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DEPARTMENT OF AGRICULTURAL ECONOMICS

Purdue University

Lafayette, Indiana

211(d) ANNUAL REPORT 1975/1976

Purdue University

June 30, 1976

Department of Agricultural Economics

West Lafayette, Indiana
47907

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211(d) Annual Report for 1976

Title: Expansion of Competence in the Design and Execution of Ruminant Livestock Development Programs for the Tropics: With Emphasis on the Analysis of Systems of Production and Marketing.

Grantee: Purdue University, Lafayette, Indiana

Director: T. Kelley White

A. Statistical Summary:

Period of Grant: June 29, 1972 to June 28, 1977

Amount of Grant: $400,000

Expenditures:	For current year	$115,091
	Accumulated,	$292,079
	Anticipated for next year	$90,000

B. Narrative Summary:

The fourth year (1975-76) of the 211(d) Grant was one of accomplishment, reevaluation, and new initiative for the Purdue 211(d) team. The fundamental objective of applying systems analysis to the ruminant livestock industry of a specific country was achieved with the development of a working model of the livestock industry of Guyana. Having achieved this primary objective relatively early in the year, it was possible to concentrate efforts during the remainder of the year on modification and improvement of the basic model, achieving better integration between the industry model and other consortium inputs, and seeking a working relationship in a second country to evaluate the transferability of the knowledge gained by the Consortium.

The major thrust of the Purdue effort during the first half of the year was on achieving a first generation computerized model of the Guyanese livestock industry which was sufficiently realistic to be useful in policy analysis. This was achieved in cooperation with other members of the Consortium through a series of workshops. Additional field data were collected in Guyana to update information relative to prices and slaughter volume.

The 211(d) Consortium conducted a two day workshop in Georgetown, Guyana early in 1976. As a part of this workshop, the livestock industry model was briefly described and a set of alternative policy runs was presented. These served as a basis for discussion of policy alternatives and usefulness of the systems model framework for the Guyanese setting. This workshop served as a final report of the formal working relationship between the Government of Guyana and the 211(d) Livestock Consortium. An effort was made to open the door for a continuing working relationship between the consortium and the Government of Guyana.

The collaborative research effort undertaken between Purdue University and a member of the faculty of economics of the University of Guyana, begun during the previous year, was concluded. Results of a household survey of meat consumption were analyzed to provide insight into the nature of the demand for beef in Guyana.

USAID conducted a fourth year review of the set of 211(d) grants comprising the Ruminant Livestock Consortium. This review provided an incentive for each member of the Consortium to conduct a self evaluation of its progress during the first four years in preparing materials for the outside review team. This was a useful exercise, but came rather late in

the life of the 211(d) grant to be very useful in increasing the efficiency with which grant funds are used.

After a number of abortive attempts to achieve working relationships with a second country for the last year of the consortium efforts, Dr. Morris, of the Purdue team, was instrumental in arranging such a relationship with Mali.

Acquisitions of materials relevant to tropical livestock analysis and systems modeling for our library were continued. Special emphasis was placed on the acquisition of data pertinent to ruminant livestock production in Central West Africa, and especially in Mali.

Expertise gained by the Purdue faculty through 211(d) activities was extensively drawn upon by USAID, The National Academy of Science, The Federal University of Viscosa in Brazil, S.A., and a number of university contract teams involved in subsector modeling of less developed countries of the world.

C. Detailed Report

I. General Background and Purpose of the Grant

The overall purpose of Purdue's 211(d) grant is well summarized in the following quote from the original grant document.

Purdue's grant is one of four that, "would explore the livestock industry from a total systems viewpoint, on the assumption that piecemeal attacks on a complex problem (nutrition, breeding, disease control, or credit) have been inadequate."

The primary objective of Purdue's grant is to strengthen our capability "to identify opportunities for significant livestock developments in LDC's, to analyze constraints to, and reasons for, such developments and to design programs to overcome constraints through an integrated, multi-disciplinary

team approach."

