS 9          HEADING 'DIARRHEA:PREU';
                                LIMITS=(1:4);
ITEM D_DIA_POST      AS 9          HEADING 'DIARRHEA:POSTUEAN';
                                LIMITS=(1:4);
ITEM D_DUMMER        AS 9          HEADING 'DUMMER:SOUS';
                                LIMITS=(1:4);
ITEM D_DYSTOCIA      AS 9          HEADING 'DYSSTOCIA';
                                LIMITS=(1:4);
ITEM D_FCOLI         AS 9          HEADING 'E. COLI';
                                LIMITS=(1:4);
ITEM D_EDENA         AS 9          HEADING 'EDEMA';
                                LIMITS=(1:4);
ITEM D_ENT_TORS      AS 9          HEADING 'ENTERIC:TORSIONS';
                                LIMITS=(1:4);
ITEM D_ENTSIP        AS 9          HEADING 'ENTSTIPELAS';
                                LIMITS=(1:4);
ITEM D_GREASY        AS 9          HEADING 'GREASY:PIG:DISEASE';
                                LIMITS=(1:4);
ITEM D_MAEHOA        AS 9          HEADING 'MAERO.:PARABUS';
                                LIMITS=(1:4);
ITEM D_MAEHOPL       AS 9          HEADING 'MAERO.:PLEURO';
                                LIMITS=(1:4);
ITEM D_MAEHOB        AS 9          HEADING 'MAERO.:BOUEL';
                                LIMITS=(1:4);
ITEM D_MSCROT        AS 9          HEADING 'HERNIA:SCROTAL';
                                LIMITS=(1:4);
ITEM D_MUMBIL        AS 9          HEADING 'HERNIA:UMBIL.';
                                LIMITS=(1:4);
ITEM D_LAME          AS 9          HEADING 'LAMENESS';
                                LIMITS=(1:4);
ITEM D_LEPTOS        AS 9          HEADING 'LEPTO.:SP:ROSIS';
                                LIMITS=(1:4);
ITEM D_LICE          AS 9          HEADING 'LICE';
                                LIMITS=(1:4);
ITEM D_MANGE        AS 9          HEADING 'MANGE';
                                LIMITS=(1:4);
ITEM D_MASTIT        AS 9          HEADING 'MASTITIS';
                                LIMITS=(1:4);
ITEM D_METRIT        AS 9          HEADING 'METRITIS';
                                LIMITS=(1:4);
ITEM D_MYCOT         AS 9          HEADING 'MYCOTOMI.:COSIS';
                                LIMITS=(1:4);
ITEM D_MUT_VIT       AS 9          HEADING 'NUTRI.:VIT. E:SELENIUM';
                                LIMITS=(1:4);
ITEM D_MUT_OT        AS 9          HEADING 'NUTRI:DEFIC:OTHER';
                                LIMITS=(1:4);
ITEM D_OSTEOC        AS 9          HEADING 'OSTEOCORN.';
                                LIMITS=(1:4);
ITEM D_PSS          AS 9          HEADING 'PSS';
                                LIMITS=(1:4);

```


[illegible]

```

DECLARE @nurstarturn(2) AS 999.99; @nurstarturn = 0;
DECLARE @livstarturn(2) AS 999.99; @livstarturn = 0;
DECLARE @live_pres_d(2) AS 999.999; @live_pres_d = 0;
DECLARE @shole_farm_eff(2) AS 999.999.99; @shole_farm_eff = 0;
DECLARE @brundiv AS 9; @brundiv = 1;

@nurs = 2.0; @sagrow = 6.0; @sfinish = 8.0;

@k = 1; /* counter for array variables to be PRINTED */

--again
SELECT CLEAR;

IF @k = 1 THEN DO;
  SELECT fw_farmcode = @ff_farmcode;
  print 'farms ' @ff_farmcode;
  @nucrates = 0;
  FOR EACH farrow DO;
    @nucrates = @nucrates + fw_nocrates;
  END;
  PRINT 'number of crates = ' @nucrates;
  @sumarea = 0; @sumarea = @ff_farmcode = 0; @sumarea = 0;
  SELECT pen_farmcode = @ff_farmcode;
  FOR EACH pensize DO;
    IF pen_usetype >= 1 THEN DO;
      IF pen_usetype <= 2 THEN @sumarea = @sumarea + pen_tot_area;
      IF pen_usetype = 3 THEN @sumarea = @sumarea + pen_tot_area;
      IF pen_usetype = 4 THEN @sumarea = @sumarea + pen_tot_area;
    END;
    /* for each pensize nmnursery g-grower f=finisher */
    print 'nursery area = ' @sumarea;
    print 'grower area = ' @sumarea;
    print 'finish area = ' @sumarea;
    @nucap = @sumarea / @nurs;
    @sgrcap = @sumarea / @sgrrow;
    @slncap = @sumarea / @sfinish;
    END; /* if @k = 1 */

    SELECT CLEAR; calculations ----- */
    print 'calling inventory'; /* inventory calculations */
    /* print 'number of quarters = ' @brundiv; */
    /* print 'calling purchases'; /* animal calculations */
    /* CALL animal; /* animal calculations */
    /* print 'calling markets'; /* market calculations */
    /* CALL market; /* market calculations */
    /* print 'calling farrowing'; /* farrow records calculations */
    /* CALL farrec; /* farrow records calculations */
    /* print 'calling feeduse'; /* feed usage calculations */
    /* CALL feeduse; /* feed usage calculations */
    /* print 'calling expense'; /* expense calculations */
    /* CALL expense; /* expense calculations */
    /* print 'calling slaughter'; /* slaughter calculations */
    /* CALL slau; /* slaughter calculations */
    /* print slau;
    IF @k = 1 THEN DO;
      /* print 'calling removal'; /* management factors */
      /* CALL removal;

```

[illegible]

ANIMAL_NON SUBROUTINE

/* ----- calculations from animal purchased ----- */

```
IF &k < 4 THEN DO;
  SELECT NAMED main p_farmcode = CONSTANT (&ff farmcode);
  /* limit view for single time period on this file only.
  Add means do not throw away other select */
  SELECT NAMED t_period ADD p_date <= &cupdate
    p_date >= &tempdate;
  END;
ELSE SELECT NAMED main p_date <= &cupdate
  p_date >= &tempdate;

&wt_purchased = 0; &stot_num_purch = 0;
&num_oglt_rep = 0; &num_bglit_rep = 0; &num_boar_rep = 0;
&boar_dol = 0; &oglt_dol = 0; &bglit_dol = 0;

FOR EACH anilpur OTU;
  &wt_purchased = &wt_purchased + (znav(&p_numpgs) * znav(&p_aveugt));
```

```
IF &k < 4 THEN DO;
  &wt_purchased = &wt_purchased + znav(&p_numpgs) * znav(&p_aveugt);
  &stot_num_purch = &stot_num_purch + znav(&p_numpgs);

  IF &p_swinecode = 6 THEN DO;
    &num_boar_rep = &num_boar_rep + znav(&p_numpgs);
    &boar_dol = &boar_dol + znav(&p_grossdolc);
  END;
```

```
IF &p_swinecode = 7 THEN DO;
  &num_oglt_rep = &num_oglt_rep + znav(&p_numpgs);
  &oglt_dol = &oglt_dol + znav(&p_grossdolc);
END;
```

```
IF &p_swinecode = 8 THEN DO;
  &num_bglit_rep = &num_bglit_rep + znav(&p_numpgs);
  &bglit_dol = &bglit_dol + znav(&p_grossdolc);
END;
```

```
END; /* If &k < 4 then do */
```

```
IF &k = 4 THEN
  FOR &i = 1 TO &fcnt DO;
```

```
  IF p_farmcode = &idfarm(&i) THEN DO;
```

```
    &wt_purchased = &wt_purchased +
      (znav(&p_numpgs) * znav(&p_aveugt));
    &stot_num_purch = &stot_num_purch + znav(&p_numpgs);
```

```
  IF &p_swinecode = 6 THEN DO;
    &num_boar_rep = &num_boar_rep + znav(&p_numpgs);
    &boar_dol = &boar_dol + znav(&p_grossdolc);
  END;
```

```
  IF &p_swinecode = 7 THEN DO;
    &num_oglt_rep = &num_oglt_rep + znav(&p_numpgs);
    &oglt_dol = &oglt_dol + znav(&p_grossdolc);
  END;
```

```
  IF &p_swinecode = 8 THEN DO;
    &num_bglit_rep = &num_bglit_rep + znav(&p_numpgs);
    &bglit_dol = &bglit_dol + znav(&p_grossdolc);
  END;
```

```
END; /* If p_farmcode = &idfarm(&i) */

END; /* for &i = 1 to &fcnt do */
```

```
/* for each ANILPUR
/* print &wt_purchased &stot_num_purch ; */
```

```
/* annual measures */
```

```
IF &k = 3 THEN
  IF &roundiv > 1 THEN DO;
    &wt_purchased = 0; &stot_num_purch = 0; &num_bglit_rep = 0;
    &num_oglt_rep = 0;
    FOR &i = 1 TO &fcnt DO;
```

```
      SELECT p_date <= &cupdate and p_date >= &tempdate
        and p_farmcode = &idfarm(&i);
      &wt_purchased = 0; &stot_num_purch = 0; &num_oglt_rep = 0; &num_bglit_rep = 0;
      FOR EACH anilpur OTU;
```

```
        &wt_purchased = &wt_purchased +
          (znav(&p_numpgs) * znav(&p_aveugt));
        &stot_num_purch = &stot_num_purch + znav(&p_numpgs);
        IF &p_swinecode = 7 THEN &num_oglt_rep = &num_oglt_rep + znav(&p_numpgs);
        IF &p_swinecode = 8 THEN &num_bglit_rep = &num_bglit_rep + znav(&p_numpgs);
      END;
```

```
      &stot_num_purch = &stot_num_purch + ((&stot_num_purch / &roundiv) * &k);
      &wt_purchased = ((&wt_purchased / &roundiv) * &k);
      &num_oglt_rep = &num_oglt_rep + ((&num_oglt_rep / &roundiv) * &k);
      &num_bglit_rep = &num_bglit_rep + ((&num_bglit_rep / &roundiv) * &k);
    END; /* for &i = 1 to &fcnt */
```

```
  IF &fcnt <= 0 THEN DO;
```

```
    &stot_num_purch = &stot_num_purch / &fcnt;
    &wt_purchased = &wt_purchased / &fcnt;
    &num_oglt_rep = &num_oglt_rep / &fcnt;
    &num_bglit_rep = &num_bglit_rep / &fcnt;
```

```
  END; /* If &k = 3 */
```

```
  IF &k > 2 THEN DO;
    IF &k = 3 THEN &divide_inte = &roundiv;
    IF &k = 4 THEN &divide_inte = &fcnt;
```

```
  IF &divide_inte > 1 THEN DO;
```

```
    &wt_purchased = &wt_purchased / &divide_inte;
    &stot_num_purch = &stot_num_purch / &divide_inte;
    &num_boar_rep = &num_boar_rep / &divide_inte;
    &num_oglt_rep = &num_oglt_rep / &divide_inte;
    &num_bglit_rep = &num_bglit_rep / &divide_inte;
    &boar_dol = &boar_dol / &divide_inte;
    &oglt_dol = &oglt_dol / &divide_inte;
    &bglit_dol = &bglit_dol / &divide_inte;
  END;
```

```
END; /* calculate gilt and boar replacement for expenses */
IF &avg_inwt > 0 THEN DO;
  &sefemrepl(&k) = ((&oglt_dol + &bglit_dol) / &avg_inwt) * 100;
  &seboarrepl(&k) = (&boar_dol / &avg_inwt) * 100;
```

```
END;
SELECT;
RETURN;
```


[illegible]

```

      &gturn(1) = &gturn(&k) * 4;
/* print 'return = ' &gturn(&k) &num_mkt_sold(&k) &num_wt_sold(&k)
SELECT ;
RETURN ;

*****
FARREC.MON SUBROUTINE
*****
/* ----- calculations from farrec database ----- */

select clear;
IF &k < 4 THEN DO;
  SELECT NAMED main fr farmcode = CONSTANT(&fr farmcode);
  SELECT NAMED t_period ADD fr_enterdate <= &curdate
    fr_enterdate >= &steppdate;
END;
ELSE
  SELECT NAMED main fr_enterdate >= &steppdate
    fr_enterdate <= &curdate;
/* limit view for single time period on this file only.
Add means do not throw away other select. */
/* list fr farmcode fr_enterdate;
&num_litters = 0; &num_mummies = 0;
FOR EACH farrec DO;
  AMPSET farrec OTU ;
  IF &k = 4 THEN /* shims quarterly average */
    FOR &i = 1 to &fnt DO;
      IF fr farmcode = &IDAPK(&i) THEN DO;
        &num_litters = &num_litters + znav(&fr_litterfar);
        &num_mummies = &num_mummies + znav(&fr_mummies);
        &num_pigs_born(&k) = &num_pigs_born(&k) + znav(&fr_pigsborn);
        &num_live_born(&k) = &num_live_born(&k) + znav(&fr_pigsalive);
        &num_pigs_wean(&k) = &num_pigs_wean(&k) + znav(&fr_pigsweaned);
        &num_lit_wean(&k) = &num_lit_wean(&k) + znav(&fr_sousweaned);
      END;
    END;
/* print fr farmcode fr_enterdate 'in farrec'; */
IF &k < 4 THEN DO;
  &num_litters = &num_litters + znav(&fr_litterfar);
  &num_mummies = &num_mummies + znav(&fr_mummies);
  &num_pigs_born(&k) = &num_pigs_born(&k) + znav(&fr_pigsborn);
  &num_live_born(&k) = &num_live_born(&k) + znav(&fr_pigsalive);
  &num_pigs_wean(&k) = &num_pigs_wean(&k) + znav(&fr_pigsweaned);
  &num_lit_wean(&k) = &num_lit_wean(&k) + znav(&fr_sousweaned);
END;
/* for each farrec */
/* calculating SHIMS annual average */
IF &k = 3 THEN
  IF &numdiv > 1 THEN DO;
    SELECT CLEAR;
    /* select all cases for dates between &steppdate and &curdate */
    &num_pigs_born = 0; &num_live_born = 0; &num_pigs_wean = 0;
    &num_lit_wean = 0;
    FOR &i = 1 to &fnt DO;
      SELECT fr_enterdate <= &curdate and fr_enterdate >= &steppdate
        and fr farmcode = &IDAPK(&i);
      &num_pigs_born = 0; &num_live_born = 0; &num_pigs_wean = 0;
      &num_lit_wean = 0;
      FOR EACH farrec DO;
        AMPSET farrec OTU ;
        &num_pigs_born = &num_pigs_born + znav(&fr_pigsborn);

```

```

      &num_litters = &num_litters + znav(&fr_litterfar);
      &num_pigs_born = &num_pigs_born + znav(&fr_pigsborn);
      &num_live_born = &num_live_born + znav(&fr_pigsalive);
      &num_pigs_wean = &num_pigs_wean + znav(&fr_pigsweaned);
      &num_lit_wean = &num_lit_wean + znav(&fr_sousweaned);
    END;
/* end of for each farrec */
&num_pigs_born = &num_pigs_born + ((&num_pigs_born/&numdiv)*4);
&num_live_born = &num_live_born + ((&num_live_born/&numdiv)*4);
&num_pigs_wean = &num_pigs_wean + ((&num_pigs_wean/&numdiv)*4);
&num_lit_wean = &num_lit_wean + ((&num_lit_wean/&numdiv)*4);
END;
/* for &i = 1 to &fnt */
IF &fnt < 0 THEN DO;
  &num_pigs_born = &num_pigs_born / &fnt;
  &num_live_born = &num_live_born / &fnt;
  &num_pigs_wean = &num_pigs_wean / &fnt;
  &num_lit_wean = &num_lit_wean / &fnt;
END;
&ac_lbopp = 0; &ac_proddp = 0;
&ac = 2;
&ac_lbopp = znav(&sliv wt) - znav(&sprev inv wt) + znav(&aut_sold)
  + znav(&aut_consumed) - znav(&aut_purchased);
/* print 'sliv wt &sprev inv wt aut sold aut consumed aut purchased';
print &sliv wt &sprev inv wt &aut_sold &aut_consumed &aut_purchased';
print &aut_purchased';
&aut_proddp = znav(&sliv num) - znav(&sprev inv num)
  + znav(&aut_num_sold) + znav(&aut_num_consumed)
  - znav(&aut_tot_num_purch);
/* print 'sliv num &sprev inv num &aut sold &aut consumed &aut num_purch';
print &sliv num &sprev inv num &aut sold &aut consumed &aut_tot_num_purch';
print &ac_lbopp &ac_proddp; print &avg_tot_feel; */
IF &avg_tot_feel > 1 THEN DO;
  &ac_lbopp(&k) = &ac_lbopp / &avg_tot_feel;
  &ac_proddp(&k) = &ac_proddp / &avg_tot_feel;
  &ac = 3;
/* and calculations for annual measures */
&divide_into = 0;
IF &k > 2 THEN DO;
  IF &k = 3 THEN &divide_into = &numdiv;
  IF &k = 4 THEN &divide_into = &fnt;
  IF &divide_into > 1 THEN DO;
    &num_pigs_born(&k) = &num_pigs_born(&k) / &divide_into;
    &num_litters = &num_litters / &divide_into;
    &num_mummies = &num_mummies / &divide_into;
    &num_live_born(&k) = &num_live_born(&k) / &divide_into;
    &num_pigs_wean(&k) = &num_pigs_wean(&k) / &divide_into;
    &num_lit_wean(&k) = &num_lit_wean(&k) / &divide_into;
  END;
END;
&ac_lbopp(&k) = znav(&sliv wt) - znav(&sprev inv wt) + znav(&aut_sold)
  + znav(&aut_consumed) - znav(&aut_purchased);
&ac_proddp(&k) = znav(&sliv num) - znav(&sprev inv num) + znav(&aut_num_sold)
  + znav(&aut_num_consumed) - znav(&aut_tot_num_purch);
/* print 'sliv wt &sprev inv wt aut sold aut consumed aut purchased';
print &sliv wt &sprev inv wt &aut sold &aut consumed &aut_tot_num_purch';
/* annual farm measure */
/* print &sliv num &sprev inv num &aut sold
  &aut consumed &aut_tot_num_purch';
/* avg_tot_feel > 1 THEN DO;
  &ac_lbopp(&k) = &ac_lbopp(&k) / &avg_tot_feel;
  &ac_proddp(&k) = &ac_proddp(&k) / &avg_tot_feel;

```

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```

&c bornpl(&k) = &num_pigs_born(&k) / &avg_tot_feml;
&c blvepl(&k) = &num_liv_born(&k) / &avg_tot_feml;
&c pweapl(&k) = &num_pigs_wean(&k) / &avg_tot_feml;
&c lweapl(&k) = &num_liv_wean(&k) / &avg_tot_feml;
END;

IF &k = 3 THEN DO;
  &c lbpp = 0; &c proppp = 0;
  &c lbpp = &c lbpp(&k) * 4;
  &c proppp = &c proppp(&k) * 4;
  &a = 1;
  &c lbppf(&a) = &c lbppf(&k) * 4;
  &c proppf(&a) = &c proppf(&k) * 4;
  &c born_year(&a) = &c bornpl(&k) * 4;
  &c blvepl_year(&a) = &c blvepl(&k) * 4;
  &c pweapl_year(&a) = &c pweapl(&k) * 4;
  &c lweapl_year(&a) = &c lweapl(&k) * 4;
  IF &znv(&numcrates) > 0 THEN &prate_yr(&a) = &c_proppp/&numcrates;
END;

IF &num_litters > 1 THEN DO;
  &c lbsf(&k) = &c lbppf(&k) / &num_litters;
  &c proppi(&k) = &c proppf(&k) / &num_litters;
  &c bornpl(&k) = &c bornpl(&k) / &num_litters;
  &c blvepl(&k) = &c blvepl(&k) / &num_litters;
  &c pweapl(&k) = &c pweapl(&k) / &num_litters;
END;

IF &avg_tot_born1 > 1 THEN
  &ftob_ratio(&k) = &avg_tot_feml / &avg_tot_born1;

IF &numcrates > 0 THEN DO;
  &ltltar_ct(&k) = &num_litters / &numcrates;
  &ltltgm_ct(&k) = &num_pigs_wean(&k) / &numcrates;
END;

IF &nurcap > 0 THEN
  &nurturn(&k) = &num_pigs_wean(&k) / &nurcap;
/* annual measure for farm nursery turnover */
IF &k = 3 THEN
  &nurturn(1) = &znv(&nurturn(&k)) * 4;
SELECT;
RETURN;

*****
FEEDUSE.NON SUBROUTINE
*****
/* ----- calculations for efficiency of feed usage ----- */

IF &k < 4 THEN DO;
  SELECT NAMED main u_farmcode = CONSTANT (&ff_farmcode);
  SELECT NAMED u_period ADD u_date >= &template
    u_date <= &cupdate;
END;
ELSE SELECT NAMED u_period u_date >= &template
  u_date <= &cupdate;

&ustart = 0; &nurs = 0; &ugrow = 0; &ufinish = 0; &ulact = 0;
&ugest = 0; &q = 1; &nwcent = 0;

FOR EACH usage DO;
  AMPSET usage 010;
  IF &k = 4 THEN DO;
    FOR &i = 1 TO &icnt DO;

```

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```

/* IF &u_farmcode = &idfarm(&i) THEN DO;
  IF &q < &i THEN DO;
    &tempum = 0;
    &tempum = &ulact + &ugest + &ustart + &nurs + &ugrow + &ufinish;
    &nwcent = &nwcent + 1;
    &q = &i;
  END;
  IF u_ration >= 1 THEN
    IF u_ration <= 3 THEN
      &ustart = &ustart + &znv(&u_amt);
    IF u_ration >= 4 THEN
      IF u_ration <= 6 THEN
        &nurs = &nurs + &znv(&u_amt);
      IF u_ration >= 7 THEN
        IF u_ration <= 9 THEN
          &ugrow = &ugrow + &znv(&u_amt);
        IF u_ration >= 10 THEN
          IF u_ration <= 12 THEN
            &ufinish = &ufinish + &znv(&u_amt);
          IF u_ration >= 13 THEN
            &ulact = &ulact + &znv(&u_amt);
          IF u_ration >= 14 THEN
            &ugest = &ugest + &znv(&u_amt);
          IF u_ration >= 15 THEN
            &ustart = &ustart + &znv(&u_amt);
          IF u_ration >= 16 THEN
            IF u_ration <= 18 THEN
              &ugest = &ugest + &znv(&u_amt);
            IF u_ration >= 19 THEN
              IF &k < 4 THEN DO;
                IF u_ration >= 1 THEN
                  &ustart = &ustart + &znv(&u_amt);
                IF u_ration >= 4 THEN
                  &nurs = &nurs + &znv(&u_amt);
                IF u_ration >= 7 THEN
                  &ugrow = &ugrow + &znv(&u_amt);
                IF u_ration >= 10 THEN
                  &ufinish = &ufinish + &znv(&u_amt);
                IF u_ration >= 13 THEN
                  &ulact = &ulact + &znv(&u_amt);
                IF u_ration >= 16 THEN
                  &ugest = &ugest + &znv(&u_amt);
                IF u_ration >= 19 THEN
                  &ustart = &ustart + &znv(&u_amt);
              END;
              /* for each USAGE */
              /* & if &k < 4 */
              /* &checkfeed used to determine whether to print report */
              IF &k = 1 THEN DO;
                &checkfeed = 0;
                &checkfeed = &ulact + &ugest + &ustart + &nurs + &ugrow + &ufinish;
              END;
            IF &k > 2 THEN DO;
              IF &k = 3 THEN &divide into = &urndiv;
              IF &k = 4 THEN &divide into = &icnt;
              IF &divide into > 1 THEN DO;
                &ustart = &ustart / &divide into;
                &nurs = &nurs / &divide into;
                &ugrow = &ugrow / &divide into;
                &ufinish = &ufinish / &divide into;
                &ulact = &ulact / &divide into;
                &ugest = &ugest / &divide into;
              END;
            IF &k > 2 THEN DO;

```

```

/*
  Augest = Augest / &divide into;
  annual average for farm */
IF &k = 3 THEN DO;
  &start = 0; &sumurs = 0; &augrow = 0 ; &aufinish = 0 ;
  &salect = 0; &selec = 0;
  &saustar = &start + 4;
  &sumurs = &sumurs + 4;
  &augrow = &augrow + 4;
  &aufinish = &aufinish + 4;
  &salect = &salect + 4;
  &selec = &selec + 4;
  &saugest = &saugest + 4;
  &stotfeedcon = 0;
  &stotfeedcon = &salect + &saugest + &saustar + &sumurs
    + &augrow + &aufinish;
  IF &ac lbpp > 0 THEN
    /* end annual average for farm */
  END;
END;

&aulecttot(&k) = &aulect; &augesttot(&k) = &augest;
&saustarttot(&k) = &saustar; &sumurstot(&k) = &sumurs;
&augrowtot(&k) = &augrow; &aufinish(&k) = &aufinish;
&adlistdays = 0; &edlistdays = INTERVAL(&stemplate,&curdate);
IF &k=3 THEN IF &brndiv > 1 THEN &edlistdays = &edlistdays/&brndiv;
/* print 'distance' &edlistdays; */
IF &edlistdays > 0 THEN DO;
  IF &znv(&avg_gest) > 0 THEN
    /* &znv(&avg_gest) = ( &augest/&znv(&avg_gest) ) / &edlistdays;
    /* print 'avg_gest' avg_gest' &augest &avg_gest (&stemplate/&avg_gest)
    (&augest/&avg_gest)/&edlistdays; */
    IF &znv(&avg_gest) > 0 THEN
      &aulectavg(&k) = ( &aulect/&znv(&avg_gest) ) / &edlistdays;
      IF &znv(&avg_star) > 0 THEN
        &saustar(&k) = ( &saustar/&znv(&avg_star) ) / &edlistdays;
        IF &znv(&avg_nurs) > 0 THEN
          &sumursavg(&k) = ( &sumurs/&znv(&avg_nurs) ) / &edlistdays;
          IF &znv(&avg_grow) > 0 THEN
            &augrowavg(&k) = ( &augrow/&znv(&avg_grow) ) / &edlistdays;
            IF &znv(&avg_finl) > 0 THEN
              &aufinishavg(&k) = ( &aufinish/&znv(&avg_finl) ) / &edlistdays;
            END;
          /* annual SHIMS average calculation for total feed consumed */
          IF &k = 3 THEN IF &brndiv > 1 THEN DO;
            &salect = 0; &sumurs = 0; &augrow = 0 ; &aufinish = 0 ;
            &saugest = 0;
            &salect = 0; &selec = 0;
            &salect = 0; &selec = 0;
          END;
          FOR &i = 1 to &icnt DO;
            SELECT u_date >= &stemplate and u_date <= &curdate
              into u_farmcode = &idfarm(&i);
            FOR EACH usage DO;
              IF u_ration <= 3 THEN
                &saustar = &saustar + &znv(&au_amt);
              IF u_ration >= 4 THEN
                &sumurs = &sumurs + &znv(&au_amt);
              IF u_ration >= 7 THEN
                &augrow = &augrow + &znv(&au_amt);
              IF u_ration <= 9 THEN
                &saugest = &saugest + &znv(&au_amt);
              IF u_ration <= 10 THEN
                &aufinish = &aufinish + &znv(&au_amt);
            END;
          END;
        END;
      END;
    END;
  END;
  /* ----- calculations for efficiency of feed usage ----- */
  IF &k < 4 THEN DO;
    SELECT NAMED main_e_farmcode = CONSTANT (&ff_farmcode);
    SELECT NAMED e_period ADD e_date >= &stemplate
      e_date <= &curdate;
    END;
    ELSE DO;
      SELECT;
      SELECT NAMED e_period e_date >= &stemplate
        e_date <= &curdate;
    END;
    &expfeed = 0; &arepair = 0; &selec = 0 ; &elabor = 0 ; &seup = 0 ;
    &sefuel = 0; &selec = 0; &sele = 0; &setruck = 0; &semark = 0;
    &seineur = 0; &seiner = 0; &setax = 0; &seother = 0;
    FOR EACH expense DO;
      AMPSET expense OTW;
    END;
    IF &k = 4 THEN DO;
      FOR &i = 1 to &icnt DO;
        IF e_farmcode = &idfarm(&i) THEN DO;
          IF &e_code = 1 THEN &expfeed = &expfeed + &znv(&e_dollar);
          IF &e_code = 2 THEN &arepair = &arepair + &znv(&e_dollar);
          IF &e_code = 3 THEN &selec = &selec + &znv(&e_dollar);
          IF &e_code = 4 THEN &seup = &seup + &znv(&e_dollar);
          IF &e_code = 5 THEN &elabor = &elabor + &znv(&e_dollar);
          IF &e_code = 6 THEN &sefuel = &sefuel + &znv(&e_dollar);
          IF &e_code = 7 THEN &selec = &selec + &znv(&e_dollar);
          IF &e_code = 8 THEN &sele = &sele + &znv(&e_dollar);
          IF &e_code = 9 THEN &setruck = &setruck + &znv(&e_dollar);
          IF &e_code = 10 THEN &semark = &semark + &znv(&e_dollar);
          IF &e_code = 11 THEN &seineur = &seineur + &znv(&e_dollar);
        END;
      END;
    END;
  END;
  IF &k < 4 THEN DO;
    SELECT NAMED e_farmcode = CONSTANT (&ff_farmcode);
    SELECT NAMED e_period ADD e_date >= &stemplate
      e_date <= &curdate;
    END;
    ELSE DO;
      SELECT;
      SELECT NAMED e_period e_date >= &stemplate
        e_date <= &curdate;
    END;
    &expfeed = 0; &arepair = 0; &selec = 0 ; &elabor = 0 ; &seup = 0 ;
    &sefuel = 0; &selec = 0; &sele = 0; &setruck = 0; &semark = 0;
    &seineur = 0; &seiner = 0; &setax = 0; &seother = 0;
    FOR EACH expense OTW;
      AMPSET expense OTW;
    END;
    IF &k = 4 THEN DO;
      FOR &i = 1 to &icnt DO;
        IF e_farmcode = &idfarm(&i) THEN DO;
          IF &e_code = 1 THEN &expfeed = &expfeed + &znv(&e_dollar);
          IF &e_code = 2 THEN &arepair = &arepair + &znv(&e_dollar);
          IF &e_code = 3 THEN &selec = &selec + &znv(&e_dollar);
          IF &e_code = 4 THEN &seup = &seup + &znv(&e_dollar);
          IF &e_code = 5 THEN &elabor = &elabor + &znv(&e_dollar);
          IF &e_code = 6 THEN &sefuel = &sefuel + &znv(&e_dollar);
          IF &e_code = 7 THEN &selec = &selec + &znv(&e_dollar);
          IF &e_code = 8 THEN &sele = &sele + &znv(&e_dollar);
          IF &e_code = 9 THEN &setruck = &setruck + &znv(&e_dollar);
          IF &e_code = 10 THEN &semark = &semark + &znv(&e_dollar);
          IF &e_code = 11 THEN &seineur = &seineur + &znv(&e_dollar);
        END;
      END;
    END;
  END;
  IF &k < 4 THEN DO;
    SELECT NAMED e_farmcode = CONSTANT (&ff_farmcode);
    SELECT NAMED e_period ADD e_date >= &stemplate
      e_date <= &curdate;
    END;
    ELSE DO;
      SELECT;
      SELECT NAMED e_period e_date >= &stemplate
        e_date <= &curdate;
    END;
    &expfeed = 0; &arepair = 0; &selec = 0 ; &elabor = 0 ; &seup = 0 ;
    &sefuel = 0; &selec = 0; &sele = 0; &setruck = 0; &semark = 0;
    &seineur = 0; &seiner = 0; &setax = 0; &seother = 0;
    FOR EACH expense OTW;
      AMPSET expense OTW;
    END;
    IF &k = 4 THEN DO;
      FOR &i = 1 to &icnt DO;
        IF e_farmcode = &idfarm(&i) THEN DO;
          IF &e_code = 1 THEN &expfeed = &expfeed + &znv(&e_dollar);
          IF &e_code = 2 THEN &arepair = &arepair + &znv(&e_dollar);
          IF &e_code = 3 THEN &selec = &selec + &znv(&e_dollar);
          IF &e_code = 4 THEN &seup = &seup + &znv(&e_dollar);
          IF &e_code = 5 THEN &elabor = &elabor + &znv(&e_dollar);
          IF &e_code = 6 THEN &sefuel = &sefuel + &znv(&e_dollar);
          IF &e_code = 7 THEN &selec = &selec + &znv(&e_dollar);
          IF &e_code = 8 THEN &sele = &sele + &znv(&e_dollar);
          IF &e_code = 9 THEN &setruck = &setruck + &znv(&e_dollar);
          IF &e_code = 10 THEN &semark = &semark + &znv(&e_dollar);
          IF &e_code = 11 THEN &seineur = &seineur + &znv(&e_dollar);
        END;
      END;
    END;
  END;
  IF &k < 4 THEN DO;
    SELECT NAMED e_farmcode = CONSTANT (&ff_farmcode);
    SELECT NAMED e_period ADD e_date >= &stemplate
      e_date <= &curdate;
    END;
    ELSE DO;
      SELECT;
      SELECT NAMED e_period e_date >= &stemplate
        e_date <= &curdate;
    END;
    &expfeed = 0; &arepair = 0; &selec = 0 ; &elabor = 0 ; &seup = 0 ;
    &sefuel = 0; &selec = 0; &sele = 0; &setruck = 0; &semark = 0;
    &seineur = 0; &seiner = 0; &setax = 0; &seother = 0;
    FOR EACH expense OTW;
      AMPSET expense OTW;
    END;
    IF &k = 4 THEN DO;
      FOR &i = 1 to &icnt DO;
        IF e_farmcode = &idfarm(&i) THEN DO;
          IF &e_code = 1 THEN &expfeed = &expfeed + &znv(&e_dollar);
          IF &e_code = 2 THEN &arepair = &arepair + &znv(&e_dollar);
          IF &e_code = 3 THEN &selec = &selec + &znv(&e_dollar);
          IF &e_code = 4 THEN &seup = &seup + &znv(&e_dollar);
          IF &e_code = 5 THEN &elabor = &elabor + &znv(&e_dollar);
          IF &e_code = 6 THEN &sefuel = &sefuel + &amp
```



```

      IF &e_code = 12 THEN &einter = &einter + znav(&e_dollar);
      IF &e_code = 13 THEN &etax = &etax + znav(&e_dollar);
      IF &e_code = 14 THEN &eother = &eother + znav(&e_dollar);
    END; /* IF &e_code = &idifarm(&e) */
  END; /* for &e1 = 1 to &icnt */
END; /* IF &k < 4 */

/* IF &k < 4 THEN DO;
  IF &e_code = 1 THEN &efeed = &efeed + znav(&e_dollar);
  IF &e_code = 2 THEN &erepair = &erepair + znav(&e_dollar);
  IF &e_code = 3 THEN &eet = &eet + znav(&e_dollar);
  IF &e_code = 4 THEN &elabor = &elabor + znav(&e_dollar);
  IF &e_code = 5 THEN &esup = &esup + znav(&e_dollar);
  IF &e_code = 6 THEN &efuel = &efuel + znav(&e_dollar);
  IF &e_code = 7 THEN &elec = &elec + znav(&e_dollar);
  IF &e_code = 8 THEN &etele = &etele + znav(&e_dollar);
  IF &e_code = 9 THEN &etruck = &etruck + znav(&e_dollar);
  IF &e_code = 10 THEN &emark = &emark + znav(&e_dollar);
  IF &e_code = 11 THEN &einsur = &einsur + znav(&e_dollar);
  IF &e_code = 12 THEN &einter = &einter + znav(&e_dollar);
  IF &e_code = 13 THEN &etax = &etax + znav(&e_dollar);
  IF &e_code = 14 THEN &eother = &eother + znav(&e_dollar);
END; */ IF &k < 4 */

```