Purdue was awarded a supplemental grant in the amount of $150,000 for the three year period beginning July 1, 1974. This supplemental funding was provided to allow Purdue, in its role as the economic and marketing component of the Consortium, to better support the biological production expertise provided by Texas A & M, Tuskegee Institute and the University of Florida. Four specific areas requiring expanded Purdue input were recognized. These are:

1. Expansion of the scope of the industry modeling activity to give greater emphasis to factor and product markets faced by livestock producers;

2. To participate in a Consortium effort to apply the systems approach to livestock development problems in a second country;

3. To exercise the integrator-catalyst role that is implicit in the industry modeling activity and;

4. To provide additional economics and systems modeling support to other Consortium members.

II. Objectives of the Grant

1. Objectives Restated

The objective of the grant is to improve the capacity of Purdue University to assist AID, other developmental agencies, and countries in the analysis of ruminant livestock production and marketing systems in the different environments of the LDC's. Such analysis should describe the system, indicate the factors that most seriously limit development, and suggest alternative policies and programs to remove limiting factors.

Steps to be taken to achieve these objectives include:

a. adapt systems approach to a specific tropical ruminant livestock production situation,

b. improve our analytical methodology,

c. increase the number of faculty with relevant experience (in systems analysis and tropical ruminant livestock production),

d. to select a country, and

e. analyze its livestock industry so as to achieve (a through c above).

2. Review of Objectives

A fourth year of experience, combined with the formal review process imposed by USAID, provides no indication that the original objective was wrongly selected. However, reinforcement is provided for the thought expressed in the annual report for 1974-75, that the technique was not adequate for achieving the objective. That is, the informal consortium structure depending upon voluntary cooperation of members is inadequate to achieve fully, the overall objectives of the set of 211(d) grants.

III. Accomplishments

Accomplishments under the 211(d) grant will be discussed under the headings of steps a through e, presented in Section II.1, and under the heading "integration of 211(d) experience" and "involvement of other Consortium members and host country."

a. Adapt systems approach to a specific tropical ruminant livestock production situation (estimated expenses $25,000).

Adaptation of the systems approach to the ruminant livestock production and marketing situation in Guyana, South America, was a major focus of

efforts during the fourth year of the project. Having attained a working model structure early in the year, emphasis was shifted from model structure per se to improving model performance in the sense of producing results which were "believable" within the Guyanese context. After preliminary tuning of the model a set of alternative interventions in the ruminant livestock industry of Guyana were modeled. The model structure, data inputs used, interventions modeled, and model outputs were presented in the Ph.D. thesis of Dr. Ralph D. May. Copies of this thesis were provided to USAID and to the Government of Guyana.

Upon completion of Dr. May's thesis, efforts were immediately begun to improve the ability of the industry model to reflect the behavior of the beef cattle industry in Guyana. Mr. Ford, a Guyanese Ph.D. student supported by the 211(d) grant, traveled to Guyana to collect current data on beef prices, the volume of slaughter, and to verify data used in modeling beef production in the Ebini and Matthews Ridge areas. A number of modifications were made in both input data used and model structure to improve the quality of output. The base situation, those interventions run by Dr. May, and some additional situations were run with the respecified model. These model results served as the basis for a report on model structure and utilization to representatives of the Government of Guyana at a workshop held by the 211(d) Consortium in Georgetown, Guyana, in March of 1976. The paper presented at the general session of the workshop is contained in Appendix A. In addition to this overview presentation of model structure and application, a more detailed description of the model, data requirements, situations modeled, and model output, along with

a discussion of the input form for the model were presented at a working session with members of the Economic Analysis Section of the Ministry of Agriculture and representatives from the World Bank Livestock Project. Two complete sets of input data, model results and input forms were left with the Economic Analysis group. Appendix B contains a table of contents listing all materials provided to the economic analysis group and copies of four of the short papers describing the model and its application.

The cooperative meat consumption study initiated in 1974-75 involving the Purdue 211(d) group and a member of the faculty of the Department of Economics of the University of Guyana was completed. This survey provided useful information concerning consumer preferences and price responsiveness with respect to meat products. A copy of the summary results of this survey is presented in Appendix C.