```
END; /* FOR EACH expense */
```

```
/* print &efeed &erepair &eet &esup 'In expenses' &k; */
```

```

IF &k > 2 THEN DO;
  IF &k = 3 THEN &divide_int = &roundv;
  IF &k = 4 THEN &divide_int = &icnt;
  IF &divide_int > 1 THEN DO;
    &efeed = &efeed / &divide_int;
    &erepair = &erepair / &divide_int;
    &eet = &eet / &divide_int;
    &elabor = &elabor / &divide_int;
    &esup = &esup / &divide_int;
    &efuel = &efuel / &divide_int;
    &elec = &elec / &divide_int;
    &etele = &etele / &divide_int;
    &etruck = &etruck / &divide_int;
    &emark = &emark / &divide_int;
    &einsur = &einsur / &divide_int;
    &einter = &einter / &divide_int;
    &etax = &etax / &divide_int;
    &eother = &eother / &divide_int;
  END;
END;

```

```

IF &avg_invnt > 0 THEN DO;
  &efeedtot(&k) = (&efeed/&avg_invnt)*100;
  &erepairtot(&k) = (&erepair/&avg_invnt)*100;
  &eetot(&k) = (&eet/&avg_invnt)*100;
  &elabortot(&k) = (&elabor/&avg_invnt)*100;
  &esuptot(&k) = (&esup/&avg_invnt)*100;
  &efueltot(&k) = (&efuel/&avg_invnt)*100;
  &electot(&k) = (&elec/&avg_invnt)*100;
  &eteletot(&k) = (&etele/&avg_invnt)*100;
  &etrucktot(&k) = (&etruck/&avg_invnt)*100;
  &emarktot(&k) = (&emark/&avg_invnt)*100;
  &einsurtot(&k) = (&einsur/&avg_invnt)*100;
  &eintertot(&k) = (&einter/&avg_invnt)*100;
  &etaxtot(&k) = (&etax/&avg_invnt)*100;
  &eothertot(&k) = (&eother/&avg_invnt)*100;
END;
SELECT ;

```

```
RETURN ;
```

```

+++++*****
SLAU NOW SUBROUTINE
+++++*****

```

```
/* calculations and output for slaughter table */
```

```
/* slaughter plant code */
/* declare &splant(3) as 9; */
```

```

SELECT CLEAR;
IF &k < 4 THEN DO;
  SELECT NAMED &in_sfarmcode = CONSTANT (&ff_sfarmcode);
  /* limit view of DB to single farm. */
  SELECT NAMED &s_date ADD &s_quarterdate >= &stempdate
    &s_quarterdate <= &scurdate;
END;
ELSE SELECT &s_quarterdate >= &stempdate and &s_quarterdate <= &scurdate;

```

```
/* The reason for this exercise is to adjust &k for quarterly
and SHIMS averages since we used to produce 4 columns. */
```

```

IF &k = 3 THEN DO;
  &newkey = 3;
  &k = 2;
END;

```

```

IF &k = 4 THEN DO;
  &newkey = 4;
  &k = 3;
END;

```

```
/* end of exercise except for bottom of file adjusted back to
original value of &k. */
```

```

&account = 0;
FOR EACH stausum DO;
  &account = &account + 1;
  IF &k = 1 THEN IF &account = 1 THEN
    &sdate(&k) = &s_date; /* &splant(&1) = &s_plant; */
    &pn(&k) = &pn(&k) + &s_pneu_none;
    &pm1(&k) = &pm1(&k) + &s_pneu_mild;
    &pm2(&k) = &pm2(&k) + &s_pneu_mod;
    &ps(&k) = &ps(&k) + &s_pneu_sev;
    &ppi(&k) = &ppi(&k) + &s_pleur;
    &ppe(&k) = &ppe(&k) + &s_pericard;
    &lin(&k) = &lin(&k) + &s_asc_none;
    &lm1(&k) = &lm1(&k) + &s_asc_mild;
    &lm2(&k) = &lm2(&k) + &s_asc_mod;
    &lis(&k) = &lis(&k) + &s_asc_sev;
    &am1(&k) = &am1(&k) + &s_mang_none;
    &am2(&k) = &am2(&k) + &s_mang_mod;
    &as(&k) = &as(&k) + &s_mang_sev;
    &rn1(&k) = &rn1(&k) + &s_rhin_none;
    &rm1(&k) = &rm1(&k) + &s_rhin_mild;
    &rm2(&k) = &rm2(&k) + &s_rhin_mod;
    &rs(&k) = &rs(&k) + &s_rhin_sev;
    &red(&k) = &red(&k) + &s_sep_dev;
    &tg(&k) = &tg(&k) + &s_good_tatt;
    &tm(&k) = &tm(&k) + &s_marg_tatt;
    &tl(&k) = &tl(&k) + &s_ill_tatt;
  END;

```

```

IF &account > 1 THEN IF &k = 1 THEN DO;
  &pn(&k) = (&pn(&k) / &account;
  &pm1(&k) = (&pm1(&k) / &account;
  &pm2(&k) = (&pm2(&k) / &account;
  &ps(&k) = (&ps(&k) / &account;
  &ppi(&k) = (&ppi(&k) / &account;
  &ppe(&k) = (&ppe(&k) / &account;
  &lin(&k) = (&lin(&k) / &account;
  &lm1(&k) = (&lm1(&k) / &account;
  &lm2(&k) = (&lm2(&k) / &account;
  &la(&k) = (&la(&k) / &account;
  &am1(&k) = (&am1(&k) / &account;
  &am2(&k) = (&am2(&k) / &account;
  &as(&k) = (&as(&k) / &account;
  &rn1(&k) = (&rn1(&k) / &account;
  &rm1(&k) = (&rm1(&k) / &account;
  &rm2(&k) = (&rm2(&k) / &account;
  &rs(&k) = (&rs(&k) / &account;
  &rad(&k) = (&rad(&k) / &account;
  &tg(&k) = (&tg(&k) / &account;
  &tm(&k) = (&tm(&k) / &account;
  &ti(&k) = (&ti(&k) / &account;
END;

&sumprn(&k) = &pn(&k) + &pm1(&k) + &pm2(&k) + &ps(&k);
IF &znv(&sumprn(&k)) > 0 THEN DO;
  &cpn(&k) = (&pn(&k) / &sumprn(&k)) * 100;
  &cpm1(&k) = (&pm1(&k) / &sumprn(&k)) * 100;
  &cpm2(&k) = (&pm2(&k) / &sumprn(&k)) * 100;
  &cps(&k) = (&ps(&k) / &sumprn(&k)) * 100;
  &cpi(&k) = (&ppi(&k) / &sumprn(&k)) * 100;
  &cpe(&k) = (&ppe(&k) / &sumprn(&k)) * 100;
END;

&sumlv(&k) = &lin(&k) + &lm1(&k) + &lm2(&k) + &ls(&k);
IF &znv(&sumlv(&k)) > 0 THEN DO;
  &lin(&k) = (&lin(&k) / &sumlv(&k)) * 100;
  &lm1(&k) = (&lm1(&k) / &sumlv(&k)) * 100;
  &lm2(&k) = (&lm2(&k) / &sumlv(&k)) * 100;
  &ls(&k) = (&ls(&k) / &sumlv(&k)) * 100;
END;

&suman(&k) = &am1(&k) + &am2(&k) + &as(&k);
IF &znv(&suman(&k)) > 0 THEN DO;
  &am1(&k) = (&am1(&k) / &suman(&k)) * 100;
  &am2(&k) = (&am2(&k) / &suman(&k)) * 100;
  &as(&k) = (&as(&k) / &suman(&k)) * 100;
END;

&sumrh(&k) = &rn(&k) + &rm1(&k) + &rm2(&k) + &rs(&k);
IF &znv(&sumrh(&k)) > 0 THEN DO;
  &rn(&k) = (&rn(&k) / &sumrh(&k)) * 100;
  &rm1(&k) = (&rm1(&k) / &sumrh(&k)) * 100;
  &rm2(&k) = (&rm2(&k) / &sumrh(&k)) * 100;
  &rs(&k) = (&rs(&k) / &sumrh(&k)) * 100;
END;

&sumtattoo = 0; &sumtattoo = &tg(&k) + &tm(&k) + &ti(&k);
IF &znv(&sumtattoo) > 0 THEN DO;
  &tg(&k) = (&tg(&k) / &sumtattoo) * 100;
  &tm(&k) = (&tm(&k) / &sumtattoo) * 100;
  &ti(&k) = (&ti(&k) / &sumtattoo) * 100;
END;

```

```

IF &breakey > 2 THEN
  &k = &breakey;
RETURN;

*****
REMOVAL.MOM SUBROUTINE
*****
/* ----- calculations from breedrem and pmort datafiles ----- */
/* This file called when &k = 1 for current period and &k = 4 */
/* for SHIMS average */
/* ----- breeding herd removals ----- */
&breuk = 0;
SELECT CLEAR;
IF &k = 1 THEN DO;
  SELECT NAMED main b farmcode = CONSTANT(&if_farmcode);
  SELECT NAMED b_period ADD b_date <= &curdate
    b_date >= &update;
END;
ELSE IF &k = 4 THEN DO;
  SELECT NAMED b_period b_date <= &curdate
    b_date >= &update;
&breuk = 4; /* set &k = 2 because variables are defined as array (2) */
&k = 2;
END;

&slow_death = 0; &slow_death = 0; &scull_death = 0;
FOR EACH breedrem DO;
  AMPSET breedrem OTW;

  IF &k = 2 THEN DO;
    FOR &i = 1 TO &icnt DO;
      IF &b farmcode = &IDFARM(&i) THEN DO;
        IF &b sex = 1 THEN IF &b removal = 1 THEN DO; /* culls */
          &scull_death = &scull_death + &b_numpigs;
          IF &b_reason = 1 THEN &cb1n(&k) = &cb1n(&k) + &b_numpigs;
          IF &b_reason = 2 THEN &cb2n(&k) = &cb2n(&k) + &b_numpigs;
          IF &b_reason = 3 THEN &cb3n(&k) = &cb3n(&k) + &b_numpigs;
          IF &b_reason = 4 THEN &cb4n(&k) = &cb4n(&k) + &b_numpigs;
          IF &b_reason = 5 THEN &cb5n(&k) = &cb5n(&k) + &b_numpigs;
          IF &b_reason = 6 THEN &cb6n(&k) = &cb6n(&k) + &b_numpigs;
          IF &b_reason = 7 THEN &cb7n(&k) = &cb7n(&k) + &b_numpigs;
          IF &b_reason = 8 THEN &cb8n(&k) = &cb8n(&k) + &b_numpigs;
          IF &b_reason = 9 THEN &cb9n(&k) = &cb9n(&k) + &b_numpigs;
          IF &b_reason = 10 THEN &cb10n(&k) = &cb10n(&k) + &b_numpigs;
          IF &b_reason = 11 THEN &cb11n(&k) = &cb11n(&k) + &b_numpigs;
          IF &b_reason = 12 THEN &cb12n(&k) = &cb12n(&k) + &b_numpigs;
        END;
      ELSE DO; /* &b removal = 2 (deaths) */
        &slow_death = &slow_death + &b_numpigs;
        IF &b_reason = 1 THEN &ab1n(&k) = &ab1n(&k) + &b_numpigs;
        IF &b_reason = 2 THEN &ab2n(&k) = &ab2n(&k) + &b_numpigs;
        IF &b_reason = 3 THEN &ab3n(&k) = &ab3n(&k) + &b_numpigs;
        IF &b_reason = 4 THEN &ab4n(&k) = &ab4n(&k) + &b_numpigs;
        IF &b_reason = 5 THEN &ab5n(&k) = &ab5n(&k) + &b_numpigs;
        IF &b_reason = 6 THEN &ab6n(&k) = &ab6n(&k) + &b_numpigs;
        IF &b_reason = 7 THEN &ab7n(&k) = &ab7n(&k) + &b_numpigs;
        IF &b_reason = 8 THEN &ab8n(&k) = &ab8n(&k) + &b_numpigs;
        IF &b_reason = 9 THEN &ab9n(&k) = &ab9n(&k) + &b_numpigs;
        IF &b_reason = 10 THEN &ab10n(&k) = &ab10n(&k) + &b_numpigs;
        IF &b_reason = 11 THEN &ab11n(&k) = &ab11n(&k) + &b_numpigs;
      END;
    END;
  END;

```



```

File: C:\UTIL\MAINFR.PGM          02/10/1989   17:57   -- Page: 059

col 49 DISPLAY(&c_blivepf(&m)) col 64 DISPLAY(&c_blivepf(&n)) ON sumfile;
write ' c. Per Litter' col 32 DISPLAY(&c_blivepf(&k))
col 49 DISPLAY(&c_blivepf(&m)) col 64 DISPLAY(&c_blivepf(&n)) ON sumfile;
write ' ' on sumfile;
write '5. Pigs Weaned' ON sumfile
write ' a. Per Quarter' col 29 DISPLAY(&num_pigs_wean(&k))
col 46 DISPLAY(&num_pigs_wean(&m)) col 61 DISPLAY(&num_pigs_wean(&n))
ON sumfile;

write ' b. Per Female' col 32 DISPLAY(&c_pweanpf(&k))
col 49 DISPLAY(&c_pweanpf(&m)) col 64 DISPLAY(&c_pweanpf(&n)) ON sumfile;

write ' c. Per Litter' col 32 DISPLAY(&c_pweanpf(&k))
col 49 DISPLAY(&c_pweanpf(&m)) col 64 DISPLAY(&c_pweanpf(&n)) ON sumfile;
write ' ' on sumfile;
write '6. Litters Weaned' ON sumfile;
write ' a. Per Quarter' col 29 DISPLAY(&num_lit_wean(&k))
col 46 DISPLAY(&num_lit_wean(&m)) col 61 DISPLAY(&num_lit_wean(&n))
ON sumfile;

write ' b. Per Female' col 32 DISPLAY(&c_lweanpf(&k))
col 49 DISPLAY(&c_lweanpf(&m)) col 64 DISPLAY(&c_lweanpf(&n)) ON sumfile;
write ' ' on sumfile;
write '7. Total Female/Born Ratio' col 32 DISPLAY(&ftcb_ratio(&k))
col 49 DISPLAY(&ftcb_ratio(&m)) col 64 DISPLAY(&ftcb_ratio(&n)) ON sumfile;
write ' ' on sumfile;
RETURN;

*****
SHIMP2.NON SUBROUTINE
*****
/* printing table 2 */
&k = 1; &l = 2; &m = 3; &n = 4;
write ' SHIMS QUARTERLY REPORT - Page 2
      ' ON sumfile;

write '
on sumfile;
write ' farm CODE: ' DISPLAY(&farmcode) col 28 DISPLAY(&tempdate1)
' ' ' DISPLAY(&curdate1) on sumfile;
write col 48 'Rolling' col 62 'Current' on sumfile;
write col 32 'Current' col 47 'Quarterly' col 63 'SHIMS'
on sumfile;
write col 32 'Period' col 48 'Average' col 62 'Average'
on sumfile;
write col 32 ' ' col 47 ' ' col 62 ' ' ON sumfile;
write 'EFFICIENCY IN FEED USAGE' ON sumfile;
write '-----' ON sumfile;
IF &checkedfeed = 0 THEN DO;
write ' No data received for this report. ' on sumfile;
FOR &l = 1 TO 22 DO;
write ' ' on sumfile;
END;
ELSE DO;
write ' 1. Lactation' on sumfile;
write col 4 'Average lbs/female/day' col 30 DISPLAY(&lectavg(&k))
col 46 DISPLAY(&lectavg(&m)) col 61 DISPLAY(&lectavg(&n)) on sumfile;
write col 4 'Total lbs fed' col 30 DISPLAY(&lecttot(&k))
col 46 DISPLAY(&lecttot(&m)) col 61 DISPLAY(&lecttot(&n)) on sumfile;
write ' ' on sumfile;
write ' 2. Gestation' on sumfile;
write col 4 'Average lbs/female/day' col 30 DISPLAY(&gestavg(&k))

```

```

File: C:\UTIL\MAINFR.PGM          02/10/1989   17:57   -- Page: 060

col 46 DISPLAY(&gestavg(&m)) col 61 DISPLAY(&gestavg(&n)) on sumfile;
write col 4 'Total lbs fed' col 30 DISPLAY(&gesttot(&k))
col 46 DISPLAY(&gesttot(&m)) col 61 DISPLAY(&gesttot(&n)) on sumfile;
write ' ' on sumfile;
write ' 3. Starter' on sumfile;
write col 4 'Average lbs/pig/day' col 30 DISPLAY(&startavg(&k))
col 46 DISPLAY(&startavg(&m)) col 61 DISPLAY(&startavg(&n)) on sumfile;
write col 4 'Total lbs fed' col 30 DISPLAY(&starttot(&k))
col 46 DISPLAY(&starttot(&m)) col 61 DISPLAY(&starttot(&n)) on sumfile;
write ' ' on sumfile;
write ' 4. Nursery' on sumfile;
write col 4 'Average lbs/pig/day' col 30 DISPLAY(&nursavg(&k))
col 46 DISPLAY(&nursavg(&m)) col 61 DISPLAY(&nursavg(&n)) on sumfile;
write col 4 'Total lbs fed' col 30 DISPLAY(&nurstot(&k))
col 46 DISPLAY(&nurstot(&m)) col 61 DISPLAY(&nurstot(&n)) on sumfile;
write ' ' on sumfile;
write ' 5. Grower' on sumfile;
write col 4 'Average lbs/pig/day' col 30 DISPLAY(&growavg(&k))
col 46 DISPLAY(&growavg(&m)) col 61 DISPLAY(&growavg(&n)) on sumfile;
write col 4 'Total lbs fed' col 30 DISPLAY(&growtot(&k))
col 46 DISPLAY(&growtot(&m)) col 61 DISPLAY(&growtot(&n)) on sumfile;
write ' ' on sumfile;
write ' 6. Finisher' on sumfile;
write col 4 'Average lbs/pig/day' col 30 DISPLAY(&finavg(&k))
col 46 DISPLAY(&finavg(&m)) col 61 DISPLAY(&finavg(&n)) on sumfile;
write col 4 'Total lbs fed' col 30 DISPLAY(&fintot(&k))
col 46 DISPLAY(&fintot(&m)) col 61 DISPLAY(&fintot(&n)) on sumfile;
END;
write ' ' on sumfile;
write 'EFFICIENCY IN FACILITY USAGE' on sumfile;
write '-----' ON sumfile;
write ' ' on sumfile;
write col 1 '1. Litters Farrowed/Crate' col 32 DISPLAY(&lfar_ct(&k))
col 48 DISPLAY(&lfar_ct(&m)) col 63 DISPLAY(&lfar_ct(&n)) on sumfile;
write ' ' on sumfile;

write col 1 '2. Pigs Weaned / Crate' col 32 DISPLAY(&lpign_ct(&k))
col 48 DISPLAY(&lpign_ct(&m)) col 63 DISPLAY(&lpign_ct(&n)) on sumfile;
write ' ' on sumfile;

write col 1 '3. Nursery Turnover' col 32 DISPLAY(&nurnturn(&k))
col 48 DISPLAY(&nurnturn(&m)) col 63 DISPLAY(&nurnturn(&n)) on sumfile;
write ' ' on sumfile;

write col 1 '4. Grower to Finisher' on sumfile;
write col 1 ' Turnover' col 32 DISPLAY(&gfturn(&k))
col 48 DISPLAY(&gfturn(&m)) col 63 DISPLAY(&gfturn(&n)) on sumfile;
write ' ' on sumfile;

&npages = 9;
for &l = 1 to &npages do;
write ' ' on sumfile;
end;
RETURN;

*****
SHIMP3.NON SUBROUTINE
*****
/* ----- calculations for OUTPUT TABLE 3 - Marketing Measures ----- */
&k = 1; &l = 2; &m = 3; &n = 4;
write ' SHIMS QUARTERLY REPORT - Page 3

```



```

File: C:\UTIL\MAINFR.PGM                                02/10/1989   17:57   --   Page: 062

col 67 DISPLAY(&c_avecsowct(&n)) ON sumfile;

write ' ' on sumfile;
write '5. Cull Boars Sold ' ON sumfile;
write col 5 'a. Number Sold' col 33 DISPLAY(&nnum_cbor_sold(&k))
col 48 DISPLAY(&nnum_cbor_sold(&n)) ON sumfile;
col 64 DISPLAY(&nnum_cbor_sold(&n)) ON sumfile;
write col 5 'b. Average Market Weight' col 36 DISPLAY(&c_avecborwt(&k))
col 51 DISPLAY(&c_avecborwt(&n)) ON sumfile;
col 67 DISPLAY(&c_avecborwt(&n)) ON sumfile;
write col 5 'c. Sales Price Per Cut' col 36 DISPLAY(&c_avecborpr(&k))
col 51 DISPLAY(&c_avecborpr(&n)) ON sumfile;
col 67 DISPLAY(&c_avecborpr(&n)) ON sumfile;
write col 5 'd. Marketing Costs Per Cut' col 36 DISPLAY(&c_avecborct(&k))
col 51 DISPLAY(&c_avecborct(&n)) ON sumfile;
col 67 DISPLAY(&c_avecborct(&n)) ON sumfile;

write ' ' on sumfile;
write '6. Boars Sold for Replacement ' ON sumfile;
write col 5 'a. Number Sold' col 33 DISPLAY(&nnum_rbor_sold(&k))
col 48 DISPLAY(&nnum_rbor_sold(&n)) ON sumfile;
col 64 DISPLAY(&nnum_rbor_sold(&n)) ON sumfile;
write col 5 'b. Average Market Weight' col 36 DISPLAY(&c_averborwt(&k))
col 51 DISPLAY(&c_averborwt(&n)) ON sumfile;
col 67 DISPLAY(&c_averborwt(&n)) ON sumfile;
write col 5 'c. Sales Price Per Cut' col 36 DISPLAY(&c_averborpr(&k))
col 51 DISPLAY(&c_averborpr(&n)) ON sumfile;
col 67 DISPLAY(&c_averborpr(&n)) ON sumfile;
write col 5 'd. Marketing Costs Per Cut' col 36 DISPLAY(&c_averborct(&k))
col 51 DISPLAY(&c_averborct(&n)) ON sumfile;
col 67 DISPLAY(&c_averborct(&n)) ON sumfile;

write ' ' on sumfile;
write '7. Open Glts Sold for Replacement ' ON sumfile;
write col 5 'a. Number Sold' col 33 DISPLAY(&nnum_oglt_sold(&k))
col 48 DISPLAY(&nnum_oglt_sold(&n)) ON sumfile;
col 64 DISPLAY(&nnum_oglt_sold(&n)) ON sumfile;
write col 5 'b. Average Market Weight' col 36 DISPLAY(&c_aveogltwt(&k))
col 51 DISPLAY(&c_aveogltwt(&n)) ON sumfile;
col 67 DISPLAY(&c_aveogltwt(&n)) ON sumfile;
write col 5 'c. Sales Price Per Cut' col 36 DISPLAY(&c_aveogltpr(&k))
col 51 DISPLAY(&c_aveogltpr(&n)) ON sumfile;
col 67 DISPLAY(&c_aveogltpr(&n)) ON sumfile;
write col 5 'd. Marketing Costs Per Cut' col 36 DISPLAY(&c_aveogltct(&k))
col 51 DISPLAY(&c_aveogltct(&n)) ON sumfile;
col 67 DISPLAY(&c_aveogltct(&n)) ON sumfile;

write ' ' on sumfile;
write '8. Bred Glts Sold for Replacement ' ON sumfile;
write col 5 'a. Number Sold' col 33 DISPLAY(&nnum_bglt_sold(&k))
col 48 DISPLAY(&nnum_bglt_sold(&n)) ON sumfile;
col 64 DISPLAY(&nnum_bglt_sold(&n)) ON sumfile;
write col 5 'b. Average Market Weight' col 36 DISPLAY(&c_avebgltwt(&k))
col 51 DISPLAY(&c_avebgltwt(&n)) ON sumfile;
col 67 DISPLAY(&c_avebgltwt(&n)) ON sumfile;
write col 5 'c. Sales Price Per Cut' col 36 DISPLAY(&c_avebgltpr(&k))
col 51 DISPLAY(&c_avebgltpr(&n)) ON sumfile;
col 67 DISPLAY(&c_avebgltpr(&n)) ON sumfile;
write col 5 'd. Marketing Costs Per Cut' col 36 DISPLAY(&c_avebgltct(&k))
col 51 DISPLAY(&c_avebgltct(&n)) ON sumfile;
col 67 DISPLAY(&c_avebgltct(&n)) ON sumfile;
write ' ' on sumfile;
write ' ' on sumfile;
RETURN ;

```

```

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col 67 DISPLAY(&c_avecsowct(&n)) ON sumfile;

write ' ' on sumfile;
write col 1 'MARKCODE: ' col 12 DISPLAY(&ff_farmcode) col 29
DISPLAY(&farmcode) ' ' col 33 DISPLAY(&curdate) ON sumfile;
write col 50 'Rolling' col 65 'Current' col 49 'Quarterly' col 65 'SHIMS' on sumfile;
write col 1 'MARKETING MEASURES' col 34 'Period' col 50
'Average' col 65 'Average' on sumfile;
write col 1 ' ' col 34 ' '
col 49 ' ' col 65 ' ' on sumfile;
write '1. Market Hogs Sold ' ON sumfile;
write col 5 'a. Number Sold' col 33 DISPLAY(&nnum_mkt_sold(&k))
col 48 DISPLAY(&nnum_mkt_sold(&n)) ON sumfile;
col 64 DISPLAY(&nnum_mkt_sold(&n)) ON sumfile;
write col 5 'b. Average Market Weight' col 36 DISPLAY(&c_aveamktwt(&k))
col 51 DISPLAY(&c_aveamktwt(&n)) ON sumfile;
col 67 DISPLAY(&c_aveamktwt(&n)) ON sumfile;
write col 5 'c. Sales Price Per Cut' col 36 DISPLAY(&c_aveamktpr(&k))
col 51 DISPLAY(&c_aveamktpr(&n)) ON sumfile;
col 67 DISPLAY(&c_aveamktpr(&n)) ON sumfile;
write col 5 'd. Marketing Costs Per Cut' col 36 DISPLAY(&c_aveamktct(&k))
col 51 DISPLAY(&c_aveamktct(&n)) ON sumfile;
col 67 DISPLAY(&c_aveamktct(&n)) ON sumfile;

write ' ' on sumfile;
write '2. Feeder Pigs Sold ' ON sumfile;
write col 5 'a. Number Sold' col 33 DISPLAY(&nnum_feed_sold(&k))
col 48 DISPLAY(&nnum_feed_sold(&n)) ON sumfile;
col 64 DISPLAY(&nnum_feed_sold(&n)) ON sumfile;
write col 5 'b. Average Market Weight' col 36 DISPLAY(&c_avefeedwt(&k))
col 51 DISPLAY(&c_avefeedwt(&n)) ON sumfile;
col 67 DISPLAY(&c_avefeedwt(&n)) ON sumfile;
write col 5 'c. Sales Price Per Cut' col 36 DISPLAY(&c_avefeedpr(&k))
col 51 DISPLAY(&c_avefeedpr(&n)) ON sumfile;
col 67 DISPLAY(&c_avefeedpr(&n)) ON sumfile;
write col 5 'd. Marketing Costs Per Cut' col 36 DISPLAY(&c_avefeedct(&k))
col 51 DISPLAY(&c_avefeedct(&n)) ON sumfile;
col 67 DISPLAY(&c_avefeedct(&n)) ON sumfile;

write ' ' on sumfile;
write '3. Underweight Market Hogs Sold ' ON sumfile;
write col 5 'a. Number Sold' col 33 DISPLAY(&nnum_uw_sold(&k))
col 48 DISPLAY(&nnum_uw_sold(&n)) ON sumfile;
col 64 DISPLAY(&nnum_uw_sold(&n)) ON sumfile;
write col 5 'b. Average Market Weight' col 36 DISPLAY(&c_aveuwtwt(&k))
col 51 DISPLAY(&c_aveuwtwt(&n)) ON sumfile;
col 67 DISPLAY(&c_aveuwtwt(&n)) ON sumfile;
write col 5 'c. Sales Price Per Cut' col 36 DISPLAY(&c_aveuwtpr(&k))
col 51 DISPLAY(&c_aveuwtpr(&n)) ON sumfile;
col 67 DISPLAY(&c_aveuwtpr(&n)) ON sumfile;
write col 5 'd. Marketing Costs Per Cut' col 36 DISPLAY(&c_aveuwtct(&k))
col 51 DISPLAY(&c_aveuwtct(&n)) ON sumfile;
col 67 DISPLAY(&c_aveuwtct(&n)) ON sumfile;

write ' ' on sumfile;
write '4. Cull Sows Sold ' ON sumfile;
write col 5 'a. Number Sold' col 33 DISPLAY(&nnum_csw_sold(&k))
col 48 DISPLAY(&nnum_csw_sold(&n)) ON sumfile;
col 64 DISPLAY(&nnum_csw_sold(&n)) ON sumfile;
write col 5 'b. Average Market Weight' col 36 DISPLAY(&c_avecsowwt(&k))
col 51 DISPLAY(&c_avecsowwt(&n)) ON sumfile;
col 67 DISPLAY(&c_avecsowwt(&n)) ON sumfile;
write col 5 'c. Sales Price Per Cut' col 36 DISPLAY(&c_avecsowpr(&k))
col 51 DISPLAY(&c_avecsowpr(&n)) ON sumfile;
col 67 DISPLAY(&c_avecsowpr(&n)) ON sumfile;
write col 5 'd. Marketing Costs Per Cut' col 36 DISPLAY(&c_avecsowct(&k))
col 51 DISPLAY(&c_avecsowct(&n)) ON sumfile;
col 67 DISPLAY(&c_avecsowct(&n)) ON sumfile;

```

```

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col 50 DISPLAY(&intertot(&n)) col 64 DISPLAY(&intertot(&n)) ON sumfile;
write ' ' on sumfile;
write '12. Taxes' col 34 DISPLAY(&taxtot(&k))
col 50 DISPLAY(&taxtot(&n)) col 64 DISPLAY(&taxtot(&n)) ON sumfile;
write ' ' on sumfile;
write '13. Replacement females' col 34 DISPLAY(&femrepl(&k))
col 50 DISPLAY(&femrepl(&n)) col 64 DISPLAY(&femrepl(&n)) ON sumfile;
write ' ' on sumfile;
write '14. Replacement boars' col 34 DISPLAY(&boarrepl(&k))
col 50 DISPLAY(&boarrepl(&n)) col 64 DISPLAY(&boarrepl(&n)) ON sumfile;
write ' ' on sumfile;
write '15. Other Expenses' col 34 DISPLAY(&othertot(&k))
col 50 DISPLAY(&othertot(&n)) col 64 DISPLAY(&othertot(&n)) ON sumfile;

DECLARE &stotcurt as 999.99; DECLARE &stotyearago as 999.99;
DECLARE &stotqrt as 999.99; DECLARE &stotshims as 999.99;
&stotcurt = 0; &stotyearago = 0; &stotqrt = 0; &stotshims = 0;
&stotcurt = &repairtot(&k) + &vettot(&k) + &labortot(&k)
+ &suvtot(&k) + &fueltot(&k) + &seectot(&k)
+ &eteletot(&k) + &etructtot(&k) + &emarttot(&k)
+ &einsurtot(&k) + &eintertot(&k) + &etaxtot(&k)
+ &femrepl(&k) + &boarrepl(&k) + &othertot(&k);
&stotqrt = &repairtot(&n) + &vettot(&n) + &labortot(&n)
+ &suvtot(&n) + &fueltot(&n) + &seectot(&n)
+ &eteletot(&n) + &etructtot(&n) + &emarttot(&n)
+ &einsurtot(&n) + &eintertot(&n) + &etaxtot(&n)
+ &femrepl(&n) + &boarrepl(&n) + &othertot(&n);
write ' ' on sumfile;
write '32. Total Non-Feed Expense' col 62 '-----' on sumfile;
col 49 DISPLAY(&stotqrt) col 63 DISPLAY(&stotshims) on sumfile;
&snopage = 11; /* NUMBER OF LINES TO FINISH OUT PAGE */
for &h = 1 to &snopage
DO
write ' ' on sumfile;
END;
RETURN ;

*****
SHIMPG5 NON SUBROUTINE
*****
/* output for slaughter table */
&k = 1; &l = 2; &m = 3;
write ' ' on sumfile;
write ' ' on sumfile;
write col 1 'FARMCODE:' col 12 DISPLAY(&farmcode) on sumfile;
write col 14 'Current Period' col 34 'Rolling Quarter' col 34
'Current SHIMS' on sumfile;
write col 1 'DATE:' col 16 DISPLAY(&sdate(&k)) col 36
' Total ' col 57 ' Total ' on sumfile;
/* omit this information for the moment */

```

```

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*****
SHIMPG4 NON SUBROUTINE
*****
/* ----- printing SHIMPG4 - TABLE 4 - production expenses ----- */
&k = 1; &l = 2; &m = 3; &n = 4;
write ' ' on sumfile;
write ' ' on sumfile;
write col 1 'FARMCODE:' col 12 DISPLAY(&farmcode) col 29
DISPLAY(&sdate(&n)) col 44 'Current' on sumfile;
write col 34 'Rolling' col 64 'Current' on sumfile;
write col 34 'Current' col 64 'Quarterly' col 64 'SHIMS' on sumfile;
write col 1 'CASH EXPENSES PER CWT PORK' col 34 'Period'
col 49 'Average' col 64 'Average' on sumfile;
write col 1 '-----' col 33 '-----'
col 48 '-----' col 64 '-----' on sumfile;
write ' ' on sumfile;
write col 1 'Purchased feed expense' col 34 DISPLAY(&feedtot(&k))
col 50 DISPLAY(&feedtot(&n)) col 64 DISPLAY(&feedtot(&n)) ON sumfile;
write ' ' on sumfile;
write '1. Non-feed expenses' on sumfile;
write '1. Repairs and Maintenance' col 34 DISPLAY(&repairtot(&k))
col 50 DISPLAY(&repairtot(&n)) col 64 DISPLAY(&repairtot(&n)) ON sumfile;
write ' ' on sumfile;
write '2. Veterinary care & drugs' col 34 DISPLAY(&vettot(&k))
col 50 DISPLAY(&vettot(&n)) col 64 DISPLAY(&vettot(&n)) ON sumfile;
write ' ' on sumfile;
write '3. Labor' col 34 DISPLAY(&labortot(&k))
col 50 DISPLAY(&labortot(&n)) col 64 DISPLAY(&labortot(&n)) ON sumfile;
write ' ' on sumfile;
write '4. Supplies' col 34 DISPLAY(&suvtot(&k))
col 50 DISPLAY(&suvtot(&n)) col 64 DISPLAY(&suvtot(&n)) ON sumfile;
write ' ' on sumfile;
write '5. Fuel' col 34 DISPLAY(&fueltot(&k))
col 50 DISPLAY(&fueltot(&n)) col 64 DISPLAY(&fueltot(&n)) ON sumfile;
write ' ' on sumfile;
write '6. Electricity' col 34 DISPLAY(&seectot(&k))
col 50 DISPLAY(&seectot(&n)) col 64 DISPLAY(&seectot(&n)) ON sumfile;
write ' ' on sumfile;
write '7. Telephone' col 34 DISPLAY(&eteletot(&k))
col 50 DISPLAY(&eteletot(&n)) col 64 DISPLAY(&eteletot(&n)) ON sumfile;
write ' ' on sumfile;
write '8. Trucking' col 34 DISPLAY(&etructtot(&k))
col 50 DISPLAY(&etructtot(&n)) col 64 DISPLAY(&etructtot(&n)) ON sumfile;
write ' ' on sumfile;
write '9. Marketing'
col 34 DISPLAY(&emarttot(&k))
col 50 DISPLAY(&emarttot(&n)) col 64 DISPLAY(&emarttot(&n)) ON sumfile;
write ' ' on sumfile;
write '10. Insurance' col 34 DISPLAY(&einsurtot(&k))
col 50 DISPLAY(&einsurtot(&n)) col 64 DISPLAY(&einsurtot(&n)) ON sumfile;
write ' ' on sumfile;
write '11. Interest' col 34 DISPLAY(&eintertot(&k))

```

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```

DISPLAY(&mi(&m)) col 62 DISPLAY(&cm(&m)) on sumfile;
write col 3 'mild' col 15 DISPLAY(&mi(&k)) col 22 DISPLAY(&cm1(&k))
col 34 DISPLAY(&mi(&l)) col 43 DISPLAY(&cm1(&l)) col 54
DISPLAY(&mi(&m)) col 62 DISPLAY(&cm1(&m)) on sumfile;
write col 3 'moderate' col 15 DISPLAY(&mi2(&k)) col 22 DISPLAY(&cm2(&k))
col 34 DISPLAY(&mi2(&l)) col 43 DISPLAY(&cm2(&l)) col 54
DISPLAY(&mi2(&m)) col 62 DISPLAY(&cm2(&m)) on sumfile;
write col 3 'severe' col 15 DISPLAY(&mi(&k)) col 22 DISPLAY(&cm(&k))
col 34 DISPLAY(&mi(&l)) col 43 DISPLAY(&cm(&l)) col 54
DISPLAY(&mi(&m)) col 62 DISPLAY(&cm(&m)) on sumfile;
write col 14 'TOTALS' col 33 '-----' col 53 '-----' on sumfile;
write col 2 'TOTALS' col 15 DISPLAY(&summi(&k)) col 34
DISPLAY(&summi(&l)) col 54 DISPLAY(&summi(&m)) on sumfile;
write ' ' on sumfile;
write 'INITIATIS' on sumfile;
write col 3 'none' col 15 DISPLAY(&mi(&k)) col 22 DISPLAY(&cm(&k))
col 34 DISPLAY(&mi(&l)) col 43 DISPLAY(&cm(&l)) col 54
DISPLAY(&mi(&m)) col 62 DISPLAY(&cm(&m)) on sumfile;
write col 3 'mild' col 15 DISPLAY(&mi1(&k)) col 22 DISPLAY(&cm1(&k))
col 34 DISPLAY(&mi1(&l)) col 43 DISPLAY(&cm1(&l)) col 54
DISPLAY(&mi1(&m)) col 62 DISPLAY(&cm1(&m)) on sumfile;
write col 3 'moderate' col 15 DISPLAY(&mi2(&k)) col 22 DISPLAY(&cm2(&k))
col 34 DISPLAY(&mi2(&l)) col 43 DISPLAY(&cm2(&l)) col 54
DISPLAY(&mi2(&m)) col 62 DISPLAY(&cm2(&m)) on sumfile;
write col 3 'severe' col 15 DISPLAY(&mi(&k)) col 22 DISPLAY(&cm(&k))
col 34 DISPLAY(&mi(&l)) col 43 DISPLAY(&cm(&l)) col 54
DISPLAY(&mi(&m)) col 62 DISPLAY(&cm(&m)) on sumfile;
write col 14 'TOTALS' col 33 '-----' col 53 '-----' on sumfile;
write col 2 'TOTALS' col 15 DISPLAY(&summi1(&k)) col 34
DISPLAY(&summi1(&l)) col 54 DISPLAY(&summi1(&m)) on sumfile;
write ' ' on sumfile;
write col 1 'SEP. DAY' col 15 DISPLAY(&rsd(&k)) col 22
DISPLAY(&rsd(&l)) col 34 DISPLAY(&rsd(&l)) col 43 DISPLAY(&rsd(&l))
col 54 DISPLAY(&rsd(&m)) col 62 DISPLAY(&rsd(&m)) on sumfile;
write ' ' on sumfile;
write 'TATTOO LEGIBILITY' on sumfile;
write '-----' on sumfile;
write col 3 'good' col 15 DISPLAY(&tg(&k)) col 22 DISPLAY(&ctg(&k))
col 34 DISPLAY(&tg(&l)) col 43 DISPLAY(&ctg(&l))
col 54 DISPLAY(&tg(&m)) col 62 DISPLAY(&ctg(&m)) on sumfile;
write col 3 'marginal' col 15 DISPLAY(&tm(&k)) col 22 DISPLAY(&ctm(&k))
col 34 DISPLAY(&tm(&l)) col 43 DISPLAY(&ctm(&l))
col 54 DISPLAY(&tm(&m)) col 62 DISPLAY(&ctm(&m)) on sumfile;
write col 3 'illegible' col 15 DISPLAY(&ti(&k)) col 22 DISPLAY(&cti(&k))
col 34 DISPLAY(&ti(&l)) col 43 DISPLAY(&cti(&l))
col 54 DISPLAY(&ti(&m)) col 62 DISPLAY(&cti(&m)) on sumfile;
write col 14 'TOTALS' col 33 '-----' col 53 '-----' on sumfile;
DECLARE &totg as 999; DECLARE &totm as 999; DECLARE &toti as 999;
&totg = 0; &totm = 0; &toti = 0; &totg = &tg(&k)+&tm(&k)+&ti(&k);
&totm = &tg(&l)+&tm(&l)+&ti(&l); &toti = &tg(&m)+&tm(&m)+&ti(&m);
write col 2 'TOTALS' col 16 DISPLAY(&totg) col 35
DISPLAY(&totm) col 55 DISPLAY(&toti) on sumfile;

```

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```

/* write 'PLANT CODE: ' col 16 DISPLAY(&plant(&k)) col 34 */
/* DISPLAY(&plant(&l)) col 52 DISPLAY(&plant(&m)) on sumfile; */
write ' # PIGS PERCENT # PIGS PERCENT' col 53
write ' # PIGS PERCENT' on sumfile;
write '-----' col 53
write '-----' on sumfile;
write 'PHEUMONIA' on sumfile;
write '-----' on sumfile;
write col 3 'none' col 15 DISPLAY(&pn(&k)) col 22 DISPLAY(&cpn(&k))
col 34 DISPLAY(&pn(&l)) col 43 DISPLAY(&cpn(&l))
col 54 DISPLAY(&pn(&m)) col 62 DISPLAY(&cpn(&m)) on sumfile;
write col 3 'mild' col 15 DISPLAY(&pm1(&k)) col 22 DISPLAY(&cpm1(&k))
col 34 DISPLAY(&pm1(&l)) col 43 DISPLAY(&cpm1(&l)) col 54
DISPLAY(&pm1(&m)) col 62 DISPLAY(&cpm1(&m)) on sumfile;
write col 3 'moderate' col 15 DISPLAY(&pm2(&k)) col 22 DISPLAY(&cpm2(&k))
col 34 DISPLAY(&pm2(&l)) col 43 DISPLAY(&cpm2(&l)) col 54
DISPLAY(&pm2(&m)) col 62 DISPLAY(&cpm2(&m)) on sumfile;
write col 3 'severe' col 15 DISPLAY(&ps(&k)) col 22 DISPLAY(&cps(&k))
col 34 DISPLAY(&ps(&l)) col 43 DISPLAY(&cps(&l)) col 54
DISPLAY(&ps(&m)) col 62 DISPLAY(&cps(&m)) on sumfile;
write col 14 'TOTALS' col 33 '-----' col 53 '-----' on sumfile;
write col 2 'TOTALS' col 15 DISPLAY(&sumpn(&k)) col 34
DISPLAY(&sumpn(&l)) col 54 DISPLAY(&sumpn(&m)) on sumfile;
write ' ' on sumfile;
write col 1 'PLEURITIS' col 15 DISPLAY(&ppi(&k)) col 22
DISPLAY(&cppi(&l)) col 34 DISPLAY(&ppi(&l)) col 43 DISPLAY(&cppi(&l))
col 54 DISPLAY(&ppi(&m)) col 62 DISPLAY(&cppi(&m)) on sumfile;
write col 1 'PERICARD.' col 15 DISPLAY(&ppe(&k)) col 22
DISPLAY(&cppe(&l)) col 34 DISPLAY(&ppe(&l)) col 43 DISPLAY(&cppe(&l))
col 54 DISPLAY(&ppe(&m)) col 62 DISPLAY(&cppe(&m)) on sumfile;
write ' ' on sumfile;
write 'LIVER SCARS' on sumfile;
write '-----' on sumfile;
write col 3 'none' col 15 DISPLAY(&lin(&k)) col 22 DISPLAY(&clin(&k))
col 34 DISPLAY(&lin(&l)) col 43 DISPLAY(&clin(&l)) col 54
DISPLAY(&lin(&m)) col 62 DISPLAY(&clin(&m)) on sumfile;
write col 3 'mild' col 15 DISPLAY(&lim1(&k)) col 22 DISPLAY(&clim1(&k))
col 34 DISPLAY(&lim1(&l)) col 43 DISPLAY(&clim1(&l)) col 54
DISPLAY(&lim1(&m)) col 62 DISPLAY(&clim1(&m)) on sumfile;
write col 3 'moderate' col 15 DISPLAY(&lim2(&k)) col 22 DISPLAY(&clim2(&k))
col 34 DISPLAY(&lim2(&l)) col 43 DISPLAY(&clim2(&l)) col 54
DISPLAY(&lim2(&m)) col 62 DISPLAY(&clim2(&m)) on sumfile;
write col 3 'severe' col 15 DISPLAY(&lis(&k)) col 22 DISPLAY(&clis(&k))
col 34 DISPLAY(&lis(&l)) col 43 DISPLAY(&clis(&l)) col 54
DISPLAY(&lis(&m)) col 62 DISPLAY(&clis(&m)) on sumfile;
write col 14 'TOTALS' col 33 '-----' col 53 '-----' on sumfile;
write col 2 'TOTALS' col 15 DISPLAY(&sumlinv(&k)) col 34
DISPLAY(&sumlinv(&l)) col 54 DISPLAY(&sumlinv(&m)) on sumfile;
write ' ' on sumfile;
write 'MANGE' on sumfile;
write '-----' on sumfile;
write col 3 'none' col 15 DISPLAY(&mn(&k)) col 22 DISPLAY(&cmn(&k))
col 34 DISPLAY(&mn(&l)) col 43 DISPLAY(&cmn(&l)) col 54

```

```

/* print 'Slaughter codes: 1 = Utica Peking Co., Utica, MI';
/* print '2 = Thornapple Valley, Inc.,';
/* print '3 = Frederick Division, Detroit, MI';
/* print '4 = Dinnier Bell Foods, Inc., Troy, MI';
/* print '5 = Wilton Foods, Inc., Logansport, IN';

RETURN;

```

```

*****
SHIMP66.MOM SUBROUTINE
*****

```

```

/* ----- Printing SHIMP66 - TABLE 6 - death losses ----- */
/* k = 1; n = 2; &linecnt = 0;
write col 1 'SHIMP66 QUARTERLY REPORT' col 34 'PIG MORTALITY SUMMARY'
col 70 'Page 6' on sumfile;
write col 1 '-----' col 34 '-----'
col 70 '-----' on sumfile;

```

```

write col 1 'FARMCODE: ' col 12 DISPLAY(&FF farmcode) col 34
DISPLAY(&template) ' - ' DISPLAY(&curdate) on sumfile;

```

```

write col 1 'Phase' col 34 'Number' col 48 'Herd #'
col 64 'SHIMS #' on sumfile;
write col 1 '-----' col 34 '-----'
col 48 '-----' col 64 '-----' on sumfile;

```

```

write 'STILLBORN' col 37 DISPLAY(&n stillborn(&k)) col 50
DISPLAY(&p stillborn(&k)) col 64 DISPLAY(&p stillborn(&n)) on sumfile;
write 'MUMMIES' col 37 DISPLAY(&n mummies(&k)) col 50
DISPLAY(&p mummies(&k)) col 64 DISPLAY(&p mummies(&n)) on sumfile;
write 'PREMATURE PIG DEATHS' on sumfile;
&linecnt = &linecnt + 8;

```

```

if znava(&nfm cru(&k)) > 0 THEN DO;
write col 1 'Crushed' col 37 DISPLAY(&nfm cru(&k))
col 50 DISPLAY(&pfm cru(&k)) col 64 DISPLAY(&pfm cru(&n)) on sumfile;
&linecnt = &linecnt + 1;
END;

```

```

if znava(&nfm cru(&k)) > 0 THEN
if znava(&pfm cru(&n)) > 0.05 THEN DO;
write col 1 'Crushed' col 64 DISPLAY(&pfm cru(&n)) on sumfile;
&linecnt = &linecnt + 1;
END;

```

```

if znava(&nfm def(&k)) > 0 THEN DO;
write col 1 'Deformed' col 37 DISPLAY(&nfm def(&k))
col 50 DISPLAY(&pfm def(&k)) col 64 DISPLAY(&pfm def(&n)) on sumfile;
&linecnt = &linecnt + 1;
END;

```

```

if znava(&nfm def(&k)) = 0 THEN
if znava(&pfm def(&n)) > 0.05 THEN DO;
write col 1 'Deformed' col 64 DISPLAY(&pfm def(&n)) on sumfile;
&linecnt = &linecnt + 1;
END;

```

```

if znava(&nfm sco(&k)) > 0 THEN DO;
write col 1 'Sours' col 37 DISPLAY(&nfm sco(&k))
col 50 DISPLAY(&pfm sco(&k)) col 64 DISPLAY(&pfm sco(&n)) on sumfile;
&linecnt = &linecnt + 1;
END;

```

```

if znava(&nfm sco(&k)) = 0 THEN
if znava(&pfm sco(&n)) > 0.05 THEN DO;
write col 1 'Sours' col 64 DISPLAY(&pfm sco(&n)) on sumfile;
&linecnt = &linecnt + 1;
END;

```

```

END;

```

```

if znava(&nfm sta(&k)) > 0 THEN DO;
write col 1 'Starved' col 37 DISPLAY(&nfm sta(&k))
col 50 DISPLAY(&pfm sta(&k)) col 64 DISPLAY(&pfm sta(&n)) on sumfile;
&linecnt = &linecnt + 1;
END;

```

```

if znava(&nfm sta(&k)) = 0 THEN
if znava(&pfm sta(&n)) > 0.05 THEN DO;
write col 1 'Starved' col 64 DISPLAY(&pfm sta(&n)) on sumfile;
&linecnt = &linecnt + 1;
END;

```

```

if znava(&nfm sud(&k)) > 0 THEN DO;
write col 1 'Sudden' col 37 DISPLAY(&nfm sud(&k))
col 50 DISPLAY(&pfm sud(&k)) col 64 DISPLAY(&pfm sud(&n)) on sumfile;
&linecnt = &linecnt + 1;
END;

```

```

if znava(&nfm sud(&k)) = 0 THEN
if znava(&pfm sud(&n)) > 0.05 THEN DO;
write col 1 'Sudden' col 64 DISPLAY(&pfm sud(&n)) on sumfile;
&linecnt = &linecnt + 1;
END;

```

```

if znava(&nfm wea(&k)) > 0 THEN DO;
write col 1 'Weak' col 37 DISPLAY(&nfm wea(&k))
col 50 DISPLAY(&pfm wea(&k)) col 64 DISPLAY(&pfm wea(&n)) on sumfile;
&linecnt = &linecnt + 1;
END;

```

```

if znava(&nfm wea(&k)) = 0 THEN
if znava(&pfm wea(&n)) > 0.05 THEN DO;
write col 1 'Weak' col 64 DISPLAY(&pfm wea(&n)) on sumfile;
&linecnt = &linecnt + 1;
END;

```

```

if znava(&nfm oth(&k)) > 0 THEN DO;
write col 1 'Other' col 36 DISPLAY(&nfm oth(&k))
col 50 DISPLAY(&pfm oth(&k)) col 64 DISPLAY(&pfm oth(&n)) on sumfile;
&linecnt = &linecnt + 1;
END;

```

```

if znava(&nfm oth(&k)) = 0 THEN
if znava(&pfm oth(&n)) > 0.05 THEN DO;
write col 1 'Other' col 64 DISPLAY(&pfm oth(&n)) on sumfile;
&linecnt = &linecnt + 1;
END;

```

```

DECLARE &puttotalnc AS 9999; DECLARE &puttotalnrc AS 999.999;

```

```

DECLARE &puttotalpc AS 999.999;
&puttotalnc = 0; &puttotalnrc = 0; &puttotalpc = 0;
&puttotaln = &nfm cru(&k) + &nfm def(&k) + &nfm sco(&k) + &nfm sta(&k)
+ &nfm sud(&k) + &nfm wea(&k) + &nfm oth(&k)
+ &n stillborn(&k) + &n mummies(&k);

```

```

&puttotalnrc = &pfm cru(&k) + &pfm def(&k) + &pfm sco(&k) + &pfm sta(&k)
+ &pfm sud(&k) + &pfm wea(&k) + &pfm oth(&k)
+ &p stillborn(&k) + &p mummies(&k);
&puttotalpc = &pfm cru(&n) + &pfm def(&n) + &pfm sco(&n) + &pfm sta(&n)
+ &pfm sud(&n) + &pfm wea(&n) + &pfm oth(&n)
+ &p stillborn(&n) + &p mummies(&n);

```

```

if &puttotaln > 0 THEN DO;
write col 34 '-----' col 50 '-----' col 64 '-----' on sumfile;
write col 10 'TOTAL' col 36 DISPLAY(&puttotalnc) col 50
DISPLAY(&puttotalnrc) col 64 DISPLAY(&puttotalpc) on sumfile;
&linecnt = &linecnt + 2;
END;

```

```

ELSE if &puttotalpc > 0 THEN DO;
write col 34 '-----' col 50 '-----' col 64 '-----' on sumfile;
write col 10 'TOTAL' col 36 DISPLAY(&puttotalnc) col 50

```

```

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write ' Abscess' col 37 DISPLAY(spw5n(ek))
col 50 DISPLAY(spw5p(ek)) col 64 DISPLAY(spw5p(en)) OM sumfile;
&linecnt = &linecnt + 1;
END;

IF znv(spwn(ek)) = 0 THEN
  IF znv(spw5p(en)) > 0.05 THEN DO;
    write ' Abscess' col 64 DISPLAY(spw5p(en)) OM sumfile;
    &linecnt = &linecnt + 1;
  END;

IF znv(spwn(ek)) > 0 THEN DO;
  write ' Chronic Poor Doer' col 37 DISPLAY(spwn(ek))
col 50 DISPLAY(spwp(ek)) col 64 DISPLAY(spwp(en)) OM sumfile;
&linecnt = &linecnt + 1;
END;

IF znv(spwn(ek)) = 0 THEN
  IF znv(spwp(en)) > 0.05 THEN DO;
    write ' Chronic Poor Doer' col 64 DISPLAY(spwp(en)) OM sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

IF znv(spwn(ek)) > 0 THEN DO;
  write ' Cannibalism' col 37 DISPLAY(spwn(ek))
col 50 DISPLAY(spwp(ek)) col 64 DISPLAY(spwp(en)) OM sumfile;
&linecnt = &linecnt + 1;
END;

IF znv(spwn(ek)) = 0 THEN
  IF znv(spwp(en)) > 0.05 THEN DO;
    write ' Cannibalism' col 64 DISPLAY(spwp(en)) OM sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

IF znv(spwn(ek)) > 0 THEN DO;
  write ' Sudden Death' col 37 DISPLAY(spwn(ek))
col 50 DISPLAY(spwp(ek)) col 64 DISPLAY(spwp(en)) OM sumfile;
&linecnt = &linecnt + 1;
END;

IF znv(spwn(ek)) = 0 THEN
  IF znv(spwp(en)) > 0.05 THEN DO;
    write ' Sudden Death' col 64 DISPLAY(spwp(en)) OM sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

IF znv(spwn(ek)) > 0 THEN DO;
  write ' Starvation' col 37 DISPLAY(spwn(ek))
col 50 DISPLAY(spwp(ek)) col 64 DISPLAY(spwp(en)) OM sumfile;
&linecnt = &linecnt + 1;
END;

IF znv(spwn(ek)) = 0 THEN
  IF znv(spwp(en)) > 0.05 THEN DO;
    write ' Starvation' col 64 DISPLAY(spwp(en)) OM sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

IF znv(spwn(ek)) > 0 THEN DO;
  write ' Other' col 37 DISPLAY(spwn(ek))
col 50 DISPLAY(spwp(ek)) col 64 DISPLAY(spwp(en)) OM sumfile;
&linecnt = &linecnt + 1;
END;

IF znv(spwn(ek)) = 0 THEN
  IF znv(spwp(en)) > 0.05 THEN DO;
    write ' Other' col 64 DISPLAY(spwp(en)) OM sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

IF znv(spwn(ek)) > 0 THEN DO;
  IF znv(spwn(ek)) > 0 THEN DO;
    write ' Other' col 37 DISPLAY(spwn(ek))
col 50 DISPLAY(spwp(ek)) col 64 DISPLAY(spwp(en)) OM sumfile;
&linecnt = &linecnt + 1;
  END;
END;

```

```

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DISPLAY(spwtotalspc) col 64 DISPLAY(spwtotalspc) on sumfile;
&linecnt = &linecnt + 2;
END;

write ' .. on sumfile;
write 'WEANED PIG DEATHS' on sumfile;
write '-----' on sumfile;
write 'Pre-Nursery Weaned Pigs' on sumfile;
&linecnt = &linecnt + 4;

IF znv(spwn(ek)) > 0 THEN DO;
  write ' Pneumonia' col 37 DISPLAY(spwn(ek))
col 50 DISPLAY(spwp(ek)) col 64 DISPLAY(spwp(en)) OM sumfile;
&linecnt = &linecnt + 1;
END;

IF znv(spwn(ek)) = 0 THEN
  IF znv(spwp(en)) > 0.05 THEN DO;
    write ' Pneumonia' col 64 DISPLAY(spwp(en)) OM sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

IF znv(spwn(ek)) > 0 THEN DO;
  write ' Scours' col 37 DISPLAY(spwn(ek))
col 50 DISPLAY(spwp(ek)) col 64 DISPLAY(spwp(en)) OM sumfile;
&linecnt = &linecnt + 1;
END;

IF znv(spwn(ek)) = 0 THEN
  IF znv(spwp(en)) > 0.05 THEN DO;
    write ' Scours' col 64 DISPLAY(spwp(en)) OM sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

IF znv(spwn(ek)) > 0 THEN DO;
  write ' Lameness' col 37 DISPLAY(spwn(ek))
col 50 DISPLAY(spwp(ek)) col 64 DISPLAY(spwp(en)) OM sumfile;
&linecnt = &linecnt + 1;
END;

IF znv(spwn(ek)) = 0 THEN
  IF znv(spwp(en)) > 0.05 THEN DO;
    write ' Lameness' col 64 DISPLAY(spwp(en)) OM sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

IF znv(spwn(ek)) > 0 THEN DO;
  write ' Scours' col 37 DISPLAY(spwn(ek))
col 50 DISPLAY(spwp(ek)) col 64 DISPLAY(spwp(en)) OM sumfile;
&linecnt = &linecnt + 1;
END;

IF znv(spwn(ek)) = 0 THEN
  IF znv(spwp(en)) > 0.05 THEN DO;
    write ' Scours' col 64 DISPLAY(spwp(en)) OM sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

IF znv(spwn(ek)) > 0 THEN DO;
  write ' Injury' col 37 DISPLAY(spwn(ek))
col 50 DISPLAY(spwp(ek)) col 64 DISPLAY(spwp(en)) OM sumfile;
&linecnt = &linecnt + 1;
END;

IF znv(spwn(ek)) = 0 THEN
  IF znv(spwp(en)) > 0.05 THEN DO;
    write ' Injury' col 64 DISPLAY(spwp(en)) OM sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

IF znv(spwn(ek)) > 0 THEN DO;
  IF znv(spwn(ek)) > 0 THEN DO;
    write ' Injury' col 37 DISPLAY(spwn(ek))
col 50 DISPLAY(spwp(ek)) col 64 DISPLAY(spwp(en)) OM sumfile;
&linecnt = &linecnt + 1;
  END;
END;

```

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```

write ' Unknown' col 37 DISPLAY(&w11n(&k))
col 50 DISPLAY(&w11p(&k)) col 64 DISPLAY(&w11p(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;
IF znnav(&w11n(&k)) = 0 THEN
write ' Unknown' col 64 DISPLAY(&w11p(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;

write ' Nursery Pig' on sumfile;
&linecnt = &linecnt + 2;
/* print &w13n(&k) &w13p(&n) ' = 1pw13n fp sp'; */
IF znnav(&w13n(&k)) > 0 THEN DO;
write ' Pneumonia' col 37 DISPLAY(&w13n(&k))
col 50 DISPLAY(&w13p(&k)) col 64 DISPLAY(&w13p(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;
IF znnav(&w13n(&k)) = 0 THEN
write ' Pneumonia' col 64 DISPLAY(&w13p(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;

/* print &w2n13(&k) &w2p13(&n) ' = 2pw13n fp sp'; */
IF znnav(&w2n13(&k)) > 0 THEN DO;
write ' Scours' col 37 DISPLAY(&w2n13(&k))
col 50 DISPLAY(&w2p13(&k)) col 64 DISPLAY(&w2p13(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;
IF znnav(&w2n13(&k)) = 0 THEN
write ' Scours' col 64 DISPLAY(&w2p13(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;

/* print &w3n13(&k) &w3p13(&n) ' = 3pw13n fp sp'; */
IF znnav(&w3n13(&k)) > 0 THEN DO;
write ' Lameness' col 37 DISPLAY(&w3n13(&k))
col 50 DISPLAY(&w3p13(&k)) col 64 DISPLAY(&w3p13(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;
IF znnav(&w3n13(&k)) = 0 THEN
write ' Lameness' col 64 DISPLAY(&w3p13(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;

/* print &w4n13(&k) &w4p13(&n) ' = 4pw13n fp sp'; */
IF znnav(&w4n13(&k)) > 0 THEN DO;
write ' Injury' col 37 DISPLAY(&w4n13(&k))
col 50 DISPLAY(&w4p13(&k)) col 64 DISPLAY(&w4p13(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;
IF znnav(&w4n13(&k)) = 0 THEN
write ' Injury' col 64 DISPLAY(&w4p13(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;

/* print &w5n13(&k) &w5p13(&n) ' = 5pw13n fp sp'; */
IF znnav(&w5n13(&k)) > 0 THEN DO;
write ' Access' col 37 DISPLAY(&w5n13(&k))
col 50 DISPLAY(&w5p13(&k)) col 64 DISPLAY(&w5p13(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;

```

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```

END;
IF znnav(&w5n13(&k)) = 0 THEN
write ' Access' col 64 DISPLAY(&w5p13(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;

/* print &w6n13(&k) &w6p13(&n) ' = 6pw13n fp sp'; */
IF znnav(&w6n13(&k)) > 0 THEN DO;
write ' Chronic Poor Doer' col 37 DISPLAY(&w6n13(&k))
col 50 DISPLAY(&w6p13(&k)) col 64 DISPLAY(&w6p13(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;
IF znnav(&w6n13(&k)) = 0 THEN
write ' Chronic Poor Doer' col 64 DISPLAY(&w6p13(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;

/* print &w7n13(&k) &w7p13(&n) ' = 7pw13n fp sp'; */
IF znnav(&w7n13(&k)) > 0 THEN DO;
write ' Cannibalism' col 37 DISPLAY(&w7n13(&k))
col 50 DISPLAY(&w7p13(&k)) col 64 DISPLAY(&w7p13(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;
IF znnav(&w7n13(&k)) = 0 THEN
write ' Cannibalism' col 64 DISPLAY(&w7p13(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;

/* print &w8n13(&k) &w8p13(&n) ' = 8pw13n fp sp'; */
IF znnav(&w8n13(&k)) > 0 THEN DO;
write ' Sudden Death' col 37 DISPLAY(&w8n13(&k))
col 50 DISPLAY(&w8p13(&k)) col 64 DISPLAY(&w8p13(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;
IF znnav(&w8n13(&k)) = 0 THEN
write ' Sudden Death' col 64 DISPLAY(&w8p13(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;

/* print &w9n13(&k) &w9p13(&n) ' = 9pw13n fp sp'; */
IF znnav(&w9n13(&k)) > 0 THEN DO;
write ' Starvation' col 37 DISPLAY(&w9n13(&k))
col 50 DISPLAY(&w9p13(&k)) col 64 DISPLAY(&w9p13(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;
IF znnav(&w9n13(&k)) = 0 THEN
write ' Starvation' col 64 DISPLAY(&w9p13(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;

/* print &w10n13(&k) &w10p13(&n) ' = 10pw13n fp sp'; */
IF znnav(&w10n13(&k)) > 0 THEN DO;
write ' Other' col 37 DISPLAY(&w10n13(&k))
col 50 DISPLAY(&w10p13(&k)) col 64 DISPLAY(&w10p13(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;
IF znnav(&w10n13(&k)) = 0 THEN
write ' Other' col 64 DISPLAY(&w10p13(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;

```

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```

IF znv(&pw14(&k)) > 0.05 THEN DO;
  write 'Abscess' col 64 DISPLAY(&pw14(&n)) ON sumfile;
  &linec = &linec + 1;
END;

IF znv(&pw14(&k)) > 0 THEN DO;
  write 'Chronic Poor Doer' col 37 DISPLAY(&pw14(1))
  col 50 DISPLAY(&pw14(&k)) col 64 DISPLAY(&pw14(&n)) ON sumfile;
  &linec = &linec + 1;
END;

IF znv(&pw14(&k)) = 0 THEN
  IF znv(&pw14(&n)) > 0.05 THEN DO;
    write 'Chronic Poor Doer' col 64 DISPLAY(&pw14(&n)) ON sumfile;
    &linec = &linec + 1;
  END;

IF znv(&pw7n14(&k)) > 0 THEN DO;
  write 'Carnibalism' col 37 DISPLAY(&pw7n14(1))
  col 50 DISPLAY(&pw7n14(&k)) col 64 DISPLAY(&pw7n14(&n)) ON sumfile;
  &linec = &linec + 1;
END;

IF znv(&pw7n14(&k)) = 0 THEN
  IF znv(&pw7n14(&n)) > 0.05 THEN DO;
    write 'Carnibalism' col 64 DISPLAY(&pw7n14(&n)) ON sumfile;
    &linec = &linec + 1;
  END;

IF znv(&pw10n14(&k)) > 0 THEN DO;
  write 'Sudden Death' col 37 DISPLAY(&pw10n14(1))
  col 50 DISPLAY(&pw10n14(&k)) col 64 DISPLAY(&pw10n14(&n)) ON sumfile;
  &linec = &linec + 1;
END;

IF znv(&pw10n14(&k)) = 0 THEN
  IF znv(&pw10n14(&n)) > 0.05 THEN DO;
    write 'Sudden Death' col 64 DISPLAY(&pw10n14(&n)) ON sumfile;
    &linec = &linec + 1;
  END;

IF znv(&pw9n14(&k)) > 0 THEN DO;
  write 'Starvation' col 37 DISPLAY(&pw9n14(&k))
  col 50 DISPLAY(&pw9n14(&k)) col 64 DISPLAY(&pw9n14(&n)) ON sumfile;
  &linec = &linec + 1;
END;

IF znv(&pw9n14(&k)) = 0 THEN
  IF znv(&pw9n14(&n)) > 0.05 THEN DO;
    write 'Starvation' col 64 DISPLAY(&pw9n14(&n)) ON sumfile;
    &linec = &linec + 1;
  END;

IF znv(&pw10n14(&k)) > 0 THEN DO;
  write 'Other' col 37 DISPLAY(&pw10n14(&k))
  col 50 DISPLAY(&pw10n14(&k)) col 64 DISPLAY(&pw10n14(&n)) ON sumfile;
  &linec = &linec + 1;
END;

IF znv(&pw10n14(&k)) = 0 THEN
  IF znv(&pw10n14(&n)) > 0.05 THEN DO;
    write 'Other' col 64 DISPLAY(&pw10n14(&n)) ON sumfile;
    &linec = &linec + 1;
  END;

IF znv(&pw11n14(&k)) > 0 THEN DO;
  write 'Unknown' col 37 DISPLAY(&pw11n14(&k))
  col 50 DISPLAY(&pw11n14(&k)) col 64 DISPLAY(&pw11n14(&n)) ON sumfile;
  &linec = &linec + 1;
END;

IF znv(&pw11n14(&k)) = 0 THEN
  IF znv(&pw11n14(&n)) > 0.05 THEN DO;
    write 'Unknown' col 64 DISPLAY(&pw11n14(&n)) ON sumfile;
    &linec = &linec + 1;
  END;

```

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```

/* print &pw13(&k) &pw13(&n) * =11pw13n fp sp; */
IF znv(&pw13(&k)) > 0 THEN DO;
  write 'Unknown' col 37 DISPLAY(&pw13(&k))
  col 50 DISPLAY(&pw13(&k)) col 64 DISPLAY(&pw13(&n)) ON sumfile;
  &linec = &linec + 1;
END;

IF znv(&pw13(&k)) = 0 THEN
  IF znv(&pw13(&n)) > 0.05 THEN DO;
    write 'Unknown' col 64 DISPLAY(&pw13(&n)) ON sumfile;
    &linec = &linec + 1;
  END;

write ' ' on sumfile;
write 'Growth Pigs' on sumfile;
&linec = &linec + 2;
IF znv(&pw14(&k)) > 0 THEN DO;
  write 'Pneumonia' col 37 DISPLAY(&pw14(1))
  col 50 DISPLAY(&pw14(&k)) col 64 DISPLAY(&pw14(&n)) ON sumfile;
  &linec = &linec + 1;
END;

IF znv(&pw14(&k)) = 0 THEN
  IF znv(&pw14(&n)) > 0.05 THEN DO;
    write 'Pneumonia' col 64 DISPLAY(&pw14(&n)) ON sumfile;
    &linec = &linec + 1;
  END;

IF znv(&pw2n14(&k)) > 0 THEN DO;
  write 'Scour' col 37 DISPLAY(&pw2n14(1))
  col 50 DISPLAY(&pw2n14(&k)) col 64 DISPLAY(&pw2n14(&n)) ON sumfile;
  &linec = &linec + 1;
END;

IF znv(&pw2n14(&k)) = 0 THEN
  IF znv(&pw2n14(&n)) > 0.05 THEN DO;
    write 'Scour' col 64 DISPLAY(&pw2n14(&n)) ON sumfile;
    &linec = &linec + 1;
  END;

IF znv(&pw3n14(&k)) > 0 THEN DO;
  write 'Lameness' col 37 DISPLAY(&pw3n14(1))
  col 50 DISPLAY(&pw3n14(&k)) col 64 DISPLAY(&pw3n14(&n)) ON sumfile;
  &linec = &linec + 1;
END;

IF znv(&pw3n14(&k)) = 0 THEN
  IF znv(&pw3n14(&n)) > 0.05 THEN DO;
    write 'Lameness' col 64 DISPLAY(&pw3n14(&n)) ON sumfile;
    &linec = &linec + 1;
  END;

IF znv(&pw4n14(&k)) > 0 THEN DO;
  write 'Injury' col 37 DISPLAY(&pw4n14(1))
  col 50 DISPLAY(&pw4n14(&k)) col 64 DISPLAY(&pw4n14(&n)) ON sumfile;
  &linec = &linec + 1;
END;

IF znv(&pw4n14(&k)) = 0 THEN
  IF znv(&pw4n14(&n)) > 0.05 THEN DO;
    write 'Injury' col 64 DISPLAY(&pw4n14(&n)) ON sumfile;
    &linec = &linec + 1;
  END;

IF znv(&pw5n14(&k)) > 0 THEN DO;
  write 'Abscess' col 37 DISPLAY(&pw5n14(1))
  col 50 DISPLAY(&pw5n14(&k)) col 64 DISPLAY(&pw5n14(&n)) ON sumfile;
  &linec = &linec + 1;
END;