Mr. Pete Wenstrand, a student in the joint master of science program with industrial management and agricultural economics, conducted a budget analysis of the use of sugarcane in livestock feeding as a special problem. This paper, contained in Appendix D, integrated data obtained from Dr. Preston's work in Chetumal, Mexico, and data provided by Dr. Mott, of the Florida 211(d) team, and applied Guyanese prices.

b. Improved analytical methodology
(estimated expenses $40,000)

A second major focus of 211(d) activities during the year consisted of efforts to improve, conceptually and operationally, the computerized model of cattle industry behavior. Experience with the early version of the model in preparation for the workshop held in Guyana identified a number of

areas in which the model was either conceptually or operationally weak. In addition, the initial objectives set forth for model capabilities were not attained in the early version of the model due to time limitations. Thus, a second version of the model had been anticipated.

One set of model modifications initiated during the year, but not yet completed are described in the thesis proposal developed by Mr. Tom Spreen, and contained as Appendix E of this report. The same set of base data developed for Guyana and used in specification of the original version of the model, are also being used in the revised version. Therefore, it will be possible to make direct comparisons of the performance of the two versions of the model. The revised model differs primarily in terms of the following characteristics:

1. It will be possible to utilize the model in a recursive mode facilitating the modeling of much longer periods of time;

2. The inventory demand for livestock and other capital goods is now modeled as a less than perfectly elastic demand function rather than as a fixed-price sales activity;

3. The relationship between herd size and composition and resource utilization is much more realistically modeled through a revised subroutine;

4. A number of revisions in internal subroutines have been made to improve the realism and operating efficiency of the model.

A second major modification of the original model was begun at the end of the year. This revision or modification differs from that discussed in the preceding papragraph in the following way. The model as revised by Mr. Spreen retains competitive market behavior as the primary behaviorial rule determining model results. Mr. Ford has begun conceptual development

of a variant of the model which would recognize the socialistic-cooperative structure of the livestock economy in Guyana as it has evolved during recent years. This modification of assumed industry behavior will not only provide a model which is more compatable with government objectives for Guyana, but also may well provide a model which is more acceptable and more useful to government decision makers in many less developed countries of the world where the economy is to some extent centrally directed.

c. Faculty with relevant experience
(estimated expenses $7,000)

For the first year since initiation of the 211(d) livestock project at Purdue, there were no changes in the faculty team contributing to this project. There was one change in the graduate student corps contributing to the project. Mr. Ralph May completed his Ph.D. program and accepted a faculty position at the University of Arkansas. Mr. May's departure had been anticipated and Mr. Spreen had been brought into the program earlier to provide an overlap and smooth transition. Mr. May had been involved in the 211(d) project since its initiation and had made valuable contributions to the Purdue effort.

d. Choice of location for work
(estimated expenses $4,091)

The 211(d) consortium through its chairman, Dr. T. C. Cartwright, of Texas A & M University, continued efforts initiated during the previous year to obtain an agreement with a second country for systems modeling application. Efforts to work out an agreement with Kenya and Tanzania were unsuccessful. Dr. Morris, of the Purdue team, was authorized by the

consortium to exploit his contacts in the African Bureau of USAID and in the Ministry of Agriculture of Mali to attempt to obtain agreement for the consortium to conduct a limited extension of its modeling activities to the Mali situation. Dr. Morris's efforts were successful and an agreement was negotiated.

e. Analysis of livestock industry
(estimated expenses $30,000)

Analysis of the Guyanese livestock industry was an integral part of the adaptation of systems analysis to the Guyanese situation and of the development of improved analytical methodology. Accomplishments in analysis in the Guyanese livestock industry have been extensively discussed in parts a and b above. Analysis of the Guyanese livestock industry has been documented in a number of papers which are contained in appendices A through D and Appendix F of this report.

Dr. Morris has continued work on a monograph describing the livestock industry in the Central West African region. This monograph will draw upon the extensive knowledge he has gained of the livestock situation in this region of the world while servicing USAID and other international donor agencies during the last few years. 211(d) grant funds have been used to extend Dr. Morris's time in a number of countries to collect additional data and fill gaps in coverage. This is seen as an excellent means of integrating his service activities into the 211(d) project.

f. Integration of 211(d) experience into ongoing program (estimated expenses $4,000)

Integration of the 211(d) experience into the department's ongoing teaching, research and service programs has continued in several ways. Additional acquisitions of library material relevant to systems modeling, tropical livestock, and economic development have been made and will become a part of the University Library resource. A list of these materials acquired during the year is presented in Appendix G. Further additions were also made to a working collection of material specific to the Central West African region. Development of this collection has been primarily due to the efforts of Dr. Morris. These efforts have been partially supported by 211(d) grant funds. This collection now includes more than 2500 items and is recognized as one of the most extensive collections on this area of the world in the U.S.