IF znv(&pw5n14(&k)) = 0 THEN
  IF znv(&pw5n14(&n)) > 0.05 THEN DO;
    write 'Abscess' col 64 DISPLAY(&pw5n14(&n)) ON sumfile;
    &linec = &linec + 1;
  END;

```

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```

IF znay(&pw1p14(&n)) > 0.05 THEN DO;
  write ' Unknown' col 64 DISPLAY(&pw1p14(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

write ' ' on sumfile;
write ' Finisher Pigs' on sumfile;
&linecnt = &linecnt + 2;
IF znay(&pw1n15(&k)) > 0 THEN DO;
  write ' Pneumonia' col 37 DISPLAY(&pw1n15(&k))
  col 50 DISPLAY(&pw1p15(&k)) col 64 DISPLAY(&pw1p15(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;
IF znay(&pw1n15(&k)) = 0 THEN
  IF znay(&pw1p15(&n)) > 0.05 THEN DO;
    write ' Pneumonia' col 64 DISPLAY(&pw1p15(&n)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
IF znay(&pw2n15(&k)) > 0 THEN DO;
  write ' Scours' col 37 DISPLAY(&pw2n15(&k))
  col 50 DISPLAY(&pw2p15(&k)) col 64 DISPLAY(&pw2p15(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;
IF znay(&pw2n15(&k)) = 0 THEN
  IF znay(&pw2p15(&n)) > 0.05 THEN DO;
    write ' Scours' col 64 DISPLAY(&pw2p15(&n)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
IF znay(&pw3n15(&k)) > 0 THEN DO;
  write ' Lameness' col 37 DISPLAY(&pw3n15(&k))
  col 50 DISPLAY(&pw3p15(&k)) col 64 DISPLAY(&pw3p15(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;
IF znay(&pw3n15(&k)) = 0 THEN
  IF znay(&pw3p15(&n)) > 0.05 THEN DO;
    write ' Lameness' col 64 DISPLAY(&pw3p15(&n)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
IF znay(&pw4n15(&k)) > 0 THEN DO;
  write ' Injury' col 37 DISPLAY(&pw4n15(&k))
  col 50 DISPLAY(&pw4p15(&k)) col 64 DISPLAY(&pw4p15(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;
IF znay(&pw4n15(&k)) = 0 THEN
  IF znay(&pw4p15(&n)) > 0.05 THEN DO;
    write ' Injury' col 64 DISPLAY(&pw4p15(&n)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
IF znay(&pw5n15(&k)) > 0 THEN DO;
  write ' Abcesses' col 37 DISPLAY(&pw5n15(&k))
  col 50 DISPLAY(&pw5p15(&k)) col 64 DISPLAY(&pw5p15(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;
IF znay(&pw5n15(&k)) = 0 THEN
  IF znay(&pw5p15(&n)) > 0.05 THEN DO;
    write ' Abcesses' col 64 DISPLAY(&pw5p15(&n)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
IF znay(&pw6n15(&k)) > 0 THEN DO;
  write ' Chronic Poor Doer' col 37 DISPLAY(&pw6n15(&k))
  col 50 DISPLAY(&pw6p15(&k)) col 64 DISPLAY(&pw6p15(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

```

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```

col 50 DISPLAY(&pw6p15(&k)) col 64 DISPLAY(&pw6p15(&n)) ON sumfile;
&linecnt = &linecnt + 1;
END;
IF znay(&pw7n15(&k)) = 0 THEN
  IF znay(&pw7p15(&n)) > 0.05 THEN DO;
    write ' Chronic Poor Doer' col 64 DISPLAY(&pw7p15(&n)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
IF znay(&pw7n15(&k)) > 0 THEN DO;
  write ' Cannibalism' col 37 DISPLAY(&pw7n15(&k))
  col 50 DISPLAY(&pw7p15(&k)) col 64 DISPLAY(&pw7p15(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;
IF znay(&pw7n15(&k)) = 0 THEN
  IF znay(&pw7p15(&n)) > 0.05 THEN DO;
    write ' Cannibalism' col 64 DISPLAY(&pw7p15(&n)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
IF znay(&pw8n15(&k)) > 0 THEN DO;
  write ' Sudden Death' col 37 DISPLAY(&pw8n15(&k))
  col 50 DISPLAY(&pw8p15(&k)) col 64 DISPLAY(&pw8p15(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;
IF znay(&pw8n15(&k)) = 0 THEN
  IF znay(&pw8p15(&n)) > 0.05 THEN DO;
    write ' Sudden Death' col 64 DISPLAY(&pw8p15(&n)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
IF znay(&pw9n15(&k)) > 0 THEN DO;
  write ' Starvation' col 37 DISPLAY(&pw9n15(&k))
  col 50 DISPLAY(&pw9p15(&k)) col 64 DISPLAY(&pw9p15(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;
IF znay(&pw9n15(&k)) = 0 THEN
  IF znay(&pw9p15(&n)) > 0 THEN DO;
    write ' Starvation' col 64 DISPLAY(&pw9p15(&n)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
IF znay(&pw10n15(&k)) > 0 THEN DO;
  write ' Other' col 37 DISPLAY(&pw10n15(&k))
  col 50 DISPLAY(&pw10p15(&k)) col 64 DISPLAY(&pw10p15(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;
IF znay(&pw10n15(&k)) = 0 THEN
  IF znay(&pw10p15(&n)) > 0.05 THEN DO;
    write ' Other' col 64 DISPLAY(&pw10p15(&n)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
IF znay(&pw11n15(&k)) > 0 THEN DO;
  write ' Unknown' col 37 DISPLAY(&pw11n15(&k))
  col 50 DISPLAY(&pw11p15(&k)) col 64 DISPLAY(&pw11p15(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;
IF znay(&pw11n15(&k)) = 0 THEN
  IF znay(&pw11p15(&n)) > 0.05 THEN DO;
    write ' Unknown' col 64 DISPLAY(&pw11p15(&n)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
DECLARE &tototaln as 9999; DECLARE &tototalp as 999.999;
DECLARE &tototaln as 999.999;
&tototaln = 0; &tototalp = 0; &tototaln = 0;

```



```

IF znv(&cb2n(&k)) > 0 THEN
  write ' Old Age' col 37 DISPLAY(&cb3n(&k))
  col 50 DISPLAY(&cb3p(&k)) col 64 DISPLAY(&cb3p(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(&cb3n(&k)) > 0 THEN DO;
  write ' Old Age' col 37 DISPLAY(&cb3n(&k))
  col 50 DISPLAY(&cb3p(&k)) col 64 DISPLAY(&cb3p(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(&cb3p(&n)) > 0 THEN DO;
  write ' Old Age' col 64 DISPLAY(&cb3p(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(&cbbn(&k)) > 0 THEN DO;
  write ' Thin/Unthrifty' col 37 DISPLAY(&cbbn(&k))
  col 50 DISPLAY(&cbbp(&k)) col 64 DISPLAY(&cbbp(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(&cbbn(&k)) > 0 THEN DO;
  write ' Thin/Unthrifty' col 64 DISPLAY(&cbbp(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(&cb5n(&k)) > 0 THEN DO;
  write ' Malitie/Poor Udder' col 37 DISPLAY(&cb5n(&k))
  col 50 DISPLAY(&cb5p(&k)) col 64 DISPLAY(&cb5p(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(&cb5n(&k)) > 0 THEN DO;
  write ' Malitie/Poor Udder' col 64 DISPLAY(&cb5p(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(&cbbn(&k)) > 0 THEN DO;
  write ' Abcess' col 37 DISPLAY(&cbbn(&k))
  col 50 DISPLAY(&cbbp(&k)) col 64 DISPLAY(&cbbp(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(&cbbn(&k)) > 0 THEN DO;
  write ' Abcess' col 64 DISPLAY(&cbbp(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(&cb7n(&k)) > 0 THEN DO;
  write ' Sudden Death' col 37 DISPLAY(&cb7n(&k))
  col 50 DISPLAY(&cb7p(&k)) col 64 DISPLAY(&cb7p(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(&cb7n(&k)) > 0 THEN DO;
  write ' Sudden Death' col 64 DISPLAY(&cb7p(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(&cbbn(&k)) > 0 THEN DO;
  write ' Depopulate' col 37 DISPLAY(&cbbn(&k))
  col 50 DISPLAY(&cbbp(&k)) col 64 DISPLAY(&cbbp(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

```

```

IF znv(&cbbn(&k)) > 0 THEN DO;
  write ' Depopulate' col 64 DISPLAY(&cbbp(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(&cbbn(&k)) > 0 THEN DO;
  write ' Poor Performance' on sumfile;
  write ' of Offspring' col 37 DISPLAY(&cbbn(&k))
  col 50 DISPLAY(&cbbp(&k)) col 64 DISPLAY(&cbbp(&n)) ON sumfile;
  &linecnt = &linecnt + 2;
END;

IF znv(&cbbn(&k)) > 0 THEN DO;
  write ' Poor Performance' on sumfile;
  write ' of Offspring' col 64 DISPLAY(&cbbp(&n)) ON sumfile;
  &linecnt = &linecnt + 2;
END;

IF znv(&cb10n(&k)) > 0 THEN DO;
  write ' Financial' col 37 DISPLAY(&cb10n(&k))
  col 50 DISPLAY(&cb10p(&k)) col 64 DISPLAY(&cb10p(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(&cb10n(&k)) > 0 THEN DO;
  write ' Financial' col 64 DISPLAY(&cb10p(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(&cb11n(&k)) > 0 THEN DO;
  write ' Other' col 37 DISPLAY(&cb11n(&k))
  col 50 DISPLAY(&cb11p(&k)) col 64 DISPLAY(&cb11p(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(&cb11n(&k)) > 0 THEN DO;
  write ' Other' col 64 DISPLAY(&cb11p(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(&cb12n(&k)) > 0 THEN DO;
  write ' Unknown' col 37 DISPLAY(&cb12n(&k))
  col 50 DISPLAY(&cb12p(&k)) col 64 DISPLAY(&cb12p(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(&cb12n(&k)) > 0 THEN DO;
  write ' Unknown' col 64 DISPLAY(&cb12p(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

write ' ' on sumfile;
write 'SOU DEATH SUMMARY' on sumfile;
write '-----' on sumfile;
&linecnt = &linecnt + 3;

IF znv(&bbn(&k)) > 0 THEN DO;
  write ' Reproductive Prob.' col 37 DISPLAY(&bbn(&k))
  col 50 DISPLAY(&bbp(&k)) col 64 DISPLAY(&bbp(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(&bbn(&k)) > 0 THEN DO;
  write ' Reproductive Prob.' col 64 DISPLAY(&bbp(&n)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

```

```

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IF znv(ab2n(ek)) > 0 THEN DO;
  write 'Lameness/injury/down' col 37 DISPLAY(ab2n(ek))
  col 50 DISPLAY(ab2p(ek)) col 64 DISPLAY(ab2p(en)) OM sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(ab2n(ek)) = 0 THEN
  IF znv(ab2p(en)) > 0.05 THEN DO;
    write 'Lameness/injury/down' col 64 DISPLAY(ab2p(en)) OM sumfile;
    &linecnt = &linecnt + 1;
  END;

IF znv(ab3n(ek)) > 0 THEN DO;
  write 'Old Age' col 37 DISPLAY(ab3n(ek))
  col 50 DISPLAY(ab3p(ek)) col 64 DISPLAY(ab3p(en)) OM sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(ab3n(ek)) = 0 THEN
  IF znv(ab3p(en)) > 0.05 THEN DO;
    write 'Old Age' col 64 DISPLAY(ab3p(en)) OM sumfile;
    &linecnt = &linecnt + 1;
  END;

IF znv(ab4n(ek)) > 0 THEN DO;
  write 'Thin/Unthrifty' col 37 DISPLAY(ab4n(ek))
  col 50 DISPLAY(ab4p(ek)) col 64 DISPLAY(ab4p(en)) OM sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(ab4n(ek)) = 0 THEN
  IF znv(ab4p(en)) > 0.05 THEN DO;
    write 'Thin/Unthrifty' col 64 DISPLAY(ab4p(en)) OM sumfile;
    &linecnt = &linecnt + 1;
  END;

IF znv(ab5n(ek)) > 0 THEN DO;
  write 'Mastitis/Poor Udder' col 37 DISPLAY(ab5n(ek))
  col 50 DISPLAY(ab5p(ek)) col 64 DISPLAY(ab5p(en)) OM sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(ab5n(ek)) = 0 THEN
  IF znv(ab5p(en)) > 0.05 THEN DO;
    write 'Mastitis/Poor Udder' col 64 DISPLAY(ab5p(en)) OM sumfile;
    &linecnt = &linecnt + 1;
  END;

IF znv(ab6n(ek)) > 0 THEN DO;
  write 'Abcess' col 37 DISPLAY(ab6n(ek))
  col 50 DISPLAY(ab6p(ek)) col 64 DISPLAY(ab6p(en)) OM sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(ab6n(ek)) = 0 THEN
  IF znv(ab6p(en)) > 0.05 THEN DO;
    write 'Abcess' col 64 DISPLAY(ab6p(en)) OM sumfile;
    &linecnt = &linecnt + 1;
  END;

IF znv(ab7n(ek)) > 0 THEN DO;
  write 'Sudden Death' col 37 DISPLAY(ab7n(ek))
  col 50 DISPLAY(ab7p(ek)) col 64 DISPLAY(ab7p(en)) OM sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(ab7n(ek)) = 0 THEN
  IF znv(ab7p(en)) > 0.05 THEN DO;
    write 'Sudden Death' col 64 DISPLAY(ab7p(en)) OM sumfile;
    &linecnt = &linecnt + 1;
  END;

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IF znv(ab8n(ek)) > 0 THEN DO;
  write 'Depopulate' col 37 DISPLAY(ab8n(ek))
  col 50 DISPLAY(ab8p(ek)) col 64 DISPLAY(ab8p(en)) OM sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(ab8n(ek)) = 0 THEN
  IF znv(ab8p(en)) > 0.05 THEN DO;
    write 'Depopulate' col 64 DISPLAY(ab8p(en)) OM sumfile;
    &linecnt = &linecnt + 1;
  END;

IF znv(ab9n(ek)) > 0 THEN DO;
  write 'Poor Performance' on sumfile;
  write 'of Offspring' col 37 DISPLAY(ab9n(ek))
  col 50 DISPLAY(ab9p(ek)) col 64 DISPLAY(ab9p(en)) OM sumfile;
  &linecnt = &linecnt + 2;
END;

IF znv(ab9n(ek)) = 0 THEN
  IF znv(ab9p(en)) > 0.05 THEN DO;
    write 'Poor Performance' on sumfile;
    write 'of Offspring' col 64 DISPLAY(ab9p(en)) OM sumfile;
    &linecnt = &linecnt + 2;
  END;

IF znv(ab10n(ek)) > 0 THEN DO;
  write 'Financial' col 37 DISPLAY(ab10n(ek))
  col 50 DISPLAY(ab10p(ek)) col 64 DISPLAY(ab10p(en)) OM sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(ab10n(ek)) = 0 THEN
  IF znv(ab10p(en)) > 0.05 THEN DO;
    write 'Financial' col 64 DISPLAY(ab10p(en)) OM sumfile;
    &linecnt = &linecnt + 1;
  END;

IF znv(ab11n(ek)) > 0 THEN DO;
  write 'Other' col 37 DISPLAY(ab11n(ek))
  col 50 DISPLAY(ab11p(ek)) col 64 DISPLAY(ab11p(en)) OM sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(ab11n(ek)) = 0 THEN
  IF znv(ab11p(en)) > 0.05 THEN DO;
    write 'Other' col 64 DISPLAY(ab11p(en)) OM sumfile;
    &linecnt = &linecnt + 1;
  END;

IF znv(ab12n(ek)) > 0 THEN DO;
  write 'Unknown' col 37 DISPLAY(ab12n(ek))
  col 50 DISPLAY(ab12p(ek)) col 64 DISPLAY(ab12p(en)) OM sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(ab12n(ek)) = 0 THEN
  IF znv(ab12p(en)) > 0.05 THEN DO;
    write 'Unknown' col 64 DISPLAY(ab12p(en)) OM sumfile;
    &linecnt = &linecnt + 1;
  END;

/* .....
write ' ' on sumfile;
write 'Boars' on sumfile;
&linecnt = &linecnt + 2;
IF znv(ab13n(ek)) > 0 THEN DO;
  write 'Reproductive Prob.' col 37 DISPLAY(ab13n(ek))
  col 50 DISPLAY(ab13p(ek)) col 64 DISPLAY(ab13p(en)) OM sumfile;
  &linecnt = &linecnt + 1;

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```

END;
IF znv(abb1n(ek)) = 0 THEN
  IF znv(abb1p(ek)) > 0.05 THEN DO;
    write ' Reproductive Prob.' col 64 DISPLAY(abb1p(ek)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

IF znv(abb2n(ek)) > 0 THEN DO;
  write ' Lameess/injury/Down' col 37 DISPLAY(abb2n(ek))
  col 50 DISPLAY(abb2p(ek)) col 64 DISPLAY(abb2p(ek)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(abb2n(ek)) = 0 THEN
  IF znv(abb2p(ek)) > 0.05 THEN DO;
    write ' Lameess/injury/Down' col 64 DISPLAY(abb2p(ek)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

IF znv(abb3n(ek)) > 0 THEN DO;
  write ' Old Age' col 37 DISPLAY(abb3n(ek))
  col 50 DISPLAY(abb3p(ek)) col 64 DISPLAY(abb3p(ek)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(abb3n(ek)) = 0 THEN
  IF znv(abb3p(ek)) > 0.05 THEN DO;
    write ' Old Age' col 64 DISPLAY(abb3p(ek)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

IF znv(abb4n(ek)) > 0 THEN DO;
  write ' Thin/Unthrifty' col 37 DISPLAY(abb4n(ek))
  col 50 DISPLAY(abb4p(ek)) col 64 DISPLAY(abb4p(ek)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(abb4n(ek)) = 0 THEN
  IF znv(abb4p(ek)) > 0.05 THEN DO;
    write ' Thin/Unthrifty' col 64 DISPLAY(abb4p(ek)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

IF znv(abb5n(ek)) > 0 THEN DO;
  write ' Mastitis/Poor Udder' col 37 DISPLAY(abb5n(ek))
  col 50 DISPLAY(abb5p(ek)) col 64 DISPLAY(abb5p(ek)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(abb5n(ek)) = 0 THEN
  IF znv(abb5p(ek)) > 0.05 THEN DO;
    write ' Mastitis/Poor Udder' col 64 DISPLAY(abb5p(ek)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

IF znv(abb6n(ek)) > 0 THEN DO;
  write ' Abcess' col 37 DISPLAY(abb6n(ek))
  col 50 DISPLAY(abb6p(ek)) col 64 DISPLAY(abb6p(ek)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(abb6n(ek)) = 0 THEN
  IF znv(abb6p(ek)) > 0.05 THEN DO;
    write ' Abcess' col 64 DISPLAY(abb6p(ek)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

IF znv(abb7n(ek)) > 0 THEN DO;
  write ' Sudden Death' col 37 DISPLAY(abb7n(ek))
  col 50 DISPLAY(abb7p(ek)) col 64 DISPLAY(abb7p(ek)) ON sumfile;
  &linecnt = &linecnt + 1;

```

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```

END;
IF znv(abb7n(ek)) = 0 THEN
  IF znv(abb7p(ek)) > 0.05 THEN DO;
    write ' Sudden Death' col 64 DISPLAY(abb7p(ek)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

IF znv(abb8n(ek)) > 0 THEN DO;
  write ' Depopulate' col 37 DISPLAY(abb8n(ek))
  col 50 DISPLAY(abb8p(ek)) col 64 DISPLAY(abb8p(ek)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(abb8n(ek)) = 0 THEN
  IF znv(abb8p(ek)) > 0.05 THEN DO;
    write ' Depopulate' col 64 DISPLAY(abb8p(ek)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

IF znv(abb9n(ek)) > 0 THEN DO;
  write ' Poor Performance' col 37 DISPLAY(abb9n(ek))
  col 50 DISPLAY(abb9p(ek)) col 64 DISPLAY(abb9p(ek)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(abb9n(ek)) = 0 THEN
  IF znv(abb9p(ek)) > 0.05 THEN DO;
    write ' Poor Performance' col 64 DISPLAY(abb9p(ek)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

IF znv(abb10n(ek)) > 0 THEN DO;
  write ' Financial' col 37 DISPLAY(abb10n(ek))
  col 50 DISPLAY(abb10p(ek)) col 64 DISPLAY(abb10p(ek)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(abb10n(ek)) = 0 THEN
  IF znv(abb10p(ek)) > 0.05 THEN DO;
    write ' Financial' col 64 DISPLAY(abb10p(ek)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

IF znv(abb11n(ek)) > 0 THEN DO;
  write ' Other' col 37 DISPLAY(abb11n(ek))
  col 50 DISPLAY(abb11p(ek)) col 64 DISPLAY(abb11p(ek)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(abb11n(ek)) = 0 THEN
  IF znv(abb11p(ek)) > 0.05 THEN DO;
    write ' Other' col 64 DISPLAY(abb11p(ek)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

IF znv(abb12n(ek)) > 0 THEN DO;
  write ' Unknown' col 37 DISPLAY(abb12n(ek))
  col 50 DISPLAY(abb12p(ek)) col 64 DISPLAY(abb12p(ek)) ON sumfile;
  &linecnt = &linecnt + 1;
END;

IF znv(abb12n(ek)) = 0 THEN
  IF znv(abb12p(ek)) > 0.05 THEN DO;
    write ' Unknown' col 64 DISPLAY(abb12p(ek)) ON sumfile;
    &linecnt = &linecnt + 1;
  END;
END;

DECLARE &btotals as 9999; DECLARE &btotals as 999.99%;
DECLARE &btotals as 999.99%;
&btotals = 0; &btotals = 0; &btotals = 0;

```

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```

write ' ' on sumfile;
write 'pigs weaned/sow/year' col 40 DISPLAY($pwean_year($k))
col 60 DISPLAY($pwean_year($k)) on sumfile;

write ' ' on sumfile;
write 'pigs produced/sow/year' col 43 DISPLAY($ac_prodp($k))
col 63 DISPLAY($ac_prodp($k)) on sumfile;

write ' ' on sumfile;
write 'pounds marketable pork/sow/year' col 39 DISPLAY($ac_lbsp($k))
col 59 DISPLAY($ac_lbsp($k)) on sumfile;

write ' ' on sumfile;
write 'litters weaned/sow/year' col 40 DISPLAY($lwean_year($k))
col 60 DISPLAY($lwean_year($k)) on sumfile;

write ' ' on sumfile;
write 'pigs produced/crate/year' col 40 DISPLAY($pcrate_yr($k))
col 60 DISPLAY($pcrate_yr($k)) on sumfile;

write ' ' on sumfile;
write 'Annual nursery turnover' col 43 DISPLAY($annurturn($k))
col 63 DISPLAY($annurturn($k)) on sumfile;

write ' ' on sumfile;
write 'Annual grow-finish turnover' col 43 DISPLAY($agfturn($k))
col 63 DISPLAY($agfturn($k)) on sumfile;

write ' ' on sumfile;
write 'Average age at weaning' col 43 DISPLAY($avg_age_wean($k))
col 63 DISPLAY($avg_age_wean($k)) on sumfile;

write ' ' on sumfile;
write 'Average postweaning days-to-market' col 43
DISPLAY($avg_pd_dtm($k)) col 63 DISPLAY($avg_pd_dtm($k)) on sumfile;

write ' ' on sumfile;
write 'Average postweaning pig days-to-market' on sumfile;
write ' (corrected for death loss)' col 43
DISPLAY($avg_pd_dtm($k)) col 63 DISPLAY($avg_pd_dtm($k)) on sumfile;
write ' ' on sumfile;
write 'Whole farm feed efficiency' col 39 DISPLAY($hole_farm_eff($k))
col 59 DISPLAY($hole_farm_eff($k)) on sumfile;

write ' ' on sumfile;

RETURN ;

```

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```

$btotain = $b1p($k)+$b2p($k)+$b3p($k)+$b4p($k)+$b5p($k)+$b6p($k)+
$b7p($k)+$b8p($k)+$b9p($k)+$b10p($k)+$b11p($k)+$b12p($k)+
$b13p($k)+$b14p($k)+$b15p($k)+$b16p($k)+$b17p($k)+$b18p($k)+
$b19p($k)+$b20p($k)+$b21p($k)+$b22p($k)+$b23p($k)+$b24p($k)+
$b25p($k)+$b26p($k)+$b27p($k)+$b28p($k)+$b29p($k)+$b30p($k)+
$b31p($k)+$b32p($k)+$b33p($k)+$b34p($k)+$b35p($k)+$b36p($k)+
$b37p($k)+$b38p($k)+$b39p($k)+$b40p($k)+$b41p($k)+$b42p($k)+
$b43p($k)+$b44p($k)+$b45p($k)+$b46p($k)+$b47p($k)+$b48p($k)+
$b49p($k)+$b50p($k)+$b51p($k)+$b52p($k)+$b53p($k)+$b54p($k)+
$b55p($k)+$b56p($k)+$b57p($k)+$b58p($k)+$b59p($k)+$b60p($k)+
$b61p($k)+$b62p($k)+$b63p($k)+$b64p($k)+$b65p($k)+$b66p($k)+
$b67p($k)+$b68p($k)+$b69p($k)+$b70p($k)+$b71p($k)+$b72p($k)+
$b73p($k)+$b74p($k)+$b75p($k)+$b76p($k)+$b77p($k)+$b78p($k)+
$b79p($k)+$b80p($k)+$b81p($k)+$b82p($k)+$b83p($k)+$b84p($k)+
$b85p($k)+$b86p($k)+$b87p($k)+$b88p($k)+$b89p($k)+$b90p($k)+
$b91p($k)+$b92p($k)+$b93p($k)+$b94p($k)+$b95p($k)+$b96p($k)+
$b97p($k)+$b98p($k)+$b99p($k)+$b100p($k)+$b101p($k)+$b102p($k)+
$b103p($k)+$b104p($k)+$b105p($k)+$b106p($k)+$b107p($k)+$b108p($k)+
$b109p($k)+$b110p($k)+$b111p($k)+$b112p($k)+$b113p($k)+$b114p($k)+
$b115p($k)+$b116p($k)+$b117p($k)+$b118p($k)+$b119p($k)+$b120p($k)+
$b121p($k)+$b122p($k)+$b123p($k)+$b124p($k)+$b125p($k)+$b126p($k)+
$b127p($k)+$b128p($k)+$b129p($k)+$b130p($k)+$b131p($k)+$b132p($k)+
$b133p($k)+$b134p($k)+$b135p($k)+$b136p($k)+$b137p($k)+$b138p($k)+
$b139p($k)+$b140p($k)+$b141p($k)+$b142p($k)+$b143p($k)+$b144p($k)+
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$b1207p($k)+$b1208p($k)+$b1209p($k)+$b1210p($k)+$b1211p($k)+$b1212p($k)+
$b1213p($k)+$b1214p($k)+$b1215p($k)+$b1216p($k)+$b1217p($k)+$b1218p($k)+
$b1219p($k)+$b1220p($k)+$b1221p($k)+$b1222p($k)+$b1223p($k)+$b1224p($k)+
$b1225p($k)+$b1226p($k)+$b1227p($k)+$b1228p($k)+$b1229p($k)+$b1230p($k)+
$b1231p($k)+$b1232p($k)+$b1233p($k)+$b1234p($k)+$b1235p($k)+$b1236p($k)+
$b1237p($k)+$b1238p($k)+$b1239p($k)+$b1240p($k)+$b1241p($k)+$b1242p($k)+
$b1243p($k)+$b1244p($k)+$b1245p($k)+$b1246p($k)+$b1247p($k)+$b1248p($k)+
$b1249p($k)+$b1250p($k)+$b1251p($k)+$b1252p($k)+$b1253p($k)+$b1254p($k)+
$b1255p($k)+$b1256p($k)+$b1257p($k)+$b1258p($k)+$b1259p($k)+$b1260p($k)+
$b1261p($k)+$b1262p($k)+$b1263p($k)+$b1264p($k)+$b1265p($k)+$b1266p($k)+
$b1267p($k)+$b1268p($k)+$b1269p
```

APPENDIX D

APPENDIX D

SHIMS QUARTERLY REPORT

FARM CODE: 5728

10/01/87 - 12/31/87

Page 1

	End Current <u>Period</u>	Rolling Quarterly <u>Average</u>	Current SHIMS <u>Average</u>
<u>INVENTORIES</u>			
Gestating Females	422	405	267
Lactating Females	88	88	67
Open Sows	0	0	3
Cull Sows	0	14	8
Open Gilts	7	111	3
Boars	58	62	36
Pre-weaned Pigs	673	734	618
Pre-nursery Pigs	0	0	0
Nursery Pigs	907	763	615
Grower Pigs	795	677	518
Finisher Pigs	2,219	2,336	1,434
<u>REPRODUCTIVE EFFICIENCY MEASURES</u>			
1. Pounds Marketable Pork Produced			
a. Per Quarter	598,780.00	507,733.00	339,983.33
b. Per Female	1,018.33	821.95	868.04
c. Per Litter	2,123.33	1,767.56	1,749.49
2. Pigs Produced			
a. Per Quarter	2,652.00	2,606.25	1,513.00
b. Per Female	4.51	4.22	3.86
c. Per Litter	9.40	9.07	7.79
3. Pigs Born			
a. Per Quarter	3,042.00	3,194.50	2,081.00
b. Per Female	5.17	5.17	5.31
c. Per Litter	10.79	11.12	10.71
4. Pigs Born Live			
a. Per Quarter	2,856.00	2,980.75	1,937.67
b. Per Female	4.86	4.83	4.95
c. Per Litter	10.13	10.38	9.97
5. Pigs Weaned			
a. Per Quarter	2,639.00	2,567.25	1,785.00
b. Per Female	4.49	4.16	4.56
c. Per Litter	9.36	8.94	9.19
6. Litters Weaned			
a. Per Quarter	245.00	236.00	185.33
b. Per Female	0.42	0.38	0.47
7. Total Female/Boar Ratio	8.98	9.92	10.98

SHIMS QUARTERLY REPORT - Page 2

FARM CODE: 5728

10/01/87 - 12/31/87

	<u>Current Period</u>	<u>Rolling Quarterly Average</u>	<u>Current SHIMS Average</u>
<u>EFFICIENCY IN FEED USAGE</u>			
1. Lactation			
Average lbs/female/day	8.99	9.49	5.53
Total lbs fed	72,000	76,000	33,685
2. Gestation			
Average lbs/female/day	11.18	10.04	6.99
Total lbs fed	418,015	370,012	169,825
3. Starter			
Average lbs/pig/day	0.35	0.58	0.31
Total lbs fed	24,012	38,503	17,509
4. Nursery			
Average lbs/pig/day	2.37	2.44	1.45
Total lbs fed	173,049	169,512	81,203
5. Grower			
Average lbs/pig/day	2.23	1.89	2.29
Total lbs fed	143,000	116,250	108,050
6. Finisher			
Average lbs/pig/day	7.26	5.97	4.02
Total lbs fed	1,542,612	1,269,670	524,121
<u>EFFICIENCY IN FACILITY USAGE</u>			
1. Litters Farrowed/Crate	3.20	3.26	3.04
2. Pigs Weaned / Crate	29.99	29.17	27.89
3. Nursery Turnover	2.23	2.17	1.72
4. Grower to Finisher Turnover	0.65	0.55	0.65

SHIMS QUARTERLY REPORT - Page 3

FARMCODE: 5728

10/01/87 - 12/31/87

<u>MARKETING MEASURES</u>	<u>Current Period</u>	<u>Rolling Quarterly Average</u>	<u>Current SHIMS Average</u>
1. Market Hogs Sold			
a. Number Sold	2,457.00	2,050.50	1,243.33
b. Average Market Weight	239.16	232.30	240.05
c. Sales Price Per Cwt	43.53	50.41	43.14
d. Marketing Costs Per Cwt	0.00	0.00	0.00
2. Feeder Pigs Sold			
a. Number Sold	100.00	214.25	225.33
b. Average Market Weight	29.00	43.22	48.40
c. Sales Price Per Cwt	156.66	120.59	98.16
d. Marketing Costs Per Cwt	0.00	0.00	0.00
3. Underweight Market Hogs Sold			
a. Number Sold	2.00	2.50	0.67
b. Average Market Weight	150.00	114.00	149.25
c. Sales Price Per Cwt	49.67	37.63	49.67
d. Marketing Costs Per Cwt	0.00	0.00	0.00
4. Cull Sows Sold			
a. Number Sold	72.00	76.50	70.00
b. Average Market Weight	486.60	465.44	439.74
c. Sales Price Per Cwt	40.87	41.03	35.38
d. Marketing Costs Per Cwt	0.00	0.00	0.00
5. Cull Boars Sold			
a. Number Sold	2.00	8.50	3.33
b. Average Market Weight	557.50	397.50	370.37
c. Sales Price Per Cwt	27.98	35.72	42.08
d. Marketing Costs Per Cwt	0.00	0.00	0.00
6. Boars Sold for Replacement			
a. Number Sold	0.00	0.00	0.00
b. Average market Weight	0.00	0.00	0.00
c. Sales Price Per Cwt	0.00	0.00	0.00
d. Marketing Costs Per Cwt	0.00	0.00	0.00
7. Open Gilts Sold for Replacement			
a. Number Sold	30.00	29.00	10.33
b. Average Market Weight	276.67	251.12	277.19
c. Sales Price Per Cwt	54.96	62.24	54.27
d. Marketing Costs Per Cwt	0.00	0.00	0.00
8. Bred Gilts Sold for Replacement			
a. Number Sold	0.00	0.00	0.00
b. Average Market Weight	0.00	0.00	0.00
c. Sales Price Per Cwt	0.00	0.00	0.00
d. Marketing Costs Per Cwt	0.00	0.00	0.00

SHIMS QUARTERLY REPORT - Page 4

FARMCODE: 5728

10/01/87 - 12/31/87

<u>CASH EXPENSES PER CWT PORK</u>	<u>Current Period</u>	<u>Rolling Quarterly Average</u>	<u>Current SHIMS Average</u>
Purchased feed expense	13.87	11.95	17.41
Non-feed expenses			
1. Repairs and Maintenance	1.61	0.77	1.35
2. Veterinary care & drugs	0.30	0.34	0.57
3. Labor	3.42	2.85	2.40
4. Supplies	0.20	0.14	0.12
5. Fuel	0.35	0.32	0.25
6. Electricity	1.21	0.83	0.82
7. Telephone	0.00	0.00	0.02
8. Trucking	0.02	0.02	0.01
9. Marketing	0.42	0.43	0.52
10. Insurance	0.36	0.35	0.31
11. Interest	0.81	1.66	1.06
12. Taxes	0.11	0.29	0.06
13. Replacement females	0.00	0.00	0.00
14. Replacement boars	0.00	0.00	0.00
15. Other Expenses	<u>1.85</u>	<u>3.28</u>	<u>1.13</u>
Total Non-Feed Expense	10.66	11.28	8.62

SHIMS QUARTERLY REPORT - Page 5

FARMCODE: 5728

10/01/87 - 12/31/87

SLAUGHTER CHECK RESULTS

DATE:	Current Period 11/03/87		Rolling Quarter Total		Current SHIMS Total	
	# PIGS	PERCENT	# PIGS	PERCENT	# PIGS	PERCENT
<u>PNEUMONIA</u>						
none	26	43.33%	109	42.58%	166	25.00%
mild	32	53.33%	131	51.17%	340	51.20%
moderate	2	3.33%	14	5.47%	90	13.55%
severe	<u>0</u>	0.00%	<u>2</u>	0.78%	<u>68</u>	10.24%
TOTALS	60		256		664	
Pleuritis	1	1.67%	2	0.78%	10	1.51%
Pericard.	0	0.00%	0	0.00%	2	0.30%
<u>LIVER SCARS</u>						
none	56	93.33%	238	92.97%	596	89.49%
mild	4	6.67%	15	5.86%	47	7.06%
moderate	0	0.00%	3	1.17%	9	1.35%
severe	<u>0</u>	0.00%	<u>0</u>	0.00%	<u>14</u>	2.10%
TOTALS	60		256		666	
<u>MANGE</u>						
none	44	100.00%	394	98.25%	475	95.57%
mild	0	0.00%	6	1.50%	15	3.02%
moderate	0	0.00%	1	0.25%	3	0.60%
severe	<u>0</u>	0.00%	<u>0</u>	0.00%	<u>4</u>	0.80%
TOTALS	44		401		497	
<u>RHINITIS</u>						
none	36	81.82%	114	85.71%	180	57.14%
mild	7	15.91%	15	11.28%	86	27.30%
moderate	0	0.00%	2	1.50%	35	11.11%
severe	<u>1</u>	2.27%	<u>2</u>	1.50%	<u>14</u>	4.44%
TOTALS	44		133		315	
Sep. Dev.	1	2.27%	17	12.78%	51	16.19%
<u>TATTOO LEGIBILITY</u>						
good	44	100.00%	400	99.75%	474	95.37%
marginal	0	0.00%	1	0.25%	18	3.62%
illegible	<u>0</u>	0.00%	<u>0</u>	0.00%	<u>5</u>	1.01%
TOTALS	44		401		497	

SHIMS QUARTERLY REPORT - Page 6

FARMCODE: 5728

10/01/87 - 12/31/87

PIG MORTALITY SUMMARY

	<u>Number</u>	<u>Herd %*</u>	<u>SHIMS %*</u>
STILLBORN	138	4.54%	5.24%
MUMMIES	48	1.58%	1.67%
PREWEANED PIG DEATHS			
Crushed	105	4.63%	9.01%
Deformed	52	2.29%	7.23%
Scours	21	0.93%	3.61%
Starved	85	3.75%	4.59%
Sudden	64	2.82%	4.69%
Weak	63	2.78%	3.40%
Other	33	1.46%	2.32%
TOTAL	609	24.78%	41.76%
WEANED PIG DEATHS			
Pre-Nursery Weaned Pigs			
Chronic Poor Doer	1	0.00%	0.00%
Other	1	0.00%	0.00%
Nursery Pigs			
Pneumonia	2	0.08%	0.05%
Scours	1	0.04%	0.00%
Chronic Poor Doer	16	0.66%	0.27%
Sudden Death	2	0.08%	0.05%
Other	8	0.33%	0.16%
Unknown	17	0.71%	1.14%
Grower Pigs			
Injury	1	0.05%	0.00%
Abscess	5	0.24%	0.13%
Other	5	0.24%	0.13%
Unknown	1	0.05%	0.77%
Finisher Pigs			
Pneumonia	1	0.01%	0.00%
Lameness	2	0.03%	0.02%
Abscess	5	0.07%	0.05%
Chronic Poor Doer	1	0.01%	0.02%
Sudden Death	2	0.03%	0.02%
Other	19	0.27%	0.14%
Unknown	4	0.06%	0.65%
TOTAL	94	2.96%	3.60%

* Monthly Deaths as % of Average Inventory

SHIMS QUARTERLY REPORT - Page 7

FARMCODE: 5728

10/01/87 - 12/31/87

BREEDING HERD REMOVALS

	<u>Number</u>	<u>Herd Percent*</u>	<u>SHIMS Percent*</u>
<u>SOW REMOVALS</u>			
Culls	72	4.08%	5.96%
Deaths	<u>1</u>	<u>0.06%</u>	<u>0.26%</u>
TOTAL	73	4.14%	6.22%

BOAR REMOVALS

Culls	2	1.02%	3.11%
Deaths	<u>0</u>	<u>0.00%</u>	<u>0.00%</u>
TOTAL	2	1.02%	3.11%

	<u>Number</u>	<u>Herd Percent**</u>	<u>SHIMS Percent**</u>
<u>SOW CULL SUMMARY</u>			
Reproductive Prob.	12	23.53%	29.75%
Lameness/Injury/Down	8	15.69%	6.01%
Old Age	20	39.22%	10.44%
Thin/Unthrifty			4.43%
Mastitis/Poor Udder	3	5.88%	2.22%
Abscess	1	1.96%	0.32%
Poor Performance of Offspring	4	7.84%	45.89%
Other	2	3.92%	0.63%
Unknown	1	1.96%	0.32%

SOW DEATH SUMMARY

Lameness/Injury/Down			66.67%
Unknown	1	100.00%	33.33%

* Monthly Removals as % of Average Inventory

** Percent of Total Removals

SHIMS QUARTERLY REPORT - Page 8

FARMCODE: 5728

10/01/87 - 12/31/87

Summary Table - Annual Measures

Number of Quarters: 4	<u>Farm</u>	<u>SHIMS</u>
Pigs born/sow/year	20.68	21.26
Pigs born live/sow/year	19.32	19.60
Pigs weaned/sow/year	16.64	16.97
Pigs produced/sow/year	16.88	15.74
Pounds marketable pork/sow/year	3,287.80	3,247.03
Litters weaned/sow/year	1.52	1.74
Pigs produced/crate/year	118.47	97.27
Annual nursery turnover	8.68	6.49
Annual grow-finish turnover	2.20	2.46
Whole farm feed efficiency	4.02	2.11

APPENDIX E

APPENDIX E

SWINE HEALTH INFORMATION MANAGEMENT SYSTEM VARIABLE COST ESTIMATIONS

A. Initial visit—dollars/farm

1. personnel

2.5 hours travel
+ 2.5 hours on farm
5.0 hours total

5.0 hours * \$20.00/hour = \$100.00

2. travel

120 miles * \$0.22/mile = \$26.40

3. forms

30 pages * \$0.05/page = \$1.50

4. data entry (approximately 1081 individual data items per farm per initial visit)

labor: 0.25 hours * \$6.00/hour = \$1.50
computer time: 0.25 hours * \$1.30/hour = \$0.33
total = \$1.83

5. data storage

12 months * \$0.20/month = \$2.40

B. On-farm data collection—dollars/farm/year

1. producer time

2 hours/month * 12 months * \$5.00/hour = \$120.00

2. forms

5 pages/month * 12 months * \$0.05/page = \$3.00

3. data entry (approximately 8640 individual data items per farm per year)

labor:
1/6 hour/month * 12 months * \$6.00/hour = \$12.00
computer time:
1/6 hour/month * 12 months * \$1.30/hour = \$ 2.60
total = \$14.60

4. data storage

$$\begin{aligned}
 \$0.05/\text{month} * 12 \text{ months} &= \$0.60 \\
 \$0.05/\text{month} * 11 \text{ months} &= \$0.55 \\
 \$0.05/\text{month} * 10 \text{ months} &= \$0.50 \\
 \$0.05/\text{month} * 9 \text{ months} &= \$0.45 \\
 \$0.05/\text{month} * 8 \text{ months} &= \$0.40 \\
 \$0.05/\text{month} * 7 \text{ months} &= \$0.35 \\
 \$0.05/\text{month} * 6 \text{ months} &= \$0.30 \\
 \$0.05/\text{month} * 5 \text{ months} &= \$0.25 \\
 \$0.05/\text{month} * 4 \text{ months} &= \$0.20 \\
 \$0.05/\text{month} * 3 \text{ months} &= \$0.15 \\
 \$0.05/\text{month} * 2 \text{ months} &= \$0.10 \\
 \$0.05/\text{month} * 1 \text{ months} &= \underline{\$0.05} \\
 \text{total} &= \$3.90
 \end{aligned}$$

C. Slaughter health checks—estimated average costs for one health check per farm per quarter in dollars/farm/year (one check ranges from 100 to 240 pigs).

1. personnel

$$4 \text{ hours/quarter} * 4 \text{ quarters} * \$15.00/\text{hour} = \$240.00$$

2. travel

$$80 \text{ miles/quarter} * 4 \text{ quarters} * \$0.22/\text{mile} = \$70.40$$

3. forms

$$5 \text{ pages/quarter} * 4 \text{ quarters} * \$0.05/\text{page} = \$1.00$$

4. administration

telephone:

$$5 \text{ calls/quarter} * 4 \text{ quarters} * \$2.00/\text{call} = \$40.00$$

labor:

$$0.25 \text{ hours/quarter} * 4 \text{ quarters} * \$15.00/\text{hour} = \underline{\$15.00}$$

$$\text{total} = \$55.00$$

5. report

labor and data entry (approximately 26 individual data elements per farm per slaughter health check):

$$1 \text{ hour/quarter} * 4 \text{ quarters} * \$15.00/\text{hour} = \$60.00$$

computer time:

$$\$1.00/\text{quarter} * 4 \text{ quarters} = \$4.00$$

postage:

$$\$0.22/\text{quarter} * 4 \text{ quarters} = \$0.88$$

forms:

$$2 \text{ pages/quarter} * 4 \text{ quarters} * \$0.05/\text{page} = \underline{\$0.40}$$

$$\text{total} = \$65.28$$

D. Quarterly report—dollars/farm/year

1. personnel

$$1/6 \text{ hour/quarter} * 4 \text{ quarters} * \$6.00/\text{hour} = \$ 4.00$$

2. computer

connect and computation:

$$\$3.02/\text{quarter} * 4 \text{ quarters} = \$12.08$$

printing:

$$\$0.19/\text{quarter} * 4 \text{ quarters} = \underline{\$ 0.76}$$

$$\text{total} = \$12.84$$

3. mailing

labor:

$$1/12 \text{ hour/quarter} * 4 \text{ quarters} * \$6.00/\text{hour} = \$2.00$$

postage:

$$\$0.22/\text{quarter} * 4 \text{ quarters} = \underline{\$0.88}$$

$$\text{total} = \$2.88$$

APPENDIX F

APPENDIX F

```

File: C:\UTIL\SMIMS.SIM      02/10/1989  18:00  --  Page: 002

' The following section initializes the space-effect variables
SpEff = 0
SPP = SOM(11) / RNE(11)
CALL SPACE(11, SPP, SpEff)
BotSpEff = .005 * SpEff
TopSpEff = 1.115 * SpEff
IF IRAND = 0 THEN
    SpEff(11) = SpEff
ELSE CALL TRIDIST(BotSpEff, SpEff, TopSpEff, SpEffY(11))
END IF
SpEffY(11) = SpEffY(11)

' calculate total beginning MGF Inventory
TotInv0 = TotInv0 + MB(11)

' calculate total ending MGF Inventory
TotInvE = TotInvE + RNE(11)

' calculate total MGF deaths
MToDth = MToDth + MOTH0(11)

FOR I23 = 1 TO 5
    DPA(11, I23) = FAP(11, I23) - FAC(11, I23)
NEXT I23

NEXT I1

DTot = TotInv0 - TotInvE 'calculates the change in total MGF Inventory
MADO = ME(4) - MB(4) - MPUR + MBMD + MBMC 'calculates glts added to herd
Theta = MADO - MToDth - MToMkt - MToDth + DTot - MPPO - MADO

' Theta is the difference between observed and calculated pigs in the
' system. It is an indicator of errors in the data and will be used
' as a warning flag when it exceeds 3% of the ending observed inventory.
CritTheta = TotInvE * .03

IF Theta > CritTheta THEN
    IF MONTE = 1 THEN
        PRINT "WARNING: CALCULATIONS INDICATE DATA INCONSISTENCY WHICH EXCEEDS"
        PRINT " 3% OF THE TOTAL ENDING INVENTORY. THIS SITUATION IS LIKELY TO"
        PRINT "  ADVERSELY AFFECT THE QUALITY OF THE SIMULATION RESULTS."
    END IF
END IF

' The following IF sets the projected pericarditis rate equal to the amount
' that the projected pericarditis rate exceeds the projected pleuritis rate.
IF DRP(14) >= DRP(13) THEN
    DRP(14) = DRP(14) - DRP(13)
ELSE DRP(14) = 0
END IF

' The following IF sets the projected septal deviation rate equal to the
' amount that the projected septal deviation rate exceeds the projected
' total rhinitis rate.
TEMPDRP = DRP(10) + DRP(11) + DRP(12)
IF DRP(15) >= TEMPDRP THEN
    DRP(15) = DRP(15) - TEMPDRP
ELSE DRP(15) = 0
END IF

' The following IF sets the observed pericarditis rate equal to the amount
' that the observed pericarditis rate exceeds the observed pleuritis rate.

```

```

File: C:\UTIL\SMIMS.SIM      02/10/1989  18:00  --  Page: 001

***** MONTE CARLO PROGRAM FOR MGF SIMULATION *****
***** INITIALIZATION *****

'SINGLE: 'INIT.B1'
K = 40

REDIM QTV(K) AS SINGLE, RMUR(LMUR) AS SINGLE, RGRO(LGRO) AS SINGLE

IRAND = IRAND2
IPD = 1
TotInv0 = 0
TotInvE = 0
' calculate number of groups to mean in next quarter
MGPPSWP = INT((MTTP + KDay(3)) / LPool(3))
TTimeFin = DELAY + (LPool(1) / 2) 'calculates total time in finisher phase
FOR I3 = 1 TO 3
    TOTTHSIM(I3) = 0
    RNE(I3) = CSNG(ME(I3))
    ' calculate number of deaths per iteration
    DthIP(13) = (RNDTNP(13) / MTTP) / IPD
    ROUT(I3) = 0
    PIGDAYS(I3) = 0
NEXT I3

DthPPUR = DthIP(13) * IPD
DthPPGO = DthIP(2) * IPD
' initialize discrete delays
FOR I30 = 1 TO LMUR
    RMUR(I30) = 0
NEXT I30

FOR I31 = 1 TO LGRO
    RGRO(I31) = 0
NEXT I31

RMURGRP = LMUR / LPool(3)
RMURUM = RNE(3) / RMURGRP

FOR I32 = 1 TO RMURGRP
    RMUR(KDay(3) + ((I32 - 1) * (LPool(3)))) = RMURUM
NEXT I32

MGROGRP = LGRO / LPool(2)
RGROUM = RNE(2) / MGROGRP

FOR I33 = 1 TO MGROGRP
    RGRO(KDay(2) + ((I33 - 1) * (LPool(2)))) = RGROUM
NEXT I33

PoolM = (KDay(1) / LPool(1)) * (RNE(1) * ((LPool(1) / 2) / TTimeFin))
DLINE = RNE(1) - PoolM
FOR I2 = 1 TO K
    ' initialize intermediate finisher DELAY storages
    QTV(I2) = DLINE / K
NEXT I2

FOR I1 = 1 TO 3

```

```

File: C:\UTIL\SHIMS.SIM                                02/10/1989  18:01  -- Page: 004

FOR I10 = 1 TO 3
  DADG(I10) = ABS((SPECFF(I10) - SPECFF(I10))) * -.01
  IF (SPECFF(I10) - SPECFF(I10)) > 0 THEN DADG(I10) = (1 / (1 + DADG(I10)
-----)) - 1
  'TRANSFORMATION OF PROPORTION IF SPACE IS INCREASING
  DADG(I10) = -(DADG(I10) / (1 + DADG(I10)))
FOR I11 = 1 TO 15
  IF IRAND = 0 THEN
    DCur(I10, I11) = DAVE(I10, I11)
  ELSE CALL TRIDIST(DLOC(I10, I11), DAVE(I10, I11), DHI(I10, I11), DCur(I1
-----> 0, I11))
  END IF
  NEXT I11
NEXT I10

IF NOELSOURCE = 2 THEN
  CALL DelMODDOR(I), DCur(I), DELAY, LPool(I), DADG(I), LMUR, LGRO, FAddadJ(I))
END IF

CALL OCTDEL(RIM(3), ROUT(3), RMUR(3), LMUR, DthPOPUR, RME(3))
TOTDTHSIM(3) = TOTDTHSIM(3) + DthPOPUR
RME(3) = 0
FOR I36 = 1 TO LMUR
  RME(3) = RME(3) + RMUR(I36)
NEXT I36
PIGDAYS(3) = PIGDAYS(3) + RME(3)
RIM(2) = ROUT(3)
IF ROUT(3) > 0 THEN
  NPIGSGOLD = NPIGSGOLD + NPPS(IU)
  RIM(2) = ROUT(3) - NPPS(IU)
END IF
CALL OCTDEL(RIM(2), ROUT(2), RGRO(I), LGRO, DthPOPGR, RME(2))
TOTDTHSIM(2) = TOTDTHSIM(2) + DthPOPGR
RME(2) = 0
FOR I35 = 1 TO LGRO
  RME(2) = RME(2) + RGRO(I35)
NEXT I35
PIGDAYS(2) = PIGDAYS(2) + RME(2)
RIM(1) = ROUT(2)
19 = 0
DO WHILE 19 < IPO
  19 = 19 + 1
  DelDth = DthP1P(1) * DelME / (DelME + PoolH)
  PoolDth = DthP1P(1) * PoolH / (DelME + PoolH)
  CALL DELTV(RIM(1), ROUT(1), QTV(1), DelME, DelDth, DELAY, SDt, K)
  TOTDTHSIM(1) = TOTDTHSIM(1) + DelDth + PoolDth
  PoolH = PoolH - PoolDth + (ROUT(1) * SDt)
  RME(1) = PoolH + DelME
  PIGDAYS(1) = PIGDAYS(1) + (RME(1) * SDt)
LOOP
19
IF KDay(1) = LPool(1) THEN

```

```

File: C:\UTIL\SHIMS.SIM                                02/10/1989  18:00  -- Page: 003

IF DROX(14) >= DROX(13) THEN
  DROX(14) = DROX(14) - DROX(13)
ELSE DROX(14) = 0
END IF

'The following IF sets the observed septal deviation rate equal to the
'amount that the observed septal deviation rate exceeds the observed
'total rhinitis rate.
TEMPOR = DROX(10) + DROX(11) + DROX(12)
IF DROX(15) >= TEMPOR THEN
  DROX(15) = DROX(15) - TEMPOR
ELSE DROX(15) = 0
END IF

FOR I6 = 1 TO 15
  DOR(I6) = (DOR(I6) - DROX(I6)) / (NITP * IPO)
NEXT I6

'The following section distributes the projected feeder pig sales and
'pigs weaned over the upcoming quarter.
NTPPS = 0
NTPU = 0
FOR IGU = 1 TO (NGRpslwp - 1)
  NPPS(IGU) = CLING(NPP / NGRpslwp)
  NPU(IGU) = CLING(LMUR / NGRpslwp)
  NTPPS = NTPPS + NPPS(IGU)
  NTPU = NTPU + NPU(IGU)
NEXT IGU
NPPS(NGRpslwp) = NPPP - NTPPS
NPU(NGRpslwp) = LMUR - NTPU
IU = 0
17 = 0
MEANED = 0
NPIGSGOLD = 0
THOSSOLD = 0
SDt = 1 / IPO
DO WHILE 17 < NITP
  17 = 17 + 1
  'update counters
  LOCATE 12, 44: PRINT 17
  THISTIME = TIMER
  THISTIME = (THISTIME - STARTTIME) / 60
  LOCATE 14, 45: PRINT USING "###.###"; THISTIME
  FOR I8 = 1 TO 3
    RIM(I8) = 0
    'Initialize flow rates into phases
    NOUTfin = 0
    'Initialize number of pigs marketed
    NMean = 0
    'Initialize number of pigs weaned
    IF KDay(3) = LPool(3) THEN
      IU = IU + 1
      NMean = NPU(IU)
      RIM(3) = CSNG(NMean)
      NMEANED = NMEANED + NMean
    END IF
  CALL FADJ(FAddadJ(I), LGRO, LMUR, MFADay(I), DFA(I), 17, IRAND, LPool(1), NOT
-----> FE)

```



```

File: C:\UTIL\SHIMS.SIM          02/10/1989   18:01   -- Page: 009

INPUT =
---->PMSFEED(2)      Projected pounds of grower feed per grower pigday = "
INPUT =
---->PPMSFEED(3)     Projected pounds of nursery feed per nursery pigday = "
END IF

PRINT : PRINT =
-----Print--
PRINT =               combine purchased and raised feeds"; PRINT
INPUT =              Projected finisher feed price = $ , PPRICE(1)
INPUT =              Projected grower feed price = $ , PPRICE(2)
INPUT =              Projected nursery feed price = $ , PPRICE(3); PRIM
-----?

WRITE = 0
IF IBAND = 1 THEN
  IF NRMN = 200 THEN
    IF MODSOURCE = 1 THEN
      IF MODLSOURCE = 2 THEN
        PRINT =
        ---->ILES=
        ---->?       INPUT =
                      IF WRITE = 1 THEN
                        OPEN "C:\\" + DIRECTS + "\MONTCAR\\" + "%DELAY." + QUAMPIS FOR OUTPU
        ---->? AS #0  OPEN "C:\\" + DIRECTS + "\MONTCAR\\" + "%KTGS." + QUAMPIS FOR OUTPU
        ---->? AS #0  END IF
                      END IF
                      END IF
                      END IF
                    END IF
                    END IF
                    END IF
                    END IF
                  STARTIME = TIMER
FOR MONTE = 1 TO NRMN
  IF MONTE = 1 THEN
    CLS : FOR ISCREEN = 1 TO 8: PRINT : NEXT ISCREEN
    PRINT =
    PRINT =
    PRINT =
    PRINT : PRINT =
    LOCATE 11, 47: PRINT MONTE
    LOCATE 12, 46: PRINT 17
    TRISTIME = TIMER
    TRISTIME = (TRISTIME - STARTIME) / 60
    LOCATE 14, 45: PRINT USING "#99.##9"; TRISTIME
    LOCATE 14, 53: PRINT "MINUTES"
    END IF
  LOCATE 11, 47: PRINT MONTE
    TRISTIME = TIMER
    TRISTIME = (TRISTIME - STARTIME) / 60
    LOCATE 14, 45: PRINT USING "#99.##9"; TRISTIME
    OPEN "C:\\" + DIRECTS + "\\" + FILE35 + ".DAT" FOR INPUT AS #3
    INPUT #3, NR(3), NR(2), NR(1), NR(4), PMPP
    INPUT #3, PMSFEED(3), PMSFEED(2), PMSFEED(1)
    INPUT #3, SON(3), SON(2), SON(1), LPOOL(3), LPOOL(2), LPOOL(1)
    INPUT #3, KDAY(3), KDAY(2), KDAY(1), LNMR, LGRO
    INPUT #3, MOTH(3), MOTH(2), MOTH(1), NMBO
    INPUT #3, MNRO, NGRCPLW, NITOTKST, NFPO, NPUR

```



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File: C:\UTIL\SHIMS.SIM      02/10/1989  18:01  -- Page: 012

INPUT #2, NBHC, MGRP, MTOT, MTK, MFPO, MPUR
INPUT #2, NBHC, MT, IPD, DRO(3), MFPS(1), MPUR(1)
INPUT #2, DRO(2), MFPS(2), MPUR(2), DRO(1), MFPS(3), MPUR(3)
INPUT #2, DRO(4), MFPS(4), MPUR(4), DRO(5), MFPS(5), MPUR(5)
INPUT #2, DRO(6), MFPS(6), MPUR(6), DRO(7), MFPS(7), MPUR(7)
INPUT #2, DRO(8), MFPS(8), MPUR(8), DRO(9), MFPS(9), MPUR(9)
INPUT #2, DRO(10), MFPS(10), MPUR(10), DRO(11), MFPS(11), MPUR(11)
INPUT #2, DRO(12), MFPS(12), MPUR(12), DRO(13), MFPS(13), MPUR(13)
INPUT #2, DRO(14), MFPS(14), MPUR(14), DRO(15), MFPS(15), MPUR(15)
INPUT #2, FAC(3, 1), MFADAY(3, 1), FAC(3, 2), MFADAY(3, 2)
INPUT #2, FAC(3, 3), MFADAY(3, 3), FAC(3, 4), MFADAY(3, 4)
INPUT #2, FAC(3, 5), MFADAY(3, 5), FAC(2, 1), MFADAY(2, 1)
INPUT #2, FAC(2, 2), MFADAY(2, 2), FAC(2, 3), MFADAY(2, 3)
INPUT #2, FAC(2, 4), MFADAY(2, 4), FAC(2, 5), MFADAY(2, 5)
INPUT #2, FAC(1, 1), MFADAY(1, 1), FAC(1, 2), MFADAY(1, 2)
INPUT #2, FAC(1, 3), MFADAY(1, 3), FAC(1, 4), MFADAY(1, 4)
INPUT #2, FAC(1, 5), MFADAY(1, 5), IRAND, NOTFE
INPUT #2, EXPS(1), EXPS(2), EXPS(3), EXPS(4), EXPS(5), EXPS(6), EXPS(7), EXPS(8)
INPUT #2, EXPS(9), EXPS(10), EXPS(11), EXPS(12), EXPS(13), EXPS(14), EXPS(15), E
----->XPS(16)
CLOSE #2

IF MDLSOURCE = 1 THEN
  MDLSOURCES = "actual observation"
  OPEN "C:\\" + DIRECTS + "\\" + FILE45 + ".DEL" FOR INPUT AS #5
  INPUT #5, TOTDEL, PIGDAYS(1), PIGDAYS(2), PIGDAYS(3)
  CLOSE #5
  DELAY = TOTDEL - (LPOOL(1) / 2)
  END IF

IF MDLSOURCE = 2 THEN
  MDLSOURCES = "model projection"
  OPEN "C:\\" + DIRECTS + "\\" + FILE28 + ".DEL" FOR INPUT AS #5
  INPUT #5, TOTDEL, PIGDAYS(1), PIGDAYS(2), PIGDAYS(3)
  CLOSE #5
  DELAY = TOTDEL - (LPOOL(1) / 2)
  END IF

IF MDLSOURCE = 3 THEN DELAY = POEL

IF MDLSOURCE = 1 THEN
  MDLSOURCES = "actual observation"
  FOR I99 = 1 TO 3
    RNDTHP(I99) = CSNG(RNDTHP(I99))
  NEXT I99
  END IF

IF MDLSOURCE = 2 THEN
  MDLSOURCES = "model projection"
  OPEN "C:\\" + DIRECTS + "\\" + VOR11 + ".RIGHTS(STRS(NQUARTER), 1) + PRODS + QUARS +
  ----->DR1" FOR INPUT AS #1
  FOR I91 = 1 TO 4
    INPUT #1, AS, BS, CS, DRP(I91)
  NEXT I91
  CLOSE #1
  OPEN "C:\\" + DIRECTS + "\\" + VOR2 + ".RIGHTS(STRS(NQUARTER), 1) + PRODS + QUARS +
  ----->DR2" FOR INPUT AS #1
  FOR I91 = 5 TO 8
    INPUT #1, AS, BS, CS, DRP(I91)
  NEXT I91
  CLOSE #1
  OPEN "C:\\" + DIRECTS + "\\" + VOR3 + ".RIGHTS(STRS(NQUARTER), 1) + PRODS + QUARS +
  ----->DR3" FOR INPUT AS #1

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File: C:\UTIL\SHIMS.SIM      02/10/1989  18:01  -- Page: 011

INPUT #3, NBHC, MT, IPD, DRO(3), MFPS(1), MPUR(1)
INPUT #3, DRO(2), MFPS(2), MPUR(2), DRO(1), MFPS(3), MPUR(3)
INPUT #3, DRO(4), MFPS(4), MPUR(4), DRO(5), MFPS(5), MPUR(5)
INPUT #3, DRO(6), MFPS(6), MPUR(6), DRO(7), MFPS(7), MPUR(7)
INPUT #3, DRO(8), MFPS(8), MPUR(8), DRO(9), MFPS(9), MPUR(9)
INPUT #3, DRO(10), MFPS(10), MPUR(10), DRO(11), MFPS(11), MPUR(11)
INPUT #3, DRO(12), MFPS(12), MPUR(12), DRO(13), MFPS(13), MPUR(13)
INPUT #3, DRO(14), MFPS(14), MPUR(14), DRO(15), MFPS(15), MPUR(15)
INPUT #3, FAC(3, 1), MFADAY(3, 1), FAC(3, 2), MFADAY(3, 2)
INPUT #3, FAC(3, 3), MFADAY(3, 3), FAC(3, 4), MFADAY(3, 4)
INPUT #3, FAC(3, 5), MFADAY(3, 5), FAC(2, 1), MFADAY(2, 1)
INPUT #3, FAC(2, 2), MFADAY(2, 2), FAC(2, 3), MFADAY(2, 3)
INPUT #3, FAC(2, 4), MFADAY(2, 4), FAC(2, 5), MFADAY(2, 5)
INPUT #3, FAC(1, 1), MFADAY(1, 1), FAC(1, 2), MFADAY(1, 2)
INPUT #3, FAC(1, 3), MFADAY(1, 3), FAC(1, 4), MFADAY(1, 4)
INPUT #3, FAC(1, 5), MFADAY(1, 5), IRAND, NOTFE
INPUT #3, EXPS(1), EXPS(2), EXPS(3), EXPS(4), EXPS(5), EXPS(6), EXPS(7), EXPS(8)
INPUT #3, EXPS(9), EXPS(10), EXPS(11), EXPS(12), EXPS(13), EXPS(14), EXPS(15), E
----->XPS(16)
CLOSE #3

OPEN "C:\\" + DIRECTS + "\\" + FILE45 + ".DAT" FOR INPUT AS #4
INPUT #4, NE(3), NE(2), NE(1), NE(4), PHPP
INPUT #4, PHOSFEED(3), PHOSFEED(2), PHOSFEED(1)
INPUT #4, SON(3), SON(2), SON(1), LPOOL(3), LPOOL(2), LPOOL(1)
INPUT #4, KDAY(3), KDAY(2), KDAY(1), LNUR, LGRO
INPUT #4, MOTH(3), MOTH(2), MOTH(1), MGRP, MPUR
INPUT #4, NBHC, MGRP, MTOT, MTK, MFPO, MPUR
INPUT #4, NBHC, MT, IPD, DRO(3), MFPS(1), MPUR(1)
INPUT #4, DRO(2), MFPS(2), MPUR(2), DRO(1), MFPS(3), MPUR(3)
INPUT #4, DRO(4), MFPS(4), MPUR(4), DRO(5), MFPS(5), MPUR(5)
INPUT #4, DRO(6), MFPS(6), MPUR(6), DRO(7), MFPS(7), MPUR(7)
INPUT #4, DRO(8), MFPS(8), MPUR(8), DRO(9), MFPS(9), MPUR(9)
INPUT #4, DRO(10), MFPS(10), MPUR(10), DRO(11), MFPS(11), MPUR(11)
INPUT #4, DRO(12), MFPS(12), MPUR(12), DRO(13), MFPS(13), MPUR(13)
INPUT #4, DRO(14), MFPS(14), MPUR(14), DRO(15), MFPS(15), MPUR(15)
INPUT #4, FAP(3, 1), MFADAY(3, 1), FAP(3, 2), MFADAY(3, 2)
INPUT #4, FAP(3, 3), MFADAY(3, 3), FAP(3, 4), MFADAY(3, 4)
INPUT #4, FAP(3, 5), MFADAY(3, 5), FAP(2, 1), MFADAY(2, 1)
INPUT #4, FAP(2, 2), MFADAY(2, 2), FAP(2, 3), MFADAY(2, 3)
INPUT #4, FAP(2, 4), MFADAY(2, 4), FAP(2, 5), MFADAY(2, 5)
INPUT #4, FAP(1, 1), MFADAY(1, 1), FAP(1, 2), MFADAY(1, 2)
INPUT #4, FAP(1, 3), MFADAY(1, 3), FAP(1, 4), MFADAY(1, 4)
INPUT #4, FAP(1, 5), MFADAY(1, 5), IRAND, NOTFE
INPUT #4, EXPS(1), EXPS(2), EXPS(3), EXPS(4), EXPS(5), EXPS(6), EXPS(7),
----->EXPS(8)
INPUT #4, EXPS(9), EXPS(10), EXPS(11), EXPS(12), EXPS(13), EXPS(14), EXPS(15),
----->EXPS(16)
INPUT #4, NFATMOGS, FATMOGUT, FATMOGPRICE
INPUT #4, NFPO, FPAT, FPPRICE
INPUT #4, MGRDUTS, UNDERUT, UNDERUTPRICE
INPUT #4, MGLTSOLD, GLTUT, GLTPRICE
INPUT #4, MGRASOLD, BGRASUT, BGRPRICE
CLOSE #4

OPEN "C:\\" + DIRECTS + "\\" + FILE28 + ".DAT" FOR INPUT AS #2
INPUT #2, NE(3), NE(2), NE(1), NE(4), PHPP
INPUT #2, PHOSFEED(3), PHOSFEED(2), PHOSFEED(1)
INPUT #2, SON(3), SON(2), SON(1), LPOOL(3), LPOOL(2), LPOOL(1)
INPUT #2, KDAY(3), KDAY(2), KDAY(1), LNUR, LGRO
INPUT #2, MOTH(3), MOTH(2), MOTH(1), MGRP, MPUR

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File: C:\UTIL\SHIMS.SIM                                02/10/1989  18:01  --  Page: 016

      OPEN "C:\\" + DIRECTS + "\EX3\" + RIGHTS(STRS(MQUARTER), 1) + PRODS + QUARS +
      -----"EX3" FOR INPUT AS #1
      FOR 189 = 9 TO 12
        INPUT #1, AS, BS, CS, EXPSP(189)
      NEXT 189
      CLOSE #1
      OPEN "C:\\" + DIRECTS + "\EX4\" + RIGHTS(STRS(MQUARTER), 1) + PRODS + QUARS +
      -----"EX4" FOR INPUT AS #1
      FOR 189 = 13 TO 16
        INPUT #1, AS, BS, CS, EXPSP(189)
      NEXT 189
      CLOSE #1
      OPEN "C:\\" + DIRECTS + "\MUT\" + RIGHTS(STRS(MQUARTER), 1) + PRODS + QUARS +
      -----"MUT" FOR INPUT AS #1
      INPUT #1, AS, BS, CS, FATHOGUT
      CLOSE #1
      OPEN "C:\\" + DIRECTS + "\MPR\" + RIGHTS(STRS(MQUARTER), 1) + PRODS + QUARS +
      -----"MPR" FOR INPUT AS #1
      INPUT #1, AS, BS, CS, FATHOGPRICE
      CLOSE #1
    END IF
  IF MCSOURCE = 3 THEN
    FOR 196 = 1 TO 16
      EXPSP(196) = PERPS(196)
    NEXT 196
    FATHOGUT = PUT
    FATHOGPRICE = PPRICE
  END IF
  IF NEEDSOURCE = 1 THEN
    NEEDSOURCES = "actual observation"
    OPEN "C:\\" + DIRECTS + "\\" + FILE4$ + ".DEL" FOR INPUT AS #5
    INPUT #5, AS, DAYS1, DAY52, DAYS3
    CLOSE #5
    THOLDAYS = (DAYS1 + DAYS2 + DAYS3) / 1000
    'The following section converts expenses from $/cwt pork produced to
    ' $/pigday.
    FOR 192 = 1 TO 16
      EXPSP(192) = (EXPSP(192) * (PMPP / 100)) / THOLDAYS
    NEXT 192
    FATHOGUT = ((NFATHOGS * FATHOGUT) + (MUNDERUTS * UNDERMUT) + (NGILTSOLD * GILTW
    -----) + (MBOARSOLD * BOARUT)) / NTCWMT
    P1 = NFATHOGS * FATHOGUT * FATHOGPRICE
    P2 = MUNDERUTS * UNDERMUT * UNDERMPRICE
    P3 = NGILTSOLD * GILTW * GILTWPRICE
    P4 = MBOARSOLD * BOARUT * BOARPRICE
    FATHOGPRICE = (P1 + P2 + P3 + P4) / ((NFATHOGS * FATHOGUT) + (MUNDERUTS * UNDERM
    -----) + (NGILTSOLD * GILTW) + (MBOARSOLD * BOARUT))
  END IF
  IF NEEDSOURCE = 2 THEN
    NEEDSOURCES = "model projection"
    OPEN "C:\\" + DIRECTS + "\VPO\" + RIGHTS(STRS(MQUARTER), 1) + PRODS + QUARS +
    -----"VPO" FOR INPUT AS #1
    FOR 189 = 1 TO 3
      INPUT #1, AS, BS, CS, EXPSP(189)
    NEXT 189
    CLOSE #1
    OPEN "C:\\" + DIRECTS + "\EX2\" + RIGHTS(STRS(MQUARTER), 1) + PRODS + QUARS +
    -----"EX2" FOR INPUT AS #1
    FOR 189 = 5 TO 8
      INPUT #1, AS, BS, CS, EXPSP(189)
    NEXT 189
    CLOSE #1
    IF IWRITE = 1 THEN
      CLOSE #8
      CLOSE #9
    END IF
  END IF
  IF NEEDSOURCE = 3 THEN
    FOR 187 = 1 TO 3
      PMSFEEDP(187) = PPMOSFEED(187)
    NEXT 187
  END IF
  *****
  OUTPUT #1 SINGLUE FILE
  *****
  IF IWRITE = 1 THEN
    CLOSE #8
    CLOSE #9
  END IF

```

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File: C:\UTIL\SHIMS.SIM                                02/10/1989  18:01  --  Page: 013

      FOR 191 = 9 TO 12
        INPUT #1, AS, BS, CS, DRP(191)
      NEXT 191
      CLOSE #1
      OPEN "C:\\" + DIRECTS + "\DRA\" + RIGHTS(STRS(MQUARTER), 1) + PRODS + QUARS +
      -----"DRA" FOR INPUT AS #1
      FOR 191 = 13 TO 15
        INPUT #1, AS, BS, CS, DRP(191)
      NEXT 191
      CLOSE #1
      OPEN "C:\\" + DIRECTS + "\DTH\" + RIGHTS(STRS(MQUARTER), 1) + PRODS + QUARS +
      -----"DTH" FOR INPUT AS #1
      FOR 190 = 1 TO 3
        INPUT #1, AS, BS, CS, RNDTHP(190)
      NEXT 190
      CLOSE #1
    END IF
  IF MODSOURCE = 3 THEN
    FOR 198 = 1 TO 15
      DRP(198) = POR(198)
    NEXT 198
    FOR 197 = 1 TO 3
      RNDTHP(197) = POTH(197)
    NEXT 197
  END IF
  IF NEEDSOURCE = 1 THEN
    NEEDSOURCES = "actual observation"
    OPEN "C:\\" + DIRECTS + "\\" + FILE4$ + ".DEL" FOR INPUT AS #5
    INPUT #5, AS, DAYS1, DAY52, DAYS3
    CLOSE #5
    THOLDAYS = (DAYS1 + DAYS2 + DAYS3) / 1000
    'The following section converts expenses from $/cwt pork produced to
    ' $/pigday.
    FOR 192 = 1 TO 16
      EXPSP(192) = (EXPSP(192) * (PMPP / 100)) / THOLDAYS
    NEXT 192
    FATHOGUT = ((NFATHOGS * FATHOGUT) + (MUNDERUTS * UNDERMUT) + (NGILTSOLD * GILTW
    -----) + (MBOARSOLD * BOARUT)) / NTCWMT
    P1 = NFATHOGS * FATHOGUT * FATHOGPRICE
    P2 = MUNDERUTS * UNDERMUT * UNDERMPRICE
    P3 = NGILTSOLD * GILTW * GILTWPRICE
    P4 = MBOARSOLD * BOARUT * BOARPRICE
    FATHOGPRICE = (P1 + P2 + P3 + P4) / ((NFATHOGS * FATHOGUT) + (MUNDERUTS * UNDERM
    -----) + (NGILTSOLD * GILTW) + (MBOARSOLD * BOARUT))
  END IF
  IF NEEDSOURCE = 2 THEN
    NEEDSOURCES = "model projection"
    OPEN "C:\\" + DIRECTS + "\EX1\" + RIGHTS(STRS(MQUARTER), 1) + PRODS + QUARS +
    -----"EX1" FOR INPUT AS #1
    FOR 189 = 1 TO 4
      INPUT #1, AS, BS, CS, EXPSP(189)
    NEXT 189
    CLOSE #1
    OPEN "C:\\" + DIRECTS + "\EX2\" + RIGHTS(STRS(MQUARTER), 1) + PRODS + QUARS +
    -----"EX2" FOR INPUT AS #1
    FOR 189 = 5 TO 8
      INPUT #1, AS, BS, CS, EXPSP(189)
    NEXT 189
    CLOSE #1
  END IF