The teaching faculty involved in the 211(d) project has continued to incorporate 211(d) experiences in class presentations. The 211(d) experience has also added to the quality and breadth of the departments livestock extension program and the sector modeling aspect of its research program. During the year a new research project has been initiated with the objective of developing a computerized model of the agricultural sector of the United States. Two members of the 211(d) team, Dr. McCarl and Dr. White, are participating in this new research activity. Their experience in modeling of the livestock industry under the 211(d) is being integrated into this new project and was important in providing the initiative to begin this new activity

Grant funds have been utilized to sponsor a number of departmental seminars during the year. Three of these seminars featured speakers who are considered to be pioneers in the area of sector and subsector modeling. Two other seminars were presented by members of the Purdue team, Dr. White and Mr. Spreen, and were efforts to further familiarize the departmental faculty and graduate student body with the 211(d) activity. A list of seminars is presented in Appendix H.

g. Involvement of other Consortium members and host country (estimated expenses $5,000)

The modeling workshop held by the Consortium at Purdue at the very end of the 1974-75 year proved to be an effective means of increasing interaction among Consortium members. The workshop framework continued to be utilized through the 1975-76 year as a means of attaining more complete interaction among Consortium members in the development and application of the livestock industry model, the biological herd model, and the preparation of the final consortium report presented to the Government of Guyana during the workshop held in Georgetown in March.

Involvement of Guyanese in the modeling effort was attempted in several ways. Mr. John Ford, a Guyanese graduate student, sponsored by the 211(d) grant, became actively involved in the Purdue and Consortium efforts to model and analyze the Guyanese livestock industry. Grant funds were utilized to bring Mr. John Dukia of the Department of Economics of The University of Guyana, to Purdue for three days during which the initial findings of the household survey of meat consumption were discussed. This provided an opportunity to interact with him on the implications of these

initial findings and to suggest further analysis of the data as well as a format for reporting these results. This opportunity was also utilized to discuss with Mr. Dukia the general modeling approach being taken and to obtain his criticisms of this approach.

Mr. John Ford visited Guyana under 211(d) sponsorship to collect data and to interact with officials of the Ministry of Agriculture concerning their assessment of the livestock situation and their goals and objectives relative to the performance of the cattle industry.

The Consortium workshop held in Georgetown in March provided an additional opportunity for the Guyanese to interact with Consortium members with respect to the Consortium findings. The Purdue team was represented by Drs. White, Morris, and McCarl. In addition to presentations in which the model and preliminary findings were presented, we utilized the remote computer terminal to demonstrate the potential for continued interaction between the Government of Guyana and the Purdue 211(d) team through the computerized model of the livestock industry. It was made clear to Guyanese representatives that the Consortium in general, and Purdue in particular, stood ready to continue cooperative efforts in analyzing alternative policy and program directions. In addition, Purdue offered to train an individual from the Agricultural Economics Section of the Ministry of Agriculture, to be selected by the Ministry, in preparation of data and utilization of the livestock industry model as an analytic tool. Upon returning to Purdue the original verbal offer was formalized by a letter to Dr. Fernandez. Unfortunately, the Guyanese have not chosen to avail themselves of either the opportunity to continue cooperative efforts to analyze various problems

or to train a member of the Ministry in utilization of the model.

IV. Development of Institutional Capabilities

The impact of the 211(d) grant on Purdue's capabilities has been concentrated primarily on the human resource of the Department of Agricultural Economics. During the first four years of the grant, eight individual faculty members have had direct involvement in grant supported activities. Seven of these staff members have been provided the opportunity to observe and study livestock production and marketing systems in one or more tropical LDC's. This exposure combined with experience in developing and utilizing a computer model of the livestock industry of a particular country has not only increased the awareness of the faculty and its knowledge of tropical livestock problems and potential, but has also greatly expanded the capability for analysis of problems associated with livestock production.

Unfortunately two faculty members who have had important involvement in the 211(d) grant activities have left the Purdue faculty for assignments in other institutions. Their contribution to Purdue's institutional capability is not totally lost as a consequence of their departure, however. We have continuted to utilize the services of Will Candler as a consultant in our 211(d) project. By maintaining contacts with the individuals in their new institutional environments the potential pool of resources available to be drawn upon in future work is expanded.