```



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File: C:\UTIL\SHIMS.SIM      02/10/1999   18:02   -- Page: 021

PRINT USING "#####"; ((SFEEDM1 + TOTMURFEED + TOTGROFEED) / 2000); PRINT
INPUT " "
Press ENTER to Continue"; AS; CLS
PRINT TAB(36); "AVERAGE"; TAB(48); "STD.DEV."; TAB(61); "LOW"; TAB(72); "HIGH"
PRINT " = 8. Projected Revenue"
PRINT " "
Market hog:
PRINT USING "#####.##"; SREVATNOG; : PRINT TAB(46);
PRINT USING "#####.##"; SREVATFAT; : PRINT TAB(57);
PRINT USING "#####.##"; SLOREVAT; : PRINT TAB(69);
PRINT USING "#####.##"; SHREVAT; : PRINT TAB(81);
PRINT " (price = "; : PRINT USING "$#.##"; FATHOGPRICE; : PRINT " per c
>ct)"
PRINT " (weight = "; : PRINT USING "###.##"; FATHOGWT; : PRINT " pounds
----per head)"
PRINT " "
PRINT USING "#####.##"; REVFP; : TAB(75);
PRINT TAB(51); " "; TAB(63); " "; TAB(75);
PRINT " (price = "; : PRINT USING "$###.##"; FPRICE; : PRINT " per cut)"
PRINT " "
PRINT " (weight = "; : PRINT USING "##.##"; FPUT; : PRINT " pounds per h
----head)"
PRINT " "
Total:
PRINT USING "#####.##"; TOTREV; : PRINT TAB(46);
PRINT USING "#####.##"; SREVATFAT; : PRINT TAB(57);
PRINT USING "#####.##"; SLOREVAT + REVFP; : PRINT TAB(69);
PRINT USING "#####.##"; SHREVAT + REVFP; : PRINT
PRINT " = 9. Projected feed Expense"
PRINT " "
finisher:
PRINT USING "#####.##"; TOTFINFEED * FPRICE(1); : PRINT TAB(46);
PRINT USING "#####.##"; SFEEDEXP1; : PRINT TAB(57);
PRINT USING "#####.##"; SFEEDLO1 * FPRICE(1); : PRINT TAB(69);
PRINT USING "#####.##"; SFEEDLO1 * FPRICE(1); : PRINT
PRINT " (price = "; : PRINT USING "$#.##"; FPRICE(1); : PRINT " per pound
---->d)"
PRINT " "
Grower:
PRINT USING "#####.##"; TOTGROFEED * FPRICE(2); : PRINT TAB(51);
PRINT " "; TAB(63); " "; TAB(75);
PRINT " (price = "; : PRINT USING "$#.##"; FPRICE(2); : PRINT " per pound
---->d)"
PRINT " "
Murkety:
PRINT USING "#####.##"; TOTMURFEED * FPRICE(3); : PRINT TAB(51);
PRINT " "; TAB(63); " "; TAB(75);
PRINT " (price = "; : PRINT USING "$#.##"; FPRICE(3); : PRINT " per pound
---->d)"
PRINT " "
Total:
PRINT USING "#####.##"; TOTFEEDEXP; : PRINT TAB(46);
PRINT USING "#####.##"; SFEEDEXP1; : PRINT TAB(57);
PRINT USING "#####.##"; TOTFEEDLO; : PRINT TAB(69);
PRINT USING "#####.##"; TOTFEDEXP1; : PRINT
INPUT TAB(36); "AVERAGE"; TAB(48); "STD.DEV."; TAB(61); "LOW"; TAB(72); "HIGH"
PRINT " = 10. Projected Non-feed Expense"
PRINT " "
Repair and maintenance:
PRINT USING "#####.##"; EXPSP(2); : PRINT TAB(46);
PRINT USING "#####.##"; EXPSP(2); : PRINT TAB(57);
PRINT USING "#####.##"; EXPSP(2) / TOTPIGDAVS; : TOTPOLO; : PRINT TAB(69);
PRINT USING "#####.##"; EXPSP(2) / TOTPIGDAVS; : TOTPOLO
PRINT " "
Veterinary care and drugs:
PRINT USING "#####.##"; EXPSP(3); : PRINT TAB(46);
PRINT USING "#####.##"; EXPSP(3); : PRINT TAB(57);
PRINT USING "#####.##"; EXPSP(3) / TOTPIGDAVS; : TOTPOLO; : PRINT TAB(69);
PRINT USING "#####.##"; EXPSP(3) / TOTPIGDAVS; : TOTPOLO
PRINT " "
Labor:
PRINT USING "#####.##"; EXPSP(4); : PRINT TAB(46);
PRINT USING "#####.##"; EXPSP(4); : PRINT TAB(57);
PRINT USING "#####.##"; EXPSP(4) / TOTPIGDAVS; : TOTPOLO; : PRINT TAB(69);
PRINT USING "#####.##"; EXPSP(4) / TOTPIGDAVS; : TOTPOLO
PRINT " "
Total:
PRINT USING "#####.##"; TOTEXP; : PRINT TAB(46);
PRINT USING "#####.##"; SOTOTEXP; : PRINT TAB(57);
PRINT USING "#####.##"; TOTEXP + TOTPOLO; : PRINT TAB(69);
PRINT USING "#####.##"; TOTEXP + TOTPOLO; : PRINT
PRINT " = 11. Projected Income Over Variable Costs"

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PRINT " "
Supplies:
PRINT USING "#####.##"; EXPSP(5); : PRINT TAB(46);
PRINT USING "#####.##"; EXPSP(5); : PRINT TAB(57);
PRINT USING "#####.##"; EXPSP(5) / TOTPIGDAVS; : TOTPOLO; : PRINT TAB(69);
PRINT USING "#####.##"; EXPSP(5) / TOTPIGDAVS; : TOTPOLO
PRINT " "
Fuel:
PRINT USING "#####.##"; EXPSP(6); : PRINT TAB(46);
PRINT USING "#####.##"; EXPSP(6); : PRINT TAB(57);
PRINT USING "#####.##"; EXPSP(6) / TOTPIGDAVS; : TOTPOLO; : PRINT TAB(69);
PRINT USING "#####.##"; EXPSP(6) / TOTPIGDAVS; : TOTPOLO
PRINT " "
Electricity:
PRINT USING "#####.##"; EXPSP(7); : PRINT TAB(46);
PRINT USING "#####.##"; EXPSP(7); : PRINT TAB(57);
PRINT USING "#####.##"; EXPSP(7) / TOTPIGDAVS; : TOTPOLO; : PRINT TAB(69);
PRINT USING "#####.##"; EXPSP(7) / TOTPIGDAVS; : TOTPOLO
PRINT " "
Telephone:
PRINT USING "#####.##"; EXPSP(8); : PRINT TAB(46);
PRINT USING "#####.##"; EXPSP(8); : PRINT TAB(57);
PRINT USING "#####.##"; EXPSP(8) / TOTPIGDAVS; : TOTPOLO; : PRINT TAB(69);
PRINT USING "#####.##"; EXPSP(8) / TOTPIGDAVS; : TOTPOLO
PRINT " "
Trucking:
PRINT USING "#####.##"; EXPSP(9); : PRINT TAB(46);
PRINT USING "#####.##"; EXPSP(9); : PRINT TAB(57);
PRINT USING "#####.##"; EXPSP(9) / TOTPIGDAVS; : TOTPOLO; : PRINT TAB(69);
PRINT USING "#####.##"; EXPSP(9) / TOTPIGDAVS; : TOTPOLO
PRINT " "
Marketing:
PRINT USING "#####.##"; EXPSP(10); : PRINT TAB(46);
PRINT USING "#####.##"; EXPSP(10); : PRINT TAB(57);
PRINT USING "#####.##"; EXPSP(10) / TOTPIGDAVS; : TOTPOLO; : PRINT TAB(69);
PRINT USING "#####.##"; EXPSP(10) / TOTPIGDAVS; : TOTPOLO
PRINT " "
Insurance:
PRINT USING "#####.##"; EXPSP(11); : PRINT TAB(46);
PRINT USING "#####.##"; EXPSP(11); : PRINT TAB(57);
PRINT USING "#####.##"; EXPSP(11) / TOTPIGDAVS; : TOTPOLO; : PRINT TAB(69);
PRINT USING "#####.##"; EXPSP(11) / TOTPIGDAVS; : TOTPOLO
PRINT " "
Interest:
PRINT USING "#####.##"; EXPSP(12); : PRINT TAB(46);
PRINT USING "#####.##"; EXPSP(12); : PRINT TAB(57);
PRINT USING "#####.##"; EXPSP(12) / TOTPIGDAVS; : TOTPOLO; : PRINT TAB(69);
PRINT USING "#####.##"; EXPSP(12) / TOTPIGDAVS; : TOTPOLO
PRINT " "
Taxes:
PRINT USING "#####.##"; EXPSP(13); : PRINT TAB(46);
PRINT USING "#####.##"; EXPSP(13); : PRINT TAB(57);
PRINT USING "#####.##"; EXPSP(13) / TOTPIGDAVS; : TOTPOLO; : PRINT TAB(69);
PRINT USING "#####.##"; EXPSP(13) / TOTPIGDAVS; : TOTPOLO
PRINT " "
Replacement females:
PRINT USING "#####.##"; EXPSP(14); : PRINT TAB(46);
PRINT USING "#####.##"; EXPSP(14); : PRINT TAB(57);
PRINT USING "#####.##"; EXPSP(14) / TOTPIGDAVS; : TOTPOLO; : PRINT TAB(69);
PRINT USING "#####.##"; EXPSP(14) / TOTPIGDAVS; : TOTPOLO
PRINT " "
Replacement boars:
PRINT USING "#####.##"; EXPSP(15); : PRINT TAB(46);
PRINT USING "#####.##"; EXPSP(15); : PRINT TAB(57);
PRINT USING "#####.##"; EXPSP(15) / TOTPIGDAVS; : TOTPOLO; : PRINT TAB(69);
PRINT USING "#####.##"; EXPSP(15) / TOTPIGDAVS; : TOTPOLO
PRINT " "
Other cash expense:
PRINT USING "#####.##"; EXPSP(16); : PRINT TAB(46);
PRINT USING "#####.##"; EXPSP(16); : PRINT TAB(57);
PRINT USING "#####.##"; EXPSP(16) / TOTPIGDAVS; : TOTPOLO; : PRINT TAB(69);
PRINT USING "#####.##"; EXPSP(16) / TOTPIGDAVS; : TOTPOLO
PRINT " "
Total:
PRINT USING "#####.##"; TOTEXP; : PRINT TAB(46);
PRINT USING "#####.##"; SOTOTEXP; : PRINT TAB(57);
PRINT USING "#####.##"; TOTEXP + TOTPOLO; : PRINT TAB(69);
PRINT USING "#####.##"; TOTEXP + TOTPOLO; : PRINT
PRINT " = 11. Projected Income Over Variable Costs"

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PRINT TAB(10); " 5. Projected Death Losses";
PRINT TAB(10); Finisher-----;
PRINT USING "#####" TOTDTHSN(1);
PRINT TAB(61); "##"; AB(73); "##"; TAB(85); "##";
PRINT TAB(10); Grower-----;
PRINT USING "#####" TOTDTHSN(2);
PRINT TAB(61); "##"; AB(73); "##"; TAB(85); "##";
PRINT TAB(10); Nursery-----;
PRINT USING "#####" TOTDTHSN(3);
PRINT TAB(61); "##"; AB(73); "##"; TAB(85); "##"; LPRINT
PRINT TAB(10); Market hogs-----;
PRINT USING "#####" SKEANI; : LPRINT TAB(57);
PRINT USING "#####" SSTDEVI; : LPRINT TAB(68);
PRINT USING "#####" SLOT; : LPRINT TAB(80);
PRINT USING "#####" SHI
PRINT TAB(10); " Feeder pigs-----";
PRINT USING "#####" NFPIGSLB;
PRINT TAB(61); "##"; AB(73); "##"; TAB(85); "##"; LPRINT
PRINT TAB(10); " 7. Projected Feed Consumption (tons)";
PRINT TAB(10); Finisher-----;
PRINT USING "#####" TOTFINFEED / 2000; : LPRINT TAB(57);
PRINT USING "#####" ((SPEEDL1 / 2000)); : LPRINT TAB(48);
PRINT USING "#####" ((SPEEDLO1 / 2000)); : LPRINT TAB(66);
PRINT USING "#####" ((SPEEDN1 / 2000))
PRINT TAB(10); " Grower-----";
PRINT USING "#####" TOTGRFEEED / 2000;
PRINT TAB(61); "##"; AB(73); "##"; TAB(85); "##";
PRINT TAB(10); " Nursery-----";
PRINT USING "#####" TOTMUNFEED / 2000;
PRINT TAB(61); "##"; AB(73); "##"; TAB(85); "##";
PRINT TAB(10); " Total-----";
PRINT USING "#####" ((TOTFEED / 2000)); : LPRINT TAB(57);
PRINT USING "#####" ((SPEEDO1 / 2000)); : LPRINT TAB(48);
PRINT USING "#####" ((SPEEDLO1 + TOTMUNFEED + TOTGRFEEED) / 2000); : LPRINT I
PRINT USING "#####" ((SPEEDN1 + TOTMUNFEED + TOTGRFEEED) / 2000); : LPRINT
PRINT TAB(10); " 8. Projected Revenue";
PRINT TAB(10); Market hogs-----;
PRINT TAB(10); REVATNOG; : LPRINT TAB(56);
PRINT USING "#####" SOREVAT; : LPRINT TAB(67);
PRINT USING "#####" SLOREVFAT; : LPRINT TAB(76);
PRINT USING "#####" SHIREVAT
PRINT TAB(10); " (price = "; : LPRINT USING "$###.##"; FATNOCPRI; : LP
PRINT TAB(10); " weight = "; : LPRINT USING "###.##"; FATWOGHT; : LPR
PRINT TAB(10); " per cwt")";
PRINT TAB(10); " 9. Projected Feed Expense";
PRINT TAB(10); Finisher-----;
PRINT USING "#####" TOTFEED * FPRICE(1); : LPRINT TAB(56);
PRINT USING "#####" SOFEEDXP1; : LPRINT TAB(67);
PRINT USING "#####" SFEEDEL01 * FPRICE(1); : LPRINT TAB(79);
PRINT USING "#####" SFEEDEL01 * FPRICE(1); : LPRINT TAB(79);
```

[illegible]


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END SUB

*****
FADDEFF BAS SUBROUTINE
*****
DECLARE SUB TRDIST (AI, BI, CI, VALCUR1)

DEFINT I-N
SUB FADDEFF (FADDAD(1), LGRO, LMR, NFADAY(1), DFA(1), I7, IRAND, LPOOL, NOTFE)
DIM FALO(3, 5) AS SINGLE, FAave(3, 5) AS SINGLE, FANI(3, 5) AS SINGLE, FACur(3,
-----5) AS SINGLE
FALO(3, 1) = 3.4: FAave(3, 1) = 12.5: FANI(3, 1) = 22
FALO(3, 2) = 2.4: FAave(3, 2) = 8.8: FANI(3, 2) = 15.5
FALO(3, 3) = 0: FAave(3, 3) = 8: FANI(3, 3) = 31
FALO(3, 4) = 3: FAave(3, 4) = 9.7: FANI(3, 4) = 22
FALO(3, 5) = 3.4: FAave(3, 5) = 12.5: FANI(3, 5) = 22
FALO(2, 1) = 1.5: FAave(2, 1) = 7.6: FANI(2, 1) = 14
FALO(2, 2) = 0: FAave(2, 2) = 11.5: FANI(2, 2) = 25
FALO(2, 3) = 0: FAave(2, 3) = 11: FANI(2, 3) = 31
FALO(2, 4) = 0: FAave(2, 4) = 1: FANI(2, 4) = 2
FALO(2, 5) = 1.5: FAave(2, 5) = 7.6: FANI(2, 5) = 14
FALO(1, 1) = 0: FAave(1, 1) = 2.8: FANI(1, 1) = 5.6
FALO(1, 2) = 0: FAave(1, 2) = 2.5: FANI(1, 2) = 5
FALO(1, 3) = 0: FAave(1, 3) = 2.5: FANI(1, 3) = 5
FALO(1, 4) = 0: FAave(1, 4) = 2: FANI(1, 4) = 2
FALO(1, 5) = 0: FAave(1, 5) = 2.8: FANI(1, 5) = 5.6
TEMPDJ = 0
FOR J1 = 1 TO 3
    FADDAD(J1) = 0
NEXT J1
FOR I21 = 1 TO 5
    IF NFADAY(1, I21) > 0 THEN
        IF I7 = NFADAY(1, I21) THEN
            IF IRAND = 0 THEN
                ELSE CALL TRDIST(FALO(1, I21), FAave(1, I21), FANI(1, I21), FACur(1
-----, I21))
            END IF
            FACur(1, I21) = FACur(1, I21) / 100
            IF DFA(1, I21) < 0 THEN FACur(1, I21) = (1 / (1 + FACur(1, I21))) -
-----1
            'CONVERSION OF PROPORTION IF FA ARE REMOVED
            FACur(1, I21) = (DFA(1, I21) + FACur(1, I21)) / NOTFE
            TEMPADJ = -(FACur(1, I21) + FACur(1, I21)) / NOTFE
            FADDAD(1) = FADDAD(1) + TEMPADJ
        END IF
        IF I7 > NFADAY(1, I21) THEN
            IF I7 < (NFADAY(1, I21) + NOTFE) THEN
                TEMPADJ = -(FACur(1, I21) + FACur(1, I21))
                FADDAD(1) = FADDAD(1) + TEMPADJ
            END IF
        END IF
    END IF

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```

END IF
END IF
IF NFADAY(2, I21) > 0 THEN
    IF I7 = NFADAY(2, I21) THEN
        IF IRAND = 0 THEN
            FACur(2, I21) = FAave(2, I21)
            ELSE CALL TRDIST(FALO(2, I21), FAave(2, I21), FANI(2, I21), FACur(2
-----, I21))
        END IF
        FACur(2, I21) = FACur(2, I21) / 100
        IF DFA(2, I21) < 0 THEN FACur(2, I21) = (1 / (1 + FACur(2, I21))) -
-----1
        'CONVERSION OF PROPORTION IF FA ARE REMOVED
        FACur(2, I21) = (DFA(2, I21) + FACur(2, I21)) / NOTFE
        TEMPADJ = -(FACur(2, I21) + FACur(2, I21)) / NOTFE
        FADDAD(2) = FADDAD(2) + TEMPADJ
    END IF
    IF I7 > NFADAY(2, I21) THEN
        IF I7 < (NFADAY(2, I21) + NOTFE) THEN
            TEMPADJ = -(FACur(2, I21) + FACur(2, I21))
            FADDAD(2) = FADDAD(2) + TEMPADJ
        END IF
    END IF
    IF I7 > NFADAY(3, I21) > 0 THEN
        IF I7 = NFADAY(3, I21) THEN
            IF IRAND = 0 THEN
                FACur(3, I21) = FAave(3, I21)
                ELSE CALL TRDIST(FALO(3, I21), FAave(3, I21), FANI(3, I21), FACur(3
-----, I21))
            END IF
            FACur(3, I21) = FACur(3, I21) / 100
            IF DFA(3, I21) < 0 THEN FACur(3, I21) = (1 / (1 + FACur(3, I21))) -
-----1
            'CONVERSION OF PROPORTION IF FA ARE REMOVED
            FACur(3, I21) = (DFA(3, I21) + FACur(3, I21)) / NOTFE
            TEMPADJ = -(FACur(3, I21) + FACur(3, I21)) / NOTFE
            FADDAD(3) = FADDAD(3) + TEMPADJ
        END IF
        IF I7 > NFADAY(3, I21) THEN
            IF I7 < (NFADAY(3, I21) + NOTFE) THEN
                TEMPADJ = -(FACur(3, I21) + FACur(3, I21))
                FADDAD(3) = FADDAD(3) + TEMPADJ
            END IF
        END IF
    END IF
    IF I7 > NFADAY(3, I21) > 0 THEN
        IF I7 < (NFADAY(3, I21) + NOTFE) THEN
            TEMPADJ = -(FACur(3, I21) + FACur(3, I21))
            FADDAD(3) = FADDAD(3) + TEMPADJ
        END IF
    END IF
NEXT I21

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MR1 = MR1 + 1
IF MR1 > 3 THEN
  MR1 = 1
  MR2 = MR2 + 1
END IF
IF MR2 > 21 THEN
  MR2 = 1
  MR3 = 1
END IF
IF MR3 < 1 THEN
  IF MR1 = 1 THEN
    OLDR = 0
    RANDOMIZE TIMER
    R(MR2, MR1) = RND(2)
  END IF
  IF MR1 > 1 THEN
    RANDOMIZE TIMER
    TEMPR = RND(2)
    TR = 0
  END IF
  CALL TABEX(Y(), X(), KTE, TEMPR, TR)
  R(MR2, MR1) = ((1 / 3) * OLDR) + ((2 / 3) * TR)
END IF
OLDR = R(MR2, MR1)
END IF
IF MR3 = 1 THEN
  RANDOMIZE TIMER
  TEMPR = RND(2)
  TR = 0
  CALL TABEX(Y(), X(), KTE, TEMPR, TR)
  R(MR2, MR1) = ((1 / 3) * R(MR2, MR1)) + ((2 / 3) * TR)
END IF
CRIT = (B - A) / (C - A)
IF R(MR2, MR1) > CRIT THEN
  VALCR = C - ((1 - R(MR2, MR1)) * (C - A)) * (C - B) * .5
ELSE
  VALCR = A + (R(MR2, MR1) * (C - A) * (B - A)) * .5
END IF
END SUB

*****
TABEX.BAS SUBROUTINE
*****
DEFINT I-N
SUB TABEX (ARRDEP(), ARRIND(), KTE, XTE, YTE) STATIC

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*****
TABEX.BAS SUBROUTINE
*****
DECLARE SUB TABEX (ARRDEP(), ARRIND(), KTE, XTE, YTE)
COMMON SHARED STARTIME AS SINGLE
DEFINT I-N
SUB TABEX (A, B, C, VALCR) STATIC
DIM R(21, 3) AS SINGLE
DIM X(100) AS SINGLE, Y(100) AS SINGLE
X(1) = .01: X(2) = .02: X(3) = .03: X(4) = .04: X(5) = .05
X(6) = .06: X(7) = .07: X(8) = .08: X(9) = .09: X(10) = .1
X(11) = .11: X(12) = .12: X(13) = .13: X(14) = .14: X(15) = .15
X(16) = .16: X(17) = .17: X(18) = .18: X(19) = .19: X(20) = .2
X(21) = .21: X(22) = .22: X(23) = .23: X(24) = .24: X(25) = .25
X(26) = .26: X(27) = .27: X(28) = .28: X(29) = .29: X(30) = .3
X(31) = .31: X(32) = .32: X(33) = .33: X(34) = .34: X(35) = .35
X(36) = .36: X(37) = .37: X(38) = .38: X(39) = .39: X(40) = .4
X(41) = .41: X(42) = .42: X(43) = .43: X(44) = .44: X(45) = .45
X(46) = .46: X(47) = .47: X(48) = .48: X(49) = .49: X(50) = .5
X(51) = .51: X(52) = .52: X(53) = .53: X(54) = .54: X(55) = .55
X(56) = .56: X(57) = .57: X(58) = .58: X(59) = .59: X(60) = .6
X(61) = .61: X(62) = .62: X(63) = .63: X(64) = .64: X(65) = .65
X(66) = .66: X(67) = .67: X(68) = .68: X(69) = .69: X(70) = .7
X(71) = .71: X(72) = .72: X(73) = .73: X(74) = .74: X(75) = .75
X(76) = .76: X(77) = .77: X(78) = .78: X(79) = .79: X(80) = .8
X(81) = .81: X(82) = .82: X(83) = .83: X(84) = .84: X(85) = .85
X(86) = .86: X(87) = .87: X(88) = .88: X(89) = .89: X(90) = .9
X(91) = .91: X(92) = .92: X(93) = .93: X(94) = .94: X(95) = .95
X(96) = .96: X(97) = .97: X(98) = .98: X(99) = .99: X(100) = 1
Y(1) = 2.607228E-02: Y(2) = .0520468: Y(3) = 7.782669E-02: Y(4) = .1033169
Y(5) = .1284231: Y(6) = .1530624: Y(7) = .1771642: Y(8) = .2005911
Y(9) = .2233293: Y(10) = .2462914: Y(11) = .2664169: Y(12) = .2844526
Y(13) = .3059529: Y(14) = .3242803: Y(15) = .3416053: Y(16) = .3579068
Y(17) = .3731715: Y(18) = .3873948: Y(19) = .4005789: Y(20) = .4127347
Y(21) = .4238796: Y(22) = .4340379: Y(23) = .4432401: Y(24) = .4515222
Y(25) = .4589253: Y(26) = .4654948: Y(27) = .4712796: Y(28) = .4763314
Y(29) = .480704: Y(30) = .4844528: Y(31) = .4876333: Y(32) = .4903015
Y(33) = .4925123: Y(34) = .4943191: Y(35) = .4957734: Y(36) = .4969242
Y(37) = .4978175: Y(38) = .4984957: Y(39) = .4989978: Y(40) = .4993586
Y(41) = .4996009: Y(42) = .4997752: Y(43) = .4998801: Y(44) = .4999419
Y(45) = .4999733: Y(46) = .4999912: Y(47) = .4999976: Y(48) = .4999996
Y(49) = .5: Y(50) = .5: Y(51) = .5: Y(52) = .5000004
Y(53) = .5000023: Y(54) = .5000048: Y(55) = .5000247: Y(56) = .5000581
Y(57) = .5001199: Y(58) = .5002248: Y(59) = .5003911: Y(60) = .5006414
Y(61) = .5010022: Y(62) = .5015843: Y(63) = .5021826: Y(64) = .5030759
Y(65) = .5042267: Y(66) = .5056811: Y(67) = .5074879: Y(68) = .5096986
Y(69) = .5123668: Y(70) = .5155473: Y(71) = .5192962: Y(72) = .5236588
Y(73) = .5287206: Y(74) = .5345054: Y(75) = .5410749: Y(76) = .548478
Y(77) = .5567601: Y(78) = .5659623: Y(79) = .5761206: Y(80) = .5872656
Y(81) = .5994214: Y(82) = .6126056: Y(83) = .6268287: Y(84) = .6420935
Y(85) = .6583949: Y(86) = .67572: Y(87) = .6940474: Y(88) = .7133477
Y(89) = .7355834: Y(90) = .7547089: Y(91) = .776671: Y(92) = .7994092
Y(93) = .8228561: Y(94) = .846938: Y(95) = .8715752: Y(96) = .8966835
Y(97) = .9221737: Y(98) = .9479536: Y(99) = .9739281: Y(100) = 1
KTE = 100
IF MR1 = 0 THEN MR2 = 1

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      ELSE TOTADJGRO = (EXP(TOTADJGRO)) - 1
    END IF
  IF TOTADJDEL > 0 THEN
    TOTADJDEL = LOG(TOTADJDEL + 1)
  ELSE TOTADJDEL = (EXP(TOTADJDEL)) - 1
  END IF
  IF TOTADJ2 > 0 THEN
    TOTADJ2 = LOG(TOTADJ2 + 1)
  ELSE TOTADJ2 = (EXP(TOTADJ2)) - 1
  END IF

  DELAY = DELAY * (1 + TOTADJNUR) * (1 + TOTADJGRO) * (1 + TOTADJDEL)
END SUB

*****
'DCTDEL.BAS SUBROUTINE
*****
DEFINT I-N
SUB DCTDEL (UDCTD, YDCTD, VDCTD(), KDCTD, DCTNPD, RME) STATIC
  IF RME > 0 THEN
    YDCTD = VDCTD(KDCTD)
    FOR IJK = KDCTD - 1 TO 1 STEP -1
      VDCTD(IJK + 1) = VDCTD(IJK) - ((VDCTD(IJK) / RME) * DCTNPD)
    NEXT IJK
    VDCTD(1) = UDCTD
  END IF
  IF RME = 0 THEN
    YDCTD = VDCTD(KDCTD)
    FOR IJK = KDCTD - 1 TO 1 STEP -1
      VDCTD(IJK + 1) = VDCTD(IJK)
    NEXT IJK
    VDCTD(1) = UDCTD
  END IF
  REM***** DCTDEL--DISCRETE DELAY
  REM UDCTD=INPUT
  REM YDCTD=OUTPUT
  REM KDCTD=NUMBER OF STAGES
  REM VDCTD( ) IS THE ARRAY OF MEMORY CELLS
END SUB

*****
'STATS.BAS SUBROUTINE
*****
DEFINT I-N
SUB STATS (VST, NRUM, SNEAN, SSTDEV, ISTV, SVST2, SNI, SLO) STATIC
  IF ISTV = 0 THEN SLO = VST
  IF NRUM > 1 THEN

```

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I15 = 2
DO WHILE I15 <= KTE
  IF KTE < ARRIND(I15) THEN EXIT DO
  I15 = I15 + 1
LOOP
IF I15 = KTE + 1 THEN I15 = KTE
YTE = (KTE - ARRIND(I15 - 1)) * (ARRDEP(I15) - 1) / (ARRIND(I15) -
-----> ARRIND(I15 - 1)) + ARDEP(I15 - 1)
END SUB