In addition to the eight faculty members who have been directly involved as team members, a number of other faculty members within the Department of Agricultural Economics and in other departments of the University have had minor involvement.

The success achieved by the 211(d) project in operating as a research team has had a demonstrative impact on the attitude of our faculty toward team research. In addition, the experience gained by the 211(d) team in subsector modeling with application at the policy analysis level has been one of the factors leading to initiation of a new research project involving two members of the 211(d) team undertaken during the last year. This project has as its objective the development of a computerized model of the agricultural sector of the United States.

The utilization of grant funds in developing our library resource with respect to computer modeling, tropical livestock and economic development has provided a collection which is unequaled in any other institution in the United States. An increasing number of requests from other institutions interested in the development problems of Central West Africa for use of our document collection has increased substantially. Efforts are continuing to better organize this collection so as to make it more accessable.

Grant funds have also been utilized to increase the capability of our department in the computer applications area through the acquisition of both hardware and software.

The 211(d) grant, therefore, has not only had an important impact on those individual faculty members directly involved, but has also influenced the thinking of a large segment of the faculty. Not only has the level of knowledge with respect to livestock production and marketing in tropical countries of the world expanded, but also our ability to deliver this expertise to various parts of the world has been increased.

V. Utilization of Institutional Resources in Development

A significant proportion of the School of Agriculture's international activities has been involved in assisting the development of the livestock sector in developing nations. These efforts are summarized in the following paragraphs.

AID Contract 639 - Purdue-Brazil Technical Assistance Project

Since the early 1950's, staff from Purdue's Department of Animal Sciences have played an important role in initiating and developing teaching, research, and extension programs in animal sciences at the Federal University of Vicosa (UFV). This has included work in animal genetics, nutrition, production management, and range pasture management. In the early 1950's, the UFV (then the UREMG) [1/] initiated a Master of Science program in Animal Sciences. In 1973 a Ph.D. program was begun in this discipline. Eleven members of the Purdue staff have been directly involved in these successful efforts. Under the participant training program several Brazilians have received M.S. and/or Ph.D. degrees at Purdue and other U.S. universities. Most of these have returned to the UFV where they are engaged in teaching and research activities.

Instituto de Lacitcinios "Candido Tostes" (Dairy Technical School) at Juiz de Fora

Under the auspices of the AID Contract 639, Purdue's School of Agriculture also provided assistance to this post-secondary technical school. This assistance was provided in recognition of the acute shortage of trained Brazilian manpower in the area of dairy product processing and handling. Purdue staff assisted in curriculum development, teaching and

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1/ Universidade Rural do Estado de Minas Gerais.

initiation of a very applied research effort. New processing equipment was purchased, installed and the staff students trained in its proper use. In cooperation with the dairy industry a successful work study program was begun. As in the case of the UFV project, a major emphasis was placed on staff development with several participants receiving B.S. and graduate training in the United States. A member of the Instituto staff (Mr. Samuel Hosken) received an M.S. in Agricultural Economics.

Ford Foundation Grant - Institutional Development Program at the National University of the South, Argentina

An important objective of this grant was to assist the Faculty of Agronomy of this university in developing a teaching and research program in range and pasture management and animal nutrition. Four Purdue staff members were involved in this endeavor. Much of the research dealt with the potential of introducing and establishing improved varieties of grasses that would increase the carrying capacity of pastures in this semi-arid region. Funds made available by this project, the Organization of American States and various other sources supported the graduate study of several students from the University of the South at selected universities in the United States, Australia, and Europe.

Bureau of the Census Contract-Population as a Variable in the Economic Development Process with Special Emphasis on Relationships with the Agricultural Sector.

The objective of this contract was to develop a conceptual model of economic development and demographic change and the interrelationships between the two. The conceptual model was then transformed into an operational computer model. The agricultural sector, in the model, is

disaggregated to provide for separate treatment of the livestock sub-sector. It is anticipated that the general structure of this model will be used as a basis for modeling specific LDC situations by the Bureau of the Census. The large scale systems modeling experience gained in this project is useful in 211(d) modeling.

USAID Contract - Analysis of Low-income Problems in Agriculture - Brazil and Mexico.

This new funding source will be utilized to continue and expand, on a multi-institutional basis, a research effort begun by Purdue University under the support of a Ford Foundation Grant. The objective of this research is to better understand the economic decision making process of the family household-firm as it relates to rural poverty.

Foreign Graduate Student Training

During the past 20 years the Agricultural Economics Department at Purdue has made an important contribution to the economic development of many countries by providing advanced degree training to their students. Evidence that Purdue is recognized as an important center of higher education for students from other countries is provided by the fact that we received applications from some forty foreign countries. During the 1975-76 academic year we had students enrolled form Brazil, Canada, Sweden, Mexico, Nigeria, Japan, Saudia Arabia, Iraq, Guyana, Nicaraqua, Philippines, Malaysia, Peru, Spain, India and Ethiopia. During 1975-76, several thesis were completed which treat various aspects of livestock production or marketing either in developing or developed countries of the world. These are:

May, Ralph D., Ph.D., "A Systems Model of the Cattle Economy--A Guyana Application", December 1975.

Mitchell, Lennis D., M.S., "A Study of Large Scale Implementation of the Three-Sided Tote Slide-On System and Its Effect On A Dairy Processor", May 1976.

Schoney, Richard A., Ph.D., "An Economic Analysis of Selected Hay Packaging Systems Under Stochastic Weather Conditions", May 1976.

Cotton, Byron C., M.S., "The Impact of Promotional Deals on Household Consumption of Major Dairy Products", August 1976.

Holland, Forrest D., M.S., "A Time Series Analysis of Live Cattle Futures Prices", August 1976.

Novakovic, Andrew M., M.S., "The Impact of Imports of Manufactured Milk Products on the United States Dairy Industry", August 1976.

Utilization of Departmental Expertise by USAID and Other Institutions

During the past year the African Bureau of USAID has made extensive use of departmental expertise gained through the 211(d) activity. Dr. Morris has served as a consultant to USAID in program planning and evaluation in a number of countries in Central West Africa. Professor White served as a consultant on project evaluation in Upper Volta for USAID. Professors Morris and White were selected to serve as members of study groups of the World Food and Nutrition Study of the National Academy of Sciences. In addition, the Consortium was asked to provide input to the National Academy subgroup on livestock productivity. Professor White was called upon to serve as a consultant to the Federal University of Vicosa, Department of Rural Economics, on a research project involving the modeling of beef production in Brazil. He also was invited to participate in a workshop held at Iowa State University on systems modeling application in livestock production. Dr. McCarl was invited to participate in the US-USSR Joint

Working Session in the application of computers to management to be held in Moscow in October of 1976.

VI. Other Resources for Grant Related Activities

Physical facilities and general administrative overhead are provided by the University without charge. Incidental consulting with other staff members is also provided as a University contribution.

VII. Next Year's Plan of Work and Anticipated Expenditures

The following activities are planned for 1976-77:

a. Complete development of the second generation model of the Guyanese livestock industry (estimated expenditures $15,000). The second generation model will constitute the basis for the Ph.D. thesis of Mr. Spreen. It represents major modification of the original version, especially in that it be recursive and thus capable of modeling longer run impacts of interventions. A number of other modifications are designed to increase the ability of the model to simulate real world behavior. This version of the model will retain competitive market behavior as the force driving the model.

b. Continue development of a livestock industry model with a multiple goal objective function (estimated expenditures $20,000). This model will constitute the basis for the Ph.D. thesis of Mr. Ford. Relaxation of the assumption of a competitive market economy as the environment within which the livestock industry exists is the major difference between this version of the model and that proposed in (a) above. Such a model structure will be more appropriate for countries where government plays an important and direct role in livestock production and marketing.

c. Adaptation of the livestock industry model developed for Guyana to represent conditions in Mali (estimated expenditures $44,000).

Existing data describing the structure and behavior of the livestock industry of Mali will be used to respecify the the existing Guyana model to reflect Malian conditions. This model will serve only as a first approximation of a "Mali Model". However, it will be useful to the Consortium and the Purdue team in evaluating the transferability of the Guyanese experience. It will also serve as a basis for further effort to develop an operational model for Mali.

d. Participate in a joint 211(d) Consortium--Mali modeling workshop in Bamako (estimated expenditures $9,000).