*****
'DELMOD.BAS SUBROUTINE
*****
DEFINT I-N
SUB DelMod (DDR(), DCur(), DELAY, LPool(), DADG(), LNMUR, LGRO, FADJadJ()) STATIC
  TOTADJNUR = 0
  TOTADJGRO = 0
  TOTADJDEL = 0
  TEMPADJ = 0
  FOR MM = 1 TO 15
    DCur(3, MM) = DCur(3, MM) * -.01
    DCur(2, MM) = DCur(2, MM) * -.01
    DCur(1, MM) = DCur(1, MM) * -.01
    IF DDR(MM) < 0 THEN
      DCur(3, MM) = (1 / (1 + DCur(3, MM))) - 1
      DCur(2, MM) = (1 / (1 + DCur(2, MM))) - 1
      DCur(1, MM) = (1 / (1 + DCur(1, MM))) - 1
    END IF
    DCur(3, MM) = DCur(3, MM) * ABS(DDR(MM))
    TEMPADJ = -(DCur(3, MM) / (1 + DCur(3, MM)))
    TOTADJNUR = TOTADJNUR + TEMPADJ
    DCur(2, MM) = DCur(2, MM) * ABS(DDR(MM))
    TEMPADJ = -(DCur(2, MM) / (1 + DCur(2, MM)))
    TOTADJGRO = TOTADJGRO + TEMPADJ
    DCur(1, MM) = DCur(1, MM) * ABS(DDR(MM))
    TEMPADJ = -(DCur(1, MM) / (1 + DCur(1, MM)))
    TOTADJDEL = TOTADJDEL + TEMPADJ
  NEXT MM
  TOTADJNUR = TOTADJNUR + DADG(3) + FADJadJ(3)
  TOTADJGRO = TOTADJGRO + DADG(2) + FADJadJ(2)
  TOTADJDEL = TOTADJDEL + DADG(1) + FADJadJ(1)
  *****SEND THROUGH LOG FUNCTIONS*****
  IF TOTADJNUR > 0 THEN
    TOTADJNUR = LOG(TOTADJNUR + 1)
  ELSE TOTADJNUR = (EXP(TOTADJNUR)) - 1
  END IF
  IF TOTADJGRO > 0 THEN
    TOTADJGRO = LOG(TOTADJGRO + 1)

```

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      DLOC(1, 11) = 2.7: DAVE(1, 11) = 5.9: DMI(1, 11) = 9
      DLOC(1, 12) = 0: DAVE(1, 12) = 2.7: DMI(1, 12) = 5.9
      DLOC(1, 13) = 0: DAVE(1, 13) = 5: DMI(1, 13) = 19.5
      DLOC(1, 14) = 0: DAVE(1, 14) = 5: DMI(1, 14) = 19.5
      DLOC(1, 15) = 0: DAVE(1, 15) = 5.9: DMI(1, 15) = 13.8
END SUB

*****
'DELTV.BAS SUBROUTINE
*****

DEFINT I-N
SUB DELTV (LDTV, YDTV, QTV(), TQTV, Dtha, DT, KDTV) STATIC
DOO1 = DTV / KDTV
DOO1 = 1 / DOO1
KDTV = KDTV - 1
FOR JJDD = 1 TO KDTV
  QTV(JJDD) = QTV(JJDD) + DT * (QTV(JJDD + 1) / DOO1 - QTV(JJDD) * DOO1) - (Dtha *
  ----> QTV(JJDD) / TQTV)
NEXT JJDD
QTV(KDTV) = QTV(KDTV) + DT * (LDTV - QTV(KDTV) * DOO1)
TQTV = 0
FOR IIDD = 1 TO KDTV
  TOTV = TOTV + QTV(IIDD)
NEXT IIDD
YDTV = QTV(1) / DOO1
'DTV = INPUT RATE
'QTV = OUTPUT RATE
'TQTV = STORAGE ARRAY
'TOTV = TOTAL STORAGE
'Dtha = NUMBER OF DEATHS
'DT = DELAY
'DT = TIME STEP
'KDTV = NUMBER OF INTERMEDIATE STAGES (DIMENSION OF STORAGE ARRAY)
END SUB

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      IF VST > SNI THEN SNI = VST
      IF VST < SLO THEN SLO = VST
      ISV1 = ISV1 + 1
      SVST = SVST + VST
      VS12 = VS12 + VST
      SVS12 = SVS12 + VS12

      IF ISTV = MRLM THEN
        SNEAN = SVST / MRLM
        SSTDEV = ((SVS12 - (SVST * SVST / MRLM)) / (MRLM - 1)) ^ .5
      END IF
END IF
END SUB

*****
'DISFF.BAS SUBROUTINE
*****

DEFINT I-N
SUB DISFF (DLOC(), DAVE(), DMI())
DLOC(1, 1) = 4.4: DAVE(1, 1) = 12.2: DMI(1, 1) = 26
DLOC(1, 2) = 2.1: DAVE(1, 2) = 4.4: DMI(1, 2) = 12.6
DLOC(1, 3) = 0: DAVE(1, 3) = 1.6: DMI(1, 3) = 4.4
DLOC(1, 4) = 4.3: DAVE(1, 4) = 9.1: DMI(1, 4) = 13.9
DLOC(1, 5) = 2.4: DAVE(1, 5) = 5: DMI(1, 5) = 7.7
DLOC(1, 6) = 0: DAVE(1, 6) = 1.2: DMI(1, 6) = 5
DLOC(1, 7) = 7.6: DAVE(1, 7) = 12.5: DMI(1, 7) = 20.6
DLOC(1, 8) = 4.6: DAVE(1, 8) = 7.6: DMI(1, 8) = 12.5
DLOC(1, 9) = 0: DAVE(1, 9) = 4.6: DMI(1, 9) = 7.6
DLOC(1, 10) = 3: DAVE(1, 10) = 10: DMI(1, 10) = 15.3
DLOC(1, 11) = 0: DAVE(1, 11) = 6.5: DMI(1, 11) = 10
DLOC(1, 12) = 0: DAVE(1, 12) = 3: DMI(1, 12) = 6.5
DLOC(1, 13) = 0: DAVE(1, 13) = 5: DMI(1, 13) = 19.5
DLOC(1, 14) = 0: DAVE(1, 14) = 5: DMI(1, 14) = 19.5
DLOC(1, 15) = 0: DAVE(1, 15) = 6.5: DMI(1, 15) = 15.3

DLOC(2, 1) = 4.4: DAVE(2, 1) = 12.2: DMI(2, 1) = 26
DLOC(2, 2) = 2.1: DAVE(2, 2) = 4.4: DMI(2, 2) = 12.6
DLOC(2, 3) = 0: DAVE(2, 3) = 1.6: DMI(2, 3) = 4.4
DLOC(2, 4) = 4.3: DAVE(2, 4) = 9.1: DMI(2, 4) = 13.9
DLOC(2, 5) = 2.4: DAVE(2, 5) = 5: DMI(2, 5) = 7.7
DLOC(2, 6) = 0: DAVE(2, 6) = 1.2: DMI(2, 6) = 5
DLOC(2, 7) = 7.6: DAVE(2, 7) = 12.5: DMI(2, 7) = 20.6
DLOC(2, 8) = 4.6: DAVE(2, 8) = 7.6: DMI(2, 8) = 12.5
DLOC(2, 9) = 0: DAVE(2, 9) = 4.6: DMI(2, 9) = 7.6
DLOC(2, 10) = 6: DAVE(2, 10) = 9.2: DMI(2, 10) = 14.1
DLOC(2, 11) = 2.8: DAVE(2, 11) = 6: DMI(2, 11) = 9.2
DLOC(2, 12) = 0: DAVE(2, 12) = 2.8: DMI(2, 12) = 6
DLOC(2, 13) = 0: DAVE(2, 13) = 5: DMI(2, 13) = 19.5
DLOC(2, 14) = 0: DAVE(2, 14) = 5: DMI(2, 14) = 19.5
DLOC(2, 15) = 0: DAVE(2, 15) = 6: DMI(2, 15) = 14.1

DLOC(1, 1) = 4.4: DAVE(1, 1) = 12.2: DMI(1, 1) = 26
DLOC(1, 2) = 2.1: DAVE(1, 2) = 4.4: DMI(1, 2) = 12.6
DLOC(1, 3) = 0: DAVE(1, 3) = 1.6: DMI(1, 3) = 4.4
DLOC(1, 4) = 4.3: DAVE(1, 4) = 9.1: DMI(1, 4) = 13.9
DLOC(1, 5) = 2.4: DAVE(1, 5) = 5: DMI(1, 5) = 7.7
DLOC(1, 6) = 0: DAVE(1, 6) = 1.2: DMI(1, 6) = 5
DLOC(1, 7) = 7.6: DAVE(1, 7) = 12.5: DMI(1, 7) = 20.6
DLOC(1, 8) = 4.6: DAVE(1, 8) = 7.6: DMI(1, 8) = 12.5
DLOC(1, 9) = 0: DAVE(1, 9) = 4.6: DMI(1, 9) = 7.6
DLOC(1, 10) = 5.9: DAVE(1, 10) = 9: DMI(1, 10) = 13.8

```

```

END IF

FILES "C:\\" + DIRECTS + "\" + ".DAT": PRINT
PRINT "Choose quarter:"
PRINT #1 = 1/86      6 = 2/87
PRINT #2 = 2/86      7 = 3/87
PRINT #3 = 3/86      8 = 4/87
PRINT #4 = 4/86      9 = 1/88
PRINT #5 = 1/87      10 = 2/88 ", QUARTER

IF QUARTER = 1 THEN
  QUARS = "186": QUARMS = "485": MITM1 = 92
  ELSEIF QUARTER = 2 THEN
    QUARS = "286": QUARMS = "186": MITM1 = 90
  ELSEIF QUARTER = 3 THEN
    QUARS = "386": QUARMS = "286": MITM1 = 91
  ELSEIF QUARTER = 4 THEN
    QUARS = "486": QUARMS = "386": MITM1 = 92
  ELSEIF QUARTER = 5 THEN
    QUARS = "187": QUARMS = "486": MITM1 = 92
  ELSEIF QUARTER = 6 THEN
    QUARS = "287": QUARMS = "187": MITM1 = 90
  ELSEIF QUARTER = 7 THEN
    QUARS = "387": QUARMS = "287": MITM1 = 91
  ELSEIF QUARTER = 8 THEN
    QUARS = "487": QUARMS = "387": MITM1 = 92
  ELSEIF QUARTER = 9 THEN
    QUARS = "188": QUARMS = "487": MITM1 = 92
  ELSEIF QUARTER = 10 THEN
    QUARS = "288": QUARMS = "188": MITM1 = 90
  END IF

FILE28 = PRODS + QUARS
FILE38 = PRODS + QUARMS

OPEN "C:\\" + DIRECTS + "\" + FILE38 + ".DAT" FOR INPUT AS #3
INPUT #3, NB(3), NB(2), NB(1), NB(4), PHPP
INPUT #3, PHOSFEED(3), PHOSFEED(2), PHOSFEED(1)
INPUT #3, SOM(3), SOM(2), SOM(1), LPool(3), LPool(2), LPool(1)
INPUT #3, KDay(3), KDay(2), KDay(1)
CLOSE #3

OPEN "C:\\" + DIRECTS + "\" + FILE28 + ".DAT" FOR INPUT AS #2
INPUT #2, NE(3), NE(2), NE(1), NE(4), PHPP
INPUT #2, PHOSFEED(3), PHOSFEED(2), PHOSFEED(1)
INPUT #2, SOM(3), SOM(2), SOM(1), LPool(3), LPool(2), LPool(1)
INPUT #2, KDAYP(3), KDAYP(2), KDAYP(1), LNUM, LGMO
INPUT #2, MDTHO(3), MDTHO(2), MDTHO(1), NBMO
INPUT #2, MAND, NGRPSW, MToTmkt, MFPD, MPUR
INPUT #2, NBHC, MIT, IPO
CLOSE #2

OPEN "C:\\" + DIRECTS + "\" + FILE28 + ".MKT" FOR INPUT AS #4
INPUT #4, MKKTDAYS
REDIM MKKT(MKKTDAYS) AS INTEGER, MKTDAY(MKKTDAYS) AS INTEGER
FOR I88 = 1 TO MKKTDAYS
  INPUT #4, MKTDAY(I88)
NEXT I88

```

```

DECLARE SUB CENTROID (XC(1), XX(1))
DECLARE SUB OPTIMIZE (DELAY1, DIFF1(), AVEPOOLDAYS(1))

DEFINT I-N
.....
'OPTIMIZATION TO OBSERVE DELAY USING 'COMPLEX'
.....
DIM XX(10, 10), RR(10, 10), FF(10), CL(10), CU(10), XC(10)
DIM PIGDAYS(3, 10) AS SINGLE, DIFF(4) AS SINGLE, AVEPOOLDAYS(10) AS SINGLE
DIM NA(4) AS INTEGER, NE(4) AS INTEGER, LPool(3) AS INTEGER
DIM KDAY(3) AS INTEGER, MDTHO(3) AS INTEGER
DIM PHOSFEED(3) AS SINGLE, SOM(3) AS SINGLE
DIM KDAYP(3) AS INTEGER

COMMON SHARED /BLOCK1/ IPO AS INTEGER, MIT AS INTEGER, NBHC AS INTEGER
COMMON SHARED /BLOCK2/ MAND AS INTEGER, NGRPSW AS INTEGER, LNUM AS INTEGER
COMMON SHARED /BLOCK3/ MToTmkt AS INTEGER, MFPD AS INTEGER, LGMO AS INTEGER
COMMON SHARED /BLOCK4/ LORO AS INTEGER, MAND AS INTEGER, LPool(3) AS INTEGER
COMMON SHARED /BLOCK5/ NB(3) AS INTEGER, NE(3) AS INTEGER, LNUM AS INTEGER
COMMON SHARED /BLOCK6/ KDAY(3) AS INTEGER, MDTHO(3) AS INTEGER, NBMO AS INTEGER
COMMON SHARED /BLOCK7/ PIGDAYS(3) AS SINGLE, DIFF(4) AS SINGLE, MITM1 AS INTEGER
COMMON SHARED /BLOCK8/ MKTDAY(1) AS INTEGER, MKKT(1) AS INTEGER, MKKTDAYS AS INTEGER
COMMON SHARED /BLOCK9/ MKTDAY(1) AS INTEGER, MKKT(1) AS INTEGER, MKKTDAYS AS INTEG
-----
COMMON SHARED /BLOCK10/ MKKTDAYS(1) AS INTEGER, MKTDAY(1) AS INTEGER
COMMON SHARED /BLOCK11/ MS AS INTEGER, IEV1 AS INTEGER, KK1 AS INTEGER

CLEAR
CLS

PRINT : PRINT : PRINT : PRINT : PRINT : PRINT : PRINT : PRINT : PRINT : PRINT
PRINT "INTERACTIVE OPTIMIZATION USING 'COMPLEX'": PRINT : PRINT
---->

PRINT "Choose SHIMS producer:"
PRINT #1 = ACHMOODY
PRINT #2 = BAILEY
PRINT #3 = BALLARD
PRINT #4 = BARTON
PRINT #5 = BORTON
PRINT #6 = PRIDGEON ", PRODNUM: PRINT

IF PRODNUM = 1 THEN
  PRODS = "ACH"
  DIRECTS = "ACHMOODY"
  ELSEIF PRODNUM = 2 THEN
    PRODS = "BAIL"
    DIRECTS = "BAILEY"
  ELSEIF PRODNUM = 3 THEN
    PRODS = "BALL"
    DIRECTS = "BALLARD"
  ELSEIF PRODNUM = 4 THEN
    PRODS = "BART"
    DIRECTS = "BARTON"
  ELSEIF PRODNUM = 5 THEN
    PRODS = "BORT"
    DIRECTS = "BORTON"
  ELSEIF PRODNUM = 6 THEN
    PRODS = "PRID"
    DIRECTS = "PRIDGEON"

```

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File: C:\UTIL\DELAY.OBS      02/10/1989   18:03   --   Page: 004
CLS : PRINT : PRINT : PRINT : PRINT : PRINT : PRINT : PRINT : PR
---->PRINT
PRINT =
Calculating Delay"

'MAIN SUBROUTINE
KSTK = 0: MFE = 0
IT = 1
KCODE = 0
FOR I1 = 2 TO NV
  FOR IV = 1 TO MS
    XX(I1, IV) = 01
  NEXT IV
NEXT I1
FOR I1 = 2 TO NV
  FOR IV = 1 TO MS
    IIS = I1
    XX(I1, IV) = CL(IV) + RR(I1, IV) * (CU(IV) - CL(IV))
  NEXT IV
  KK1 = I1
  'CHECK CONSTRAINTS
  FOR IV = 1 TO MS
    IF (XX(IIS, IV) - CL(IV)) <= 0 THEN XX(IIS, IV) = CL(IV) + DELTA
    IF (CU(IV) - XX(IIS, IV)) <= 0 THEN XX(IIS, IV) = CU(IV) - DELTA
  NEXT IV
NEXT I1
KK1 = NV
FOR IIS = 1 TO NV
  'CALL FUNCTION
  MFE = MFE + 1
  DELAY = XX(IIS, 1)
  CALL OPTIMIZE(DELAY, DIFF(), AVEPOOLDAYS())
  TOPDIF = ABS(DIFF(4))
  IF ABS(DIFF(3)) > TOPDIF THEN TOPDIF = ABS(DIFF(3))
  IF ABS(DIFF(2)) > TOPDIF THEN TOPDIF = ABS(DIFF(2))
  IF ABS(DIFF(1)) > TOPDIF THEN TOPDIF = ABS(DIFF(1))
  'FF(IIS) = -1 * TOPDIF
  'FF(IIS) = -1 * (DIFF(1) ^ 2 + DIFF(2) ^ 2 + DIFF(3) ^ 2 + DIFF(4) ^ 2)
  FF(IIS) = -1 * (DIFF(1) ^ 2 + DIFF(4) ^ 2)
NEXT IIS
KOUNT = 1
IA = 0

```

```

File: C:\UTIL\DELAY.OBS      02/10/1989   18:03   --   Page: 003
FOR I89 = 1 TO MWKTDAYS
  INPUT #4, MWKT(I89)
NEXT I89
CLOSE #4
OPEN "C:\\" + DIRECTS + "\" + FILE2$ + ".MW" FOR INPUT AS #9
INPUT #9, MWDAYS
REDIM MW(MWDAYS) AS INTEGER, WMDAY(MWDAYS) AS INTEGER
FOR I98 = 1 TO MWDAYS
  INPUT #9, WMDAY(I98)
NEXT I98
FOR I99 = 1 TO MWDAYS
  INPUT #9, MWJ(I99)
NEXT I99
CLOSE #9
OPEN "C:\\" + DIRECTS + "\" + FILE3$ + ".MKT" FOR INPUT AS #7
INPUT #7, MWKTDAYSH1
REDIM MWKTDAYH1(MWKTDAYSH1) AS INTEGER
FOR I87 = 1 TO MWKTDAYSH1
  INPUT #7, MWKTDATM1(I87)
NEXT I87
CLOSE #7
STARTIME = TIMER
PRINT : PRINT
KOUNT = 0
MS = 1
MC = 1
NV = 3
ITMAX = 100
IPRINT = 0
ALPHAP = 1.4
BETA = 1
GAMMA = 5
DELTA = .0001
FOR J1 = 1 TO MS
  XX(1, J1) = 55
NEXT J1
FOR J1 = 1 TO MC
  CL(J1) = 41
  CU(J1) = 200
NEXT J1
RANDOMIZE TIMER
FOR J2 = 2 TO NV
  FOR J2 = 1 TO MS
    RR(J2, J2) = RND
  NEXT J2
NEXT J2
'CALL MAIN SUBROUTINE

```

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```

FOR ICM = 2 TO MV
  IF (FF(IEV2) - FF(ICM)) > 0 THEN IEV2 = ICM
NEXT ICM

IF (IEV2 - IEV1) <> 0 THEN EXIT DO

KSTK = KSTK + 1

IF KSTK >= 10 THEN
  PRINT : PRINT "HELP! I'M STUCK!"; BEEP
  INPUT "PERFORM OPTIMIZATION FROM THE BEGINNING (Y/N)"; ZS
  IF ZS = "Y" OR ZS = "y" THEN RUN "COMPLER"
  IF ZS = "N" OR ZS = "n" THEN END
END IF

FOR JJ = 1 TO NS
  XX(IEV1, JJ) = (XX(IEV1, JJ) + XC(JJ)) / 21
NEXT JJ

IIS = IEV1

*CHECK CONSTRAINTS

FOR IV = 1 TO NS
  IF (XX(IIS, IV) - CL(IV)) <= 0 THEN XX(IIS, IV) = CL(IV) + DELTA
  IF (CU(IV) - XX(IIS, IV)) <= 0 THEN XX(IIS, IV) = CU(IV) - DELTA
NEXT IV

*COMPUTE FUNCTION
NFE = NFE + 1
DELAY = XX(IIS, 1)
CALL OPTIMIZE(DELAY, DIFF(), AVEPOOLDAYS())
TOPDIF = ABS(DIFF(4))
IF ABS(DIFF(3)) > TOPDIF THEN TOPDIF = ABS(DIFF(3))
IF ABS(DIFF(2)) > TOPDIF THEN TOPDIF = ABS(DIFF(2))
IF ABS(DIFF(1)) > TOPDIF THEN TOPDIF = ABS(DIFF(1))
*FF(IIS) = -1 * TOPDIF
*FF(IIS) = -1 * (DIFF(1) ^ 2 + DIFF(2) ^ 2 + DIFF(3) ^ 2 + DIFF(4) ^ 2)
FF(IIS) = -1 * (DIFF(1) ^ 2 + DIFF(4) ^ 2)
LOOP '16320
KSTK = 0
IT = IT + 1
LOOP 'UNTIL (IT - ITMAX) <= 0
*****

```

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```

DO UNTIL (IT - ITMAX) <= 0
  IEV1 = 1
  FOR ICM = 2 TO MV
    IF (FF(IEV1) - FF(ICM)) > 0 THEN IEV1 = ICM
  NEXT ICM
  IEV2 = 1
  FOR ICM = 2 TO MV
    IF (FF(IEV2) - FF(ICM)) <= 0 THEN IEV2 = ICM
  NEXT ICM
  IF (FF(IEV2) - (FF(IEV1) + BETA)) < 0 THEN
    KOUNT = KOUNT + 1
    IF (KOUNT - GAMMA) < 0 THEN EXIT DO
  END IF
  IF (FF(IEV2) - (FF(IEV1) + BETA)) >= 0 THEN KOUNT = 1
  CALL CENTROID(XC(), XX())
  IF IT <= 3 * NV THEN ALPHA = 1.6 ELSE ALPHA = ALPHAP
  FOR JJ = 1 TO NS
    XX(IEV1, JJ) = (1 + ALPHA) * (XC(JJ)) - ALPHA * (XX(IEV1, JJ))
  NEXT JJ
  IIS = IEV1

*CHECK CONSTRAINTS

FOR IV = 1 TO NS
  IF (XX(IIS, IV) - CL(IV)) <= 0 THEN XX(IIS, IV) = CL(IV) + DELTA
  IF (CU(IV) - XX(IIS, IV)) <= 0 THEN XX(IIS, IV) = CU(IV) - DELTA
NEXT IV

*COMPUTE FUNCTION
NFE = NFE + 1
DELAY = XX(IIS, 1)
CALL OPTIMIZE(DELAY, DIFF(), AVEPOOLDAYS())
TOPDIF = ABS(DIFF(4))
IF ABS(DIFF(3)) > TOPDIF THEN TOPDIF = ABS(DIFF(3))
IF ABS(DIFF(2)) > TOPDIF THEN TOPDIF = ABS(DIFF(2))
IF ABS(DIFF(1)) > TOPDIF THEN TOPDIF = ABS(DIFF(1))
*FF(IIS) = -1 * TOPDIF
*FF(IIS) = -1 * (DIFF(1) ^ 2 + DIFF(2) ^ 2 + DIFF(3) ^ 2 + DIFF(4) ^ 2)
FF(IIS) = -1 * (DIFF(1) ^ 2 + DIFF(4) ^ 2)
DO '16320
  IEV2 = 1

```

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NEXT J2
CLOSE #5
TOTTIME = (EMDIME - STARTTIME) / 60
OPEN "C:\N" + DIRECTS + "\N" + FILE28 + ".CHK" FOR OUTPUT AS #6
WRITE #6, AVEPOOLDAYS(IEV2), TOTTIME
CLOSE #6
PRINT "AVE. TIME IN POOL = ", AVEPOOLDAYS(IEV2); PRINT : PRINT
PRINT "NUMBER OF ITERATIONS ="; IT; "FUNCTION EVALUATIONS ="; MFE; PRINT
PRINT "TOTAL TIME ELAPSED = "; TOTTIME; " MINUTES"
BEEP
PRINT : INPUT "RERUN OPTIMIZATION FROM THE BEGINNING (Y/N)"; Z5
IF Z5 = "Y" OR Z5 = "y" THEN RUN "COMPLEX"
IF Z5 = "N" OR Z5 = "n" THEN END
END

DEFSNG I-N
SUB CENTROID (XC(), XX())
'SUBROUTINE TO COMPUTE CENTROID
DEFINT I-N
FOR IV = 1 TO NS
  XC(IV) = 0
  FOR IL = 1 TO KK1
    XC(IV) = XC(IV) + XX(IL, IV)
  NEXT IL
  RK = KK1
  XC(IV) = (XC(IV) - XX(IEV1, IV)) / (RK - 1)
NEXT IV
END SUB

*****
'SUBROUTINE OPTIMIZE.BAS--ADAPTED FROM SHIMS.SIM
*****
DECLARE SUB DCTDEL (UDCTDI, VDCTDI, VOCTDI(), KOCTDX, DGNPOI, RNET)
DECLARE SUB DELTV (UDTVI, VDTVI, QTVI(), QTVI, DthAI, DTVI, DTI, KOTVX)
DIM PICDAYS(3, 10) AS SINGLE, DIFF(4) AS SINGLE
DIM NB(4) AS INTEGER, NE(4) AS INTEGER, LPOOL(3) AS INTEGER
DIM KDAY(3) AS INTEGER, MOINO(3) AS INTEGER
COMMON SHARED /BLOCK1/ IPD AS INTEGER, MIT AS INTEGER, NBMC AS INTEGER
COMMON SHARED /BLOCK2/ NPUR AS INTEGER, NGPSPUN AS INTEGER, ITS AS INTEGER
COMMON SHARED /BLOCK3/ NIOTMKT AS INTEGER, NPPO AS INTEGER, LMKR AS INTEGER
COMMON SHARED /BLOCK4/ LGRO AS INTEGER, NBMO AS INTEGER, NMPO AS INTEGER
COMMON SHARED /BLOCK5/ NB(3) AS INTEGER, NE(3) AS INTEGER, LPOOL(3) AS INTEGER
COMMON SHARED /BLOCK6/ KDAY(3) AS INTEGER, MOINO(3) AS INTEGER, FILE3, DIRECTS
COMMON SHARED /BLOCK7/ PICDAYS(3) AS SINGLE, DIFF(4) AS SINGLE, FILE3, DIRECTS
COMMON SHARED /BLOCK8/ UNDAY(3) AS INTEGER, MANK(3) AS INTEGER, MANDAYS AS INTEGER
COMMON SHARED /BLOCK9/ MKTDAY(3) AS INTEGER, MANK(3) AS INTEGER, MANDAYS AS INTEG

```

```

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IF (IT - ITMAX) > 0 THEN
  BEEP: PRINT "THE NUMBER OF ITERATIONS WAS EXCEEDED"; ITMAX
  PRINT "PROGRAM TERMINATED PREMATURELY"; PRINT
  INPUT "RERUN OPTIMIZATION FROM THE BEGINNING (Y/N)"; Z5
  IF Z5 = "Y" OR Z5 = "y" THEN RUN "COMPLEX"
  IF Z5 = "N" OR Z5 = "n" THEN END
END IF
FOR J2 = 1 TO NS
  XX(IEV1, J2) = XC(J2)
NEXT J2
IIS = IEV1
'COMPUTE FUNCTION
DELAY = XX(IIS, 1)
CALL OPTIMIZE(DELAY, DIFF(), AVEPOOLDAYS())
TOPDIF = ABS(DIFF(4))
IF ABS(DIFF(3)) > TOPDIF THEN TOPDIF = ABS(DIFF(3))
IF ABS(DIFF(2)) > TOPDIF THEN TOPDIF = ABS(DIFF(2))
IF ABS(DIFF(1)) > TOPDIF THEN TOPDIF = ABS(DIFF(1))
*FF(IIS) = -1 * TOPDIF
*FF(IIS) = -1 * (DIFF(1) ^ 2 + DIFF(2) ^ 2 + DIFF(3) ^ 2 + DIFF(4) ^ 2)
FF(IIS) = -1 * (DIFF(1) ^ 2 + DIFF(4) ^ 2)
EMDIME = TIMER
CLS : PRINT "VALUE OF THE FUNCTION AT THE CENTROID = "; FF(IEV1); PRINT
PRINT "COORDINATES OF THE CENTROID: ";
FOR J2 = 1 TO NS
  PRINT "XC("; J2; ") ="; XC(J2); PRINT
NEXT J2
FOR JINSPIGS = 1 TO 3
  PRINT "PICDAYS("; JINSPIGS; ") ="; PICDAYS(JINSPIGS, IEV1),
NEXT JINSPIGS
NEXT J2
PRINT "AVE. TIME IN POOL = ", AVEPOOLDAYS(IEV1); PRINT : PRINT
PRINT "BEST NON-CENTROID VALUE OF THE FUNCTION = "; FF(IEV2); PRINT
PRINT "BEST NON-CENTROID X VALUE: ";
OPEN "C:\N" + DIRECTS + "\N" + FILE28 + ".DEL" FOR OUTPUT AS #5
FOR J2 = 1 TO NS
  TOTDEL = XX(IEV2, J2) + AVEPOOLDAYS(IEV2)
  WRITE #5, TOTDEL
  PRINT "X("; J2; ") ="; XX(IEV2, J2); PRINT
  FOR JINSPIGS2 = 1 TO 3
    PRINT "PICDAYS("; JINSPIGS2; ") ="; PICDAYS(JINSPIGS2, IEV2),
    WRITE #5, PICDAYS(JINSPIGS2, IEV2)
  NEXT JINSPIGS2

```



```

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FOR 132 = 1 TO NUMGRP
  RMR(KDAY(3) + ((132 - 1) * LPOOL(3))) = RMRNUM
  RMR(KDAY(3) + ((132 - 1) * LPOOL(3))) = RMRNUM
NEXT 132

FOR 133 = 1 TO MGROGP
  RGRO(KDAY(2) + ((133 - 1) * LPOOL(2))) = RGRONUM
NEXT 133

TOTINVB = RNB(3) + RNB(2) + RNB(1) 'calculate total beginning MCF Inventory
TotInV = RNE(3) + RNE(2) + RNE(1) 'calculate total ending MCF Inventory
DTot = TOTINVB - TotInV 'calculates the change in total MCF Inventory
MADO = ME(4) - MB(4) - MPUR + MMD + MWC 'calculates glts added to herd
MTooth = MOTH(3) + MOTH(2) + MOTH(1) 'calculates total MCF deaths

'The following section distributes the projected feeder pig sales
  over the upcoming quarter.
  TFPs = 0
  IV = 1: IV1 = 1
  IFIN = 1
  IF = 0: IF = 0
  IMEANED = 0: IMEANED1 = 0
  IMFGSOLD = 0
  TMOGSOLO = 0
  FPOEST = 0 'FEEDER PIG GROUP COUNTER
  TOTOUTGRO = 0 'FEEDER PIG DEBT INITIALIZED
  TOTINFIN = 0
  TOTOUTMUR = 0: TOTOUTMUR1 = 0
  TOTINGRO = 0
  TOTOUTFIN = 0
  TOTDELIN = 0
  TOTINMUR = 0: TOTINMUR1 = 0
  POOLAYS = 0

'The following section performs the "modified" simulation
DO WHILE 18 < MIT
  18 = 18 + 1 'update counters
  RINMUR = 0 'initialize flow rates into MURSEY
  Mmean1 = 0 'initialize number of pigs weaned

  IF 18 = LNDAY(IV1) THEN
    Mmean1 = MUR(IV1)
    RINMUR = CSNG(Mmean1)
    IMEANED1 = IMEANED1 + Mmean1
    IV1 = IV1 + 1
    IF IV1 > NUMDAYS THEN IV1 = 1
  END IF

  TOTINMUR1 = TOTINMUR1 + RINMUR
  CALL DCTDEL(RINMUR, RQUTMUR, RMR1(1), LMUR, DthPOOMUR, RMRUMUR)
  TOTOUTMUR1 = TOTOUTMUR1 + RQUTMUR

  LOOP '18

DO WHILE 17 < MIT
  17 = 17 + 1 'update counters

```

```

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*****ER
COMMON SHARED /BLOCK10/ MMTDAYS#1 AS INTEGER, MKTDAY#1(1) AS INTEGER
'OPTIMIZATION ROUTINE TO DISCOVER OBSERVED DELAYS

DEFINT I-N
SUB OPTIMIZE (DELAY, DIFF(), AVEPOOLDAYS())
  DIM TOTDTHSIN(3) AS SINGLE, DthPIG(3) AS SINGLE
  DIM RIN(3) AS SINGLE, RQUT(3) AS SINGLE
  DIM RMC(3) AS SINGLE, RNE(3) AS SINGLE, RNB(3) AS SINGLE
  DIM MPUR(15) AS INTEGER, KDAY(3) AS INTEGER
  DIM MPUR(15) AS INTEGER, KDAY(3) AS INTEGER
  DIM RGROTEMP(12) AS SINGLE, RMRTEMP(12) AS SINGLE

  K = 40
  IPO = 1

  REDIM QTV(K) AS SINGLE
  REDIM RMR(LMUR) AS SINGLE
  REDIM RMR1(LMUR) AS SINGLE
  REDIM RGRO(LGRO) AS SINGLE

  FOR 13 = 1 TO 3
    KDAY(13) = KDAY(13)
    PIGDAYS(13, 116) = 0
    TOTDTHSIN(13) = 0
    RMC(13) = CSNG(ME(13))
    RNB(13) = CSNG(MB(13))
    RNE(13) = RNB(13)

    'calculate number of deaths per iteration
    DthPIG(13) = (MOTH(13) / MIT) / IPO
  NEXT 13

  RMCUR = RMC(3)
  'initialize finisher pool
  POOLM = MKT(1) = ((MIT#1 - MKTDAY#1(MMTDAYS#1)) / ((MIT#1 - MKTDAY#1(MMTDA
  -----YS#1))) + MKTDAY(1))
  DELMB = RNB(1) - POOLM
  FSTART = DELMB
  FOR 12 = 1 TO K
    QTV(12) = DELMB / K
  NEXT 12

  DthPOOMUR = DthPIG(3) * IPO
  DthPOGRO = DthPIG(2) * IPO

  NUMGRP = LMUR / LPOOL(3)
  RMRNUM = RNB(3) / NUMGRP
  MGROGP = LGRO / LPOOL(2)
  RGRONUM = RNB(2) / MGROGP

  'initialize discrete delays
  FOR 130 = 1 TO LMUR
    RMR1(130) = 0
    RMR1(130) = 0
  NEXT 130

  FOR 131 = 1 TO LGRO
    RGRO(131) = 0
  NEXT 131

```

```

FOR I8 = 1 TO 3
  RIN(I8) = 0
NEXT I8

      'Initialize flow rates into phases

      MoutFin = 0
      'Initialize number of pigs marketed
      Mwean = 0
      'Initialize number of pigs weaned

      IF I7 = MDAY(IU) THEN
        Mwean = Mwean(IU)
        RIN(3) = CSNG(Mwean)
        Mwean = Mwean + Mwean
        IU = IU + 1
      END IF

      TOTINMUR = TOTINMUR + RIN(3)
      CALL DCTDEL(RIN(3), ROUT(3), RMUR(1), LMUR, DthPDUGRO, RNC(3))
      TOTOUTMUR = TOTOUTMUR + ROUT(3)
      TOTDTHSIN(3) = TOTDTHSIN(3) + DthPDUGRO
      RNC(3) = 0

      FOR I36 = 1 TO LMUR
        RNC(3) = RNC(3) + RMUR(I36)
      NEXT I36

      PIGDAYS(3, IIS) = PIGDAYS(3, IIS) + RNC(3)

      RIN(2) = ROUT(3) - ((ROUT(3) / TOTOUTMUR) * MFPO)
      TFPS = TFPS + ((ROUT(3) / TOTOUTMUR) * MFPO)

      TOTINGRO = TOTINGRO + RIN(2)
      CALL DCTDEL(RIN(2), ROUT(2), RGRO(1), LGRO, DthPDUGRO, RNC(2))
      TOTDTHSIN(2) = TOTDTHSIN(2) + DthPDUGRO
      TOTOUTGRO = TOTOUTGRO + ROUT(2)
      RNC(2) = 0

      FOR I35 = 1 TO LGRO
        RNC(2) = RNC(2) + RGRO(I35)
      NEXT I35

      PIGDAYS(2, IIS) = PIGDAYS(2, IIS) + RNC(2)

      RIN(1) = ROUT(2)
      I9 = 0

      SDC = 1 / IPO
      DO WHILE I9 < IPO
        I9 = I9 + 1

        DELDTM = DthPITOC(1) * DELNB / (DELNB + POOLM)

        PoolDth = DthPITOC(1) * POOLM / (DELNB + POOLM)
        TOTINFN = TOTINFN + RIN(1)
        CALL DELTV(RIN(1), ROUT(1), QTV(1), DELNB, DELDTM, DELAY, SDC, K)
        TOTOUTFN = TOTOUTFN + ROUT(1)
        TOTDELDTM = TOTDELDTM + DELDTM
        TOTDTHSIN(1) = TOTDTHSIN(1) + DELDTM + PoolDth

        POOLM = POOLM - PoolDth + (ROUT(1) * SDC)
        POOLDAYS = POOLDAYS + (POOLM * SDC)

```

```

      RNC(1) = POOLM + DELNB
      PIGDAYS(1, IIS) = PIGDAYS(1, IIS) + (RNC(1) * SDC)
    LOOP
      'I9
      IF I7 = MKTDAY(IFIN) THEN
        MoutFin = CINT(POOLM)
        THOGSOLD = THOGSOLD + POOLM
        RNC(1) = RNC(1) - POOLM
        POOLM = 0
        IFIN = IFIN + 1
      END IF

      IF I7 = MKTDAY(MKTDAYS) THEN IFIN = 1

      FOR I17 = 1 TO 3
        MDAY(I17) = MDAY(I17) + 1
        IF MDAY(I17) > LPOOL(I17) THEN MDAY(I17) = 1
      NEXT I17

      IF IU > MWANDAYS THEN IU = 1
    LOOP
      'I7
      DIFF(4) = THOGSOLD - NTOTMKT - MADO
      DIFF(3) = RNC(3) - RNE(3)
      DIFF(2) = RNC(2) - RNE(2)
      DIFF(1) = RNC(1) - RNE(1)
      AVEPOOLDAYS(IIS) = POOLDAYS / THOGSOLD
    END SUB

    *****
    'SUBROUTINE DELTV.BAS
    *****

    DEFINIT I-N
    SUB DELTV (UDTV, YDTV, QTV(), TQTV, Dths, DTV, DT, KDTV) STATIC
      DDO1 = QTV / KDTV
      BDO1 = 1 / DDO1
      KDTV = KDTV - 1
      FOR JJ00 = 1 TO KDTV1
        QTV(JJ00) = QTV(JJ00) + DT * (QTV(JJ00 + 1) / DDO1 - QTV(JJ00) * BDO1) - (Dths *
        ----> QTV(JJ00) / TQTV)
      NEXT JJ00
      QTV(KDTV) = QTV(KDTV) + DT * (UDTV - QTV(KDTV) * BDO1)
      TQTV = 0
      FOR I100 = 1 TO KDTV
        TQTV = TQTV + QTV(I100)
      NEXT I100
      YDTV = QTV(1) / DDO1

      'UDTV = INPUT RATE
      'YDTV = OUTPUT RATE
      'QTV = STORAGE ARRAY
      'Dths = TOTAL STORAGE
      'DT = NUMBER OF DEATHS
      'DTV = DELAY
      'DT = TIME STEP
      'KDTV = NUMBER OF INTERMEDIATE STAGES (DIMENSION OF STORAGE ARRAY)
    END SUB

```

```

File: C:\UTIL\DELAY.OBS           02/10/1989  18:04  --  Page: 013
*****
SUBROUTINE DCTDEL BAS
*****
DEFINT I-M
SUB DCTDEL (UDCTD, YDCTD, VOCTD( ), KDCTD, DINPD, RNE) STATIC
IF RNE > 0 THEN
  YDCTD = VOCTD(KDCTD)
  FOR IJK = KDCTD - 1 TO 1 STEP -1
    VOCTD(IJK + 1) = VOCTD(IJK) - ((VOCTD(IJK) / RNE) * DINPD)
  NEXT IJK
  VOCTD(1) = UDCTD
END IF
IF RNE = 0 THEN
  YDCTD = VOCTD(KDCTD)
  FOR IJK = KDCTD - 1 TO 1 STEP -1
    VOCTD(IJK + 1) = VOCTD(IJK)
  NEXT IJK
  VOCTD(1) = UDCTD
END IF
RENAME DCTDEL--DISCRETE DELAY
REN UDCTD=INPUT
REN YDCTD=OUTPUT
REN KDCTD(VOCTD)=NUMBER OF STAGES
REN VOCTD( ) IS THE ARRAY OF MEMORY CELLS
END SUB

```

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File: C:\UTIL\ABTOPT.FLE

```
ELSEIF PROOMUM = 4 THEN
  NFOZ = 2
  PRODS = "BAR"
  DIRECTS = "BARTON"
ELSEIF PROOMUM = 5 THEN
  NFOZ = 1
  PRODS = "WOR"
  DIRECTS = "WORTON"
ELSEIF PROOMUM = 6 THEN
  PRODS = "PRID"
  DIRECTS = "PRIDGEOM"
```

END IF

WGRS(1)	"DISEASE RATES #1"
WGRS(2)	"DISEASE RATES #2"
WGRS(3)	"DISEASE RATES #3"
WGRS(4)	"DISEASE RATES #4"
WGRS(5)	"EXPENSES #1"
WGRS(6)	"EXPENSES #2"
WGRS(7)	"EXPENSES #3"
WGRS(8)	"EXPENSES #4"
WGRS(9)	"FEED CONSUMPTION"
WGRS(10)	"MARKET WEIGHT"
WGRS(11)	"MARKET PRICE"
WGRS(12)	"DEATH LOSSES"

[illegible]

```

IF WGROUP = 1 THEN
  NSTART = 1; NEND = 4
  BETA = 1E-09
  EXIS = 'DRY'; NS = 4; NV = 8
  FOR I99 = NSTART TO NEND
    WOPEN(I99) = .00001
  
```

```

NEXT 199
END IF
IF NGROUP = 2 THEN
  NSTART = 5: NEND = 8
  BETA = 1E-09
  EXIS = "DR2": NS = 4: NV = 8
  FOR 199 = NSTART TO NEND
    WPN(199) = .00001
  NEXT 199

```

```

END IF
IF NGROUP = 3 THEN
  NSTART = 9: NEND = 12
  BETA = 1E-09
  EXIS = "DR3": NS = 4: NV = 8
  FOR I99 = NSTART TO NEND
    LPEN(I99) = .00001
  
```

```

NEXT I99
END IF
IF NGROUP = 4 THEN
  NSTART = 13: NEND = 15
  BETA = 1E-09
  EXIS = "DR4": NS = 3: NV = 8
  FOR I99 = NSTART TO NEND
    LPEN(I99) = 00001
  
```

FILE: C:\MY11\ASTORY.ELE 02/10/1989 18:04 -- Page: 001

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```
DECLARE SUB TRACK2 (TBETA1(), MFOX)
DECLARE SUB TRACKER (TBETA1(), DIFFSQ, NFOX)
DECLARE SUB CENTROID (XC1(), XXI())
```

OPTIMIZATION TO DEFINE ALPHA-BETA TRACKER PARAMETERS USING 'COMPLEX'

DEFINITION

DIM XX(40, 40) AS SINGLE
DIM RR(40, 40) AS SINGLE
DIM FF(40) AS SINGLE
DIM CL(40) AS SINGLE
DIM CU(40) AS SINGLE
DIM XC(40) AS SINGLE
DIM QUARS(10)
DIM TBETA(40) AS SINGLE
DIM UK(10, 39) AS SINGLE
DIM WPN(39) AS SINGLE
DIM WGRS(12)

```
COMMON SHARED /BLOCK1/ MQUARTER AS INTEGER, PRODS, DIRECTS, QUARTS(), UK() AS SIM
-->GLE
COMMON SHARED /BLOCK2/ MSTART AS INTEGER, MEMO AS INTEGER, EXTS, KK1 AS INTEGER,
-->IEV1 AS INTEGER
COMMON SHARED /BLOCK3/ MPEN() AS SINGLE
```

0 = 2007

FINISH = 0

0 = 0001 3111 00

CLEAR
CLS $\mathbf{11002} = 0$ 0 = NSINIL
0 = 40071

FOR INIT = 1 TO 8: PRINT : NEXT INIT

SHIMS Alpha-Beta Tracker Routine": PRINT : PRINT

---: PRINT

```
PRINT "*****"  
PRINT  
PRINT "*****"  
PRINT  
PRINT "*****"  
PRINT  
PRINT "*****"  
PRINT  
PRINT "*****"  
  
Choose SHIMS producer?: PRINT  
1 = ACHMOODY "  
2 = BAILEY "  
3 = BALLARD "  
4 = BARTON "  
5 = NORTHON "  
6 = PRITGEOM "  
PRCNUMM:
```

-----: PRINCE

```
F PROOM = 1 THEN  
PROOS = "ACH"  
DIRECTS = "ACHOODY"  
ELSEIF PROOM = 2 THEN  
MFOX = 1  
PROOS = "BAIL"  
DIRECTS = "BAILEY"  
ELSEIF PROOM = 3 THEN  
MFOX = 1  
PROOS = "BALL"  
DIRECTS = "BALLABO"
```

```

File: C:\UTIL\ABTOPT.FLE                                02/10/1989   18:04   -- Page: 004

KOUNT = 0
MC = MS
ITMAX = 1000
IPRINT = 0
ALPHA = 1.4
GAMMA = 5
DELTA = .0001

FOR J1 = NSTART TO NEND
  XX(1, J1) = 2
NEXT J1

FOR J1 = NSTART TO NEND
  CL(J1) = 0
  CU(J1) = 4
NEXT J1

FOR J2 = 2 TO NV
  FOR J2 = NSTART TO NEND
    RR(12, J2) = RND
  NEXT J2
NEXT J2

'CALL MAIN SUBROUTINE

CLS : PRINT : PRINT : PRINT : PRINT : PRINT : PRINT : PR
---->PRINT
PRINT "
Calculating Beta Values"
*****

'MAIN SUBROUTINE

KSTK = 0: MFE = 0
IT = 1
KCODE = 0

FOR I1 = 2 TO NV
  FOR IV = NSTART TO NEND
    XX(11, IV) = 01
  NEXT IV
NEXT I1

FOR I1 = 2 TO NV
  FOR IV = NSTART TO NEND
    IIS = 11
    XX(11, IV) = CL(IV) + RR(11, IV) + (CU(IV) - CL(IV))
  NEXT IV
  KK1 = I1

'CHECK CONSTRAINTS

FOR IV = NSTART TO NEND
  IF (XX(11S, IV) - CL(IV)) <= 0 THEN XX(11S, IV) = CL(IV) + DELTA
  IF (CU(IV) - XX(11S, IV)) <= 0 THEN XX(11S, IV) = CU(IV) - DELTA
NEXT IV

NEXT I1
KK1 = NV

FOR IIS = 1 TO NV

```

```

File: C:\UTIL\ABTOPT.FLE                                02/10/1989   18:04   -- Page: 003

NEXT 199
END IF
IF NGROUP = 5 THEN
  NSTART = 16: MEMO = 19: BETA = .001: EXTS = "EX1": MS = 4: NV = 8
  FOR 199 = NSTART TO NEND
    UPEN(199) = 10
  NEXT 199
END IF
IF NGROUP = 6 THEN
  NSTART = 20: MEMO = 23: BETA = .001: EXTS = "EX2": MS = 4: NV = 8
  FOR 199 = NSTART TO NEND
    UPEN(199) = 10
  NEXT 199
END IF
IF NGROUP = 7 THEN
  NSTART = 24: MEMO = 27: BETA = .001: EXTS = "EX3": MS = 4: NV = 8
  FOR 199 = NSTART TO NEND
    UPEN(199) = 10
  NEXT 199
END IF
IF NGROUP = 8 THEN
  NSTART = 28: MEMO = 31: BETA = .001: EXTS = "EX4": MS = 4: NV = 8
  FOR 199 = NSTART TO NEND
    UPEN(199) = 10
  NEXT 199
END IF
IF NGROUP = 9 THEN
  NSTART = 32: MEMO = 34: BETA = .0000001: EXTS = "FPD": MS = 3: NV = 5
  FOR 199 = NSTART TO NEND
    UPEN(199) = .001
  NEXT 199
END IF
IF NGROUP = 10 THEN
  NSTART = 35: MEMO = 35: BETA = .01: EXTS = "MJT": MS = 1: NV = 3
  FOR 199 = NSTART TO NEND
    UPEN(199) = 100
  NEXT 199
END IF
IF NGROUP = 11 THEN
  NSTART = 36: MEMO = 36: BETA = .001: EXTS = "MPR": MS = 1: NV = 5
  FOR 199 = NSTART TO NEND
    UPEN(199) = 10
  NEXT 199
END IF
IF NGROUP = 12 THEN
  NSTART = 37: MEMO = 39: BETA = .00001: EXTS = "DTM": MS = 3: NV = 5
  FOR 199 = NSTART TO NEND
    UPEN(199) = .1
  NEXT 199
END IF
PRINT : PRINT

FILES "C:\\" + DIRECT$ + "\" + EXTS + "\" + EXTS + "\" + EXTS: PRINT : PRINT
PRINT "
Choose quarter to use for projection:" : PRINT
1 = 1/86
2 = 2/86
3 = 3/86
4 = 4/86
5 = 5/86
7 = 7/87
8 = 8/87
9 = 9/87
10 = 10/88
, NOQUARTER

QUARS(1) = "166": QUARS(2) = "266": QUARS(3) = "366": QUARS(4) = "466"
QUARS(5) = "187": QUARS(6) = "287": QUARS(7) = "387": QUARS(8) = "487"
QUARS(9) = "168": QUARS(10) = "268"

STARTTIME = TIMER
PRINT : PRINT

```

```

File: C:\UTIL\LABTOPT.FILE                                02/10/1989  18:05  --  Page: 006

CALL TRACKER(TRBETA(), DIFFSQ, MFOX)
FF(IIS) = -1 * DIFFSQ
LOOP2 = 1
DO WHILE LOOP2 = 1
  FOR ICH = 2 TO NV
    IEV2 = 1
    IF (FF(IEV2) - FF(ICH)) > 0 THEN IEV2 = ICH
  NEXT ICH
  IF (IEV2 - IEV1) <> 0 THEN LOOP2 = 0
  IF (IEV2 - IEV1) = 0 THEN
    KSTK = KSTK + 1
    IF KSTK >= 10 THEN
      PRINT : PRINT "HELP! I'M STUCK!"; BEEP
      INPUT "RERUN OPTIMIZATION FROM THE BEGINNING (Y/N)"; ZS
      IF ZS = "Y" OR ZS = "y" THEN
        LOOP = 1
        LOOP2 = 0
      END IF
    ELSE IF
      IF ZS = "N" OR ZS = "n" THEN
        LOOP = 2
        LOOP2 = 0
      END IF
    END IF
  END IF
  FOR JJ = NSTART TO NEND
    XX(IEV1, JJ) = (XX(IEV1, JJ) + XC(JJ)) / 21
  NEXT JJ
  IIS = IEV1
  'CHECK CONSTRAINTS
  FOR IV = NSTART TO NEND
    IF (XX(IIS, IV) - CL(IV)) <= 0 THEN XX(IIS, IV) = CL(IV) + DELTA
    IF (CU(IV) - XX(IIS, IV)) <= 0 THEN XX(IIS, IV) = CU(IV) - DELTA
  NEXT IV
  MFE = MFE + 1
  FOR JIM1 = NSTART TO NEND
    TRBETA(JIM1) = XX(IIS, JIM1)
  NEXT JIM1
  CALL TRACKER(TRBETA(), DIFFSQ, MFOX)
  FF(IIS) = -1 * DIFFSQ
  LOOP IF 'LOOP2 = 1
  IF LOOP > 0 THEN LOOP3 = 1
  KSTK = 0
  IT = IT + 1
  END IF 'IF LOOP3 = 0
  LOOP 'WHILE LOOP3 = 0
  .....
  IF LOOP > 0 THEN
    IF FINISH = 1
      IF LOOP = 1 THEN LOOP = 0
    END IF
  END IF
  IF (IT - ITMAX) > 0 THEN
    IF FINISH = 1
      BEEP: PRINT "THE NUMBER OF ITERATIONS HAS EXCEEDED"; ITMAX
      PRINT "PROGRAM TERMINATED PREMATURELY"; PRINT
      INPUT "RERUN OPTIMIZATION FROM THE BEGINNING (Y/N)"; ZS
      IF ZS = "Y" OR ZS = "y" THEN LOOP = 0
      IF ZS = "N" OR ZS = "n" THEN LOOP = 2
    END IF
  END IF

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'CALL FUNCTION
MFE = MFE + 1
FOR JIM1 = NSTART TO NEND
  TRBETA(JIM1) = XX(IIS, JIM1)
NEXT JIM1
CALL TRACKER(TRBETA(), DIFFSQ, MFOX)
FF(IIS) = -1 * DIFFSQ
NEXT IIS
COUNT = 1
IA = 0
LOOP3 = 0
DO WHILE LOOP3 = 0
  IEV1 = 1
  FOR ICH = 2 TO NV
    IF (FF(IEV1) - FF(ICH)) > 0 THEN IEV1 = ICH
  NEXT ICH
  IEV2 = 1
  FOR ICH = 2 TO NV
    IF (FF(IEV2) - FF(ICH)) <= 0 THEN IEV2 = ICH
  NEXT ICH
  IF (FF(IEV2) - (FF(IEV1) + BETA)) < 0 THEN
    COUNT = COUNT + 1
    IF (COUNT - GAMMA) >= 0 THEN LOOP3 = 1
  END IF
  IF LOOP3 = 0 THEN
    IF (FF(IEV2) - (FF(IEV1) + BETA)) >= 0 THEN COUNT = 1
  END IF
  CALL CENTROID(XC(), XX())
  IF IT <= 3 * NV THEN ALPHA = 1.6 ELSE ALPHA = ALPHAP
  FOR JJ = NSTART TO NEND
    XX(IEV1, JJ) = (IT + ALPHA) * (XC(JJ)) - ALPHA * (XX(IEV1, JJ))
  NEXT JJ
  IIS = IEV1
  'CHECK CONSTRAINTS
  FOR IV = NSTART TO NEND
    IF (XX(IIS, IV) - CL(IV)) <= 0 THEN XX(IIS, IV) = CL(IV) + DELTA
    IF (CU(IV) - XX(IIS, IV)) <= 0 THEN XX(IIS, IV) = CU(IV) - DELTA
  NEXT IV
  'COMPUTE FUNCTION
  MFE = MFE + 1
  FOR JIM1 = NSTART TO NEND
    TRBETA(JIM1) = XX(IIS, JIM1)
  NEXT JIM1

```

```

IF IFINISH = 0 THEN
  FOR J2 = NSTART TO NEND
    XX(IEV1, J2) = XC(J2)
  NEXT J2

  IIS = IEV1

  FOR JIM1 = NSTART TO NEND
    TRBETA(JIM1) = XX(IIS, JIM1)
  NEXT JIM1

  CALL TRACKER(TRBETA(), DIFFSQ, NFOQ)

  FF(IIS) = -1 * DIFFSQ

  ENOTIME = TIMER
  TOTTIME = (ENOTIME - STARTTIME) / 60
  TRBETA(40) = TOTTIME

  CLS : PRINT "PRODUCER: "; DIRECTS; "    QUARTER: "; QUARS(MQUARTER);
  -----> "    GROUP: "; NGRS(NGROUP)
  PRINT "PRINT "VALUE OF THE FUNCTION AT THE CENTROID = ", FF(IEV1): PRINT
  PRINT "COORDINATES OF THE CENTROID: "
  FOR J2 = NSTART TO NEND
    PRINT "XC("; J2; ") = "; XC(J2),
  NEXT J2

  PRINT

  PRINT "BEST NON-CENTROID VALUE OF THE FUNCTION = ", FF(IEV2): PRINT
  PRINT "BEST NON-CENTROID X VALUE: "
  FOR J2 = NSTART TO NEND
    PRINT "X("; J2; ") = "; XX(IEV2, J2),
  NEXT J2

  CALL TRACK2(TRBETA(), NFOQ) 'WRITES NEW ABT VALUES TO FILES

  PRINT

  PRINT "NUMBER OF ITERATIONS = "; IT; "FUNCTION EVALUATIONS = "; NFE: PRINT
  PRINT "TOTAL TIME CONSUMED IN OPTIMIZATION = "; TOTTIME; " MINUTES"
  BEEP
  PRINT

  INPUT "RERUN OPTIMIZATION FROM THE BEGINNING (Y/N)"; ZS
  IF ZS = "Y" OR ZS = "y" THEN ILOOP = 0
  IF ZS = "N" OR ZS = "n" THEN ILOOP = 2

END IF 'IFINISH
LOOP 'ILOOP=0
END

DEFNSG I-N
SUB CENTROID (XC(), XX())
  'SUBROUTINE TO COMPUTE CENTROID

  FOR IV = NSTART TO NEND
    XC(IV) = 0

    FOR IL = 1 TO KK1

```

```

    XC(IV) = XC(IV) + XX(IL, IV)
  NEXT IL

  RK = KK1
  XC(IV) = (XC(IV) - XX(IEV1, IV)) / (RK - 1)

  NEXT IV

END SUB

'----->
'SUBROUTINE TRACK2.BAS
'----->
DIM QUARS(10)
DIM UK(10, 39) AS SINGLE
COMMON SHARED /BLOCK1/ MQUARTER AS INTEGER, PRODS, DIRECTS, QUARS(), UK() AS SIM
----->GLE
COMMON SHARED /BLOCK2/ NSTART AS INTEGER, NEND AS INTEGER, EXTS, KK1 AS INTEGER,
-----> IEV1 AS INTEGER
SUB TRACK2 (TRBETA(), NFOQ)
  DEFINIT I-N

  DIM ALPHA(39) AS SINGLE
  DIM YPK(11, 39) AS SINGLE
  DIM YK(10, 39) AS SINGLE
  DIM YK(10, 39) AS SINGLE
  FOR I9 = NSTART TO NEND
    ALPHA(I9) = (2 * (TRBETA(I9) - .5)) - TRBETA(I9)
  NEXT I9

  OPEN "C:\\" + DIRECTS + "\\" + EXTS + "\\" + PRODS + QUARS(NFOQ) + ".\" + EXTS
  FOR I13 = NSTART TO NEND
    INPUT #3, UK(NFOQ, I13), YK(NFOQ, I13), YK(NFOQ, I13), YPK(NFOQ + 1, I
    IF YK(NFOQ, I13) < 0 THEN YK(NFOQ, I13) = 0
    IF YPK(NFOQ + 1, I13) < 0 THEN YPK(NFOQ + 1, I13) = 0
  NEXT I13
  CLOSE #3

  IF MQUARTER > (NFOQ + 1) THEN
    FOR I12 = (NFOQ + 1) TO (MQUARTER - 1)
      FILESTRS = "C:\\" + DIRECTS + "\\" + EXTS + "\\" + PRODS + STRS(MQUARTER - 1),
      1) + PRODS + QUARS(I12) + ".\" + EXTS
      OPEN FILESTRS FOR INPUT AS #3
      FOR I13 = NSTART TO NEND
        INPUT #3, UK(I12, I13), YK(I12, I13), YK(I12, I13), YPK(I12 + 1, I13)
        IF YK(I12, I13) < 0 THEN YK(I12, I13) = 0
        IF YPK(I12 + 1, I13) < 0 THEN YPK(I12 + 1, I13) = 0
      NEXT I13
    CLOSE #3
  NEXT I12

```

```

END IF
FOR I7 = (NFOZ + 1) TO NQUARTER
    FILESTRS = "C:\\" + DIRECTS + "\" + EXTS + "\" + RIGHTS(STRS(NQUARTER), 1)
    -----> PRODS + QUARS(I7) + ".\" + EXTS
    OPEN FILESTRS FOR OUTPUT AS #1
    FOR I8 = NSTART TO NEND
        YK(I7, I8) = YPK(I7, I8) + (ALPHA(I8) * (UK(I7, I8) - YPK(I7, I8)))
        YK(I7, I8) = YK(I7 - 1, I8) + (TBETA(I8) * (UK(I7, I8) - YK(I7, I8)))
        YPK(I7 + 1, I8) = YK(I7, I8) + YK(I7, I8)
        WRITE #1, UK(I7, I8), YK(I7, I8), YK(I7, I8), YPK(I7 + 1, I8)
    NEXT I8
    CLOSE #1
NEXT I7
FILESTRS = "C:\\" + DIRECTS + "\" + EXTS + "\" + RIGHTS(STRS(NQUARTER), 1)
-----> PRODS + QUARS(NQUARTER) + ".TRB"
OPEN FILESTRS FOR OUTPUT AS #1
FOR I83 = NSTART TO NEND
    WRITE #1, TBETA(I83) 'SAVES BETAS TO FILE
NEXT I83
WRITE #1, TBETA(40) 'SAVES TOTAL RUNTIME TO FILE
CLOSE #1
END SUB

*****
***** SUBROUTINE TRACKER.BAS *****
*****
DIM QUARS(10)
DIM UK(10, 39) AS SINGLE
DIM MPEN(39) AS SINGLE
COMMON SHARED /BLOCK1/ NQUARTER AS INTEGER, PRODS, DIRECTS, QUARS(), UK() AS SIN
----->GLE
COMMON SHARED /BLOCK2/ NSTART AS INTEGER, NEND AS INTEGER, EXTS, KK1 AS INTEGER,
-----> IEV1 AS INTLGR
COMMON SHARED /BLOCK3/ MPEN() AS SINGLE
SUB TRACKER (TBETA(), DIFFSQ, NFOZ)
    DIM NE(4) AS INTEGER
    DIM PRODSPEED(3) AS SINGLE
    DIM SON(3) AS SINGLE
    DIM LPOOL(3) AS INTEGER
    DIM KDAY(3) AS INTEGER
    DIM MOTHO(3) AS INTEGER
    DIM DRO(15) AS SINGLE
    DIM NFPS(15) AS INTEGER
    DIM NPM(15) AS INTEGER
    DIM NFADY(3, 5) AS INTEGER
    DIM EXPS(16) AS SINGLE
    DIM EXPDAYS(3) AS SINGLE
    DIM YK(10, 39) AS SINGLE
    NE(1) = NQUARTER
    OPEN "C:\\" + DIRECTS + "\" + PRODS + QUARS(11) + ".DAT" FOR INPUT AS #1
    INPUT #1, NE(3), NE(2), NE(1), NE(4), PHPP
    INPUT #1, PRODSPEED(3), PRODSPEED(2), PRODSPEED(1)
    INPUT #1, SON(3), SON(2), SON(1), LPOOL(3), LPOOL(2), LPOOL(1)
    INPUT #1, KDAY(3), KDAY(2), KDAY(1), LNUM, LEND
    INPUT #1, MOTHO(3), MOTHO(2), MOTHO(1), NEND
    INPUT #1, NPMO, NGRPAUN, NFOHNET, NFPO, NPMUR
    INPUT #1, NBMC, NIT IP6, DRO(3), NFPS(11), NPM(11)
    INPUT #1, DRO(2), NFPS(2), NPM(2), DRO(1), NFPS(3), NPM(3)
    INPUT #1, DRO(4), NFPS(4), NPM(4), DRO(5), NFPS(5), NPM(5)
    INPUT #1, DRO(6), NFPS(6), NPM(6), DRO(7), NFPS(7), NPM(7)
    INPUT #1, DRO(8), NFPS(8), NPM(8), DRO(9), NFPS(9), NPM(9)
    INPUT #1, DRO(10), NFPS(10), NPM(10), DRO(11), NFPS(11), NPM(11)
    INPUT #1, DRO(12), NFPS(12), NPM(12), DRO(13), NFPS(13), NPM(13)
    INPUT #1, DRO(14), NFPS(14), NPM(14), DRO(15), NFPS(15), NPM(15)
    INPUT #1, FAC(3, 1), NFADAY(3, 1), FAC(3, 2), NFADAY(3, 2)
    INPUT #1, FAC(3, 3), NFADAY(3, 3), FAC(3, 4), NFADAY(3, 4)
    INPUT #1, FAC(3, 5), NFADAY(3, 5), FAC(2, 1), NFADAY(2, 1)
    INPUT #1, FAC(2, 2), NFADAY(2, 2), FAC(2, 3), NFADAY(2, 3)
    INPUT #1, FAC(2, 4), NFADAY(2, 4), FAC(2, 5), NFADAY(2, 5)
    INPUT #1, FAC(1, 1), NFADAY(1, 1), FAC(1, 2), NFADAY(1, 2)
    INPUT #1, FAC(1, 3), NFADAY(1, 3), FAC(1, 4), NFADAY(1, 4)
    INPUT #1, FAC(1, 5), NFADAY(1, 5), IRAND, NOLFE
    INPUT #1, EXPS(1), EXPS(2), EXPS(3), EXPS(4), EXPS(5), EXPS(6), EXPS(7), EXPS(8)
    INPUT #1, EXPS(9), EXPS(10), EXPS(11), EXPS(12), EXPS(13), EXPS(14), EXPS(15), E
    ----->XPS(16)
    INPUT #1, NFATHOGS, FATHOGUT, FATHOGPRICE
    INPUT #1, NFPO, FPMU, FPPRICE
    INPUT #1, NUNDERUTS, UNDERUTUT, UNDERUTPRICE
    INPUT #1, NGILTSOLD, GILTUT, GILTPRICE
    INPUT #1, NBOARSOLD, BOARUT, BOARPRICE
    CLOSE #1
    OPEN "C:\\" + DIRECTS + "\" + PRODS + QUARS(11) + ".DEL" FOR INPUT AS #2
    INPUT #2, TOTDEL, PIGDAYS(1), PIGDAYS(2), PIGDAYS(3)
    CLOSE #2
    TOTPIGDAYS = PIGDAYS(1) + PIGDAYS(2) + PIGDAYS(3)
    THOUPIGDAYS = TOTPIGDAYS / 1000
    FOR I2 = 1 TO 15
        UK(I1, I2) = DRO(I2)
    NEXT I2
    FOR I3 = 1 TO 16
        UK(I1, I3 + 15) = (EXPS(13) * (PHPP / 100)) / THOUPIGDAYS
    NEXT I3
    FOR I4 = 1 TO 3
        UK(I1, I4 + 31) = PRODSPEED(14) / PIGDAYS(14)
    NEXT I4
    UK(I1, 35) = ((NFATHOGS * FATHOGUT) + (NUNDERUTS * UNDERUTUT) + (NGILTSOLD * GIL

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DIM YDK(10, 39) AS SINGLE
DIM YPK(11, 39) AS SINGLE
DIM ALPHA(39) AS SINGLE
DEFINT I-N
I1 = NQUARTER
OPEN "C:\\" + DIRECTS + "\" + PRODS + QUARS(11) + ".DAT" FOR INPUT AS #1
INPUT #1, NE(3), NE(2), NE(1), NE(4), PHPP
INPUT #1, PRODSPEED(3), PRODSPEED(2), PRODSPEED(1)
INPUT #1, SON(3), SON(2), SON(1), LPOOL(3), LPOOL(2), LPOOL(1)
INPUT #1, KDAY(3), KDAY(2), KDAY(1), LNUM, LEND
INPUT #1, MOTHO(3), MOTHO(2), MOTHO(1), NEND
INPUT #1, NPMO, NGRPAUN, NFOHNET, NFPO, NPMUR
INPUT #1, NBMC, NIT IP6, DRO(3), NFPS(11), NPM(11)
INPUT #1, DRO(2), NFPS(2), NPM(2), DRO(1), NFPS(3), NPM(3)
INPUT #1, DRO(4), NFPS(4), NPM(4), DRO(5), NFPS(5), NPM(5)
INPUT #1, DRO(6), NFPS(6), NPM(6), DRO(7), NFPS(7), NPM(7)
INPUT #1, DRO(8), NFPS(8), NPM(8), DRO(9), NFPS(9), NPM(9)
INPUT #1, DRO(10), NFPS(10), NPM(10), DRO(11), NFPS(11), NPM(11)
INPUT #1, DRO(12), NFPS(12), NPM(12), DRO(13), NFPS(13), NPM(13)
INPUT #1, DRO(14), NFPS(14), NPM(14), DRO(15), NFPS(15), NPM(15)
INPUT #1, FAC(3, 1), NFADAY(3, 1), FAC(3, 2), NFADAY(3, 2)
INPUT #1, FAC(3, 3), NFADAY(3, 3), FAC(3, 4), NFADAY(3, 4)
INPUT #1, FAC(3, 5), NFADAY(3, 5), FAC(2, 1), NFADAY(2, 1)
INPUT #1, FAC(2, 2), NFADAY(2, 2), FAC(2, 3), NFADAY(2, 3)
INPUT #1, FAC(2, 4), NFADAY(2, 4), FAC(2, 5), NFADAY(2, 5)
INPUT #1, FAC(1, 1), NFADAY(1, 1), FAC(1, 2), NFADAY(1, 2)
INPUT #1, FAC(1, 3), NFADAY(1, 3), FAC(1, 4), NFADAY(1, 4)
INPUT #1, FAC(1, 5), NFADAY(1, 5), IRAND, NOLFE
INPUT #1, EXPS(1), EXPS(2), EXPS(3), EXPS(4), EXPS(5), EXPS(6), EXPS(7), EXPS(8)
INPUT #1, EXPS(9), EXPS(10), EXPS(11), EXPS(12), EXPS(13), EXPS(14), EXPS(15), E
----->XPS(16)
INPUT #1, NFATHOGS, FATHOGUT, FATHOGPRICE
INPUT #1, NFPO, FPMU, FPPRICE
INPUT #1, NUNDERUTS, UNDERUTUT, UNDERUTPRICE
INPUT #1, NGILTSOLD, GILTUT, GILTPRICE
INPUT #1, NBOARSOLD, BOARUT, BOARPRICE
CLOSE #1
OPEN "C:\\" + DIRECTS + "\" + PRODS + QUARS(11) + ".DEL" FOR INPUT AS #2
INPUT #2, TOTDEL, PIGDAYS(1), PIGDAYS(2), PIGDAYS(3)
CLOSE #2
TOTPIGDAYS = PIGDAYS(1) + PIGDAYS(2) + PIGDAYS(3)
THOUPIGDAYS = TOTPIGDAYS / 1000
FOR I2 = 1 TO 15
    UK(I1, I2) = DRO(I2)
NEXT I2
FOR I3 = 1 TO 16
    UK(I1, I3 + 15) = (EXPS(13) * (PHPP / 100)) / THOUPIGDAYS
NEXT I3
FOR I4 = 1 TO 3
    UK(I1, I4 + 31) = PRODSPEED(14) / PIGDAYS(14)
NEXT I4
UK(I1, 35) = ((NFATHOGS * FATHOGUT) + (NUNDERUTS * UNDERUTUT) + (NGILTSOLD * GIL

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---->TWT) + (WBOARSOLD * BOARWT)) / NTOHMK

UK(11, 34) = ((WFAHNGS * FATMOGUT * FATMOGPRICE) + (MUNDERNTS * UNDERMTWT * UND
-->ENFAPRICE)) * (WELTSOLD * GILTWT * GILTPRICE) + (WBOARSOLD
* BOARWT * BOARPRICE)) / ((WFAHNGS * FATMOGUT) + (MUNDERNTS * UNDERMTWT) + (WEL
---->LTSOLD * GILTWT) + (WBOARSOLD *
* BOARWT))

UK(11, 37) = CSNG(MDTHOK(1))
UK(11, 38) = CSNG(MDTHOK(2))
UK(11, 39) = CSNG(MDTHOK(3))

OPEN "C:\\" + DIRECTS + "\\" + EXTS + "\\" + PRODS + QUARS(NFOZ) + ".\" + EXTS FO
---->R INPUT AS #3
FOR 16 = 1 START TO NEND
  INPUT #3 UK(NFOZ, 16), YK(NFOZ, 16), YDK(NFOZ, 16), YPK(NFOZ + 1, 16)
  IF YK(NFOZ, 16) < 0 THEN YK(NFOZ, 16) = 0
  IF YPK(NFOZ + 1, 16) < 0 THEN YPK(NFOZ + 1, 16) = 0
NEXT 16
CLOSE #3

IF NQUARTER > (NFOZ + 1) THEN
FOR 15 = (NFOZ + 1) TO NQUARTER - 1
  FILESTRS = "C:\\" + DIRECTS + "\\" + EXTS + "\\" + RIGHTS(STRS(NQUARTER - 1), 1)
----> + PRODS + QUARS(15) + ".\" + EXTS
  OPEN FILESTRS FOR INPUT AS #3
  FOR 16 = 1 START TO NEND
    INPUT #3 UK(15, 16), YK(15, 16), YDK(15, 16), YPK(15 + 1, 16)
    IF YK(15, 16) < 0 THEN YK(15, 16) = 0
    IF YPK(15 + 1, 16) < 0 THEN YPK(15 + 1, 16) = 0
  NEXT 16
  CLOSE #3
NEXT 15
END IF
DIFFSQ = 0

FOR 19 = 1 START TO NEND
  ALPHA(19) = (2 * (TBETA(19) - .5)) - TBETA(19)
NEXT 19

FOR 16 = (NFOZ + 1) TO NQUARTER
  FOR 17 = 1 START TO NEND
    IPEN1 = 0
    IPEN2 = 0
    YK(16, 17) = YPK(16, 17) + (ALPHA(17) * (UK(16, 17) - YPK(16, 17)))
    IF YK(16, 17) < 0 THEN IPEN1 = 1
    YDK(16, 17) = YDK(16 - 1, 17) + (TBETA(17) * (UK(16, 17) - YPK(16, 17)))
    YPK(16 + 1, 17) = YK(16, 17) + YDK(16, 17)
    IF YPK(16 + 1, 17) < 0 THEN IPEN2 = 1
    DIFFSQ = DIFFSQ + ((YK(16, 17) - UK(16, 17)) - 2) + (IPEN1 * WPEN(17)) + (
---->IPEN2 * WPEN(17))
  NEXT 17
NEXT 16
END SUB

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