Results of efforts to modify the Guyanese model to fit Malian conditions will serve as the basis for Purdue's contribution to a workshop to be held in Bamako, Mali, late in the fiscal year. The workshop will be sponsored jointly by the Consortium and the Government of Mali and will serve to report Consortium findings with respect to Mali. It may also serve as the beginning of a joint effort to develop an operational policy model if future funding is to be available.

e. Seminar tropical livestock development and systems modeling (estimated expenditures $1,000).

Grant resources will be used to support departmental seminars dealing with various aspects of tropical livestock development and systems modeling.

f. Library support (estimated expenditures $1,000).

Materials relevant to the tropical livestock, economic development, and systems modeling areas will be acquired for the departmental collection.

Table I. Distribution of 211(d) Grant Funds and Contributions from Other Sources of Funding

Review Period 1 July, 1975 to 30 June, 1976

Grant Related Activities	Period Under Review	Cumulative Total	211(d) Expenditures Projected Next Year	211(d) Expenditures Projected to End of Grant*	Non 211(d) Funding Amount
Research	97,491	245,191	72,000	333,100	55,000
Teaching	10,000	23,000	5,000	28,000	20,000
Libraries	600	1,450	1,000	2,450	6,000
Publication Duplication	1,500	3,620	2,000	7,620	5,000
Seminar, Workshop and Conferences	5,500	18,830	10,000	28,830	
TOTAL	115,091	292,091	90,000	400,000	

* Includes $17,921 to be expended after June 30, 1977. A one year extension without additional funding will be requested to allow completion of research associated with Mr. Ford's thesis and to prepare and publish results of the Guyana and Mali experience.

Table II. Expenditure Report
Under Institutional Grant #AID/csd 211(d) 3675
Review Period 1 July, 1975 to 30 June, 1976

	Expenditure to Date		Projected Expenditures Year		
Line Item	Period Under Review	Cumulative Total	5	Extension*	Total
Salaries	73,162	186,884	62,000	10,000	258,884
Fringe Benefits	9,478	21,082	7,000	921	29,003
Travel	8,951	34,150	6,000	1,000	41,150
Data Processing Service & Equipment	18,945	34,909	12,000	5,000	51,909
Supplies	4,555	15,054	3,000	1,000	19,054
TOTAL	115,091	292,079	90,000	17,921	400,000

* One year extension without additional funding to be requested to complete research associated with Mr. Ford's thesis and to prepare and publish results of the Guyana and Mali experiences.

LIST OF APPENDICES

Appendix A	Guyana Cattle Industry Model
Appendix B	Selected papers presented at the Livestock Modeling Workshop, Georgetown, Guyana, March 1 & 2, 1976. Table of Contents, Explanation of the Guyana Livestock Model, The Guyana Data, Trial Interventions in the Livestock Sector, and Summary.
Appendix C	Report of "Survey of Beef Consumption in Guyana"
Appendix D	Some Notes on the Use of Sugarcane for Animal Feed
Appendix E	An Application of Capital Theory in A Dynamic Linear Programming Model of the Cattle Sub-sector of Guyana
Appendix F	An Application of a Large Scale Linear Programming Sector Model To The Cattle Economy of Guyana
Appendix G	1975-76 211(d) Library Acquisitions
Appendix H	List of Seminars

Appendix A

Guyana Cattle Industry Model

Guyana Cattle Industry Model

The Guyana Cattle Industry Model (hereafter referred to as the "Model") is a simplification of the actual industry. It is designed to simulate the aggregate behavior of producers and consumers of beef and milk as they interact in the market place over time. The market for beef is assumed to be competitive (i.e. individual producers and consumers are price takers). The price and quantity of beef produced and consumed are determined by the model through the interaction of supply and demand. Both supply and demand may be modified by changing model parameters to reflect government policies and programs, and changes in technology.

Time, in the Model, is considered to consist of a number of one-year production-marketing-consumption periods. Within a period all parameters are fixed. Between years model parameters may differ due either to endogenously determined levels of decision variables or to exogenously specified shifts in parameters over time. Thus, the model has the capacity to reflect the process of adjustment within the cattle subsector over time. However, the smallest unit of time within which change can be simulated is one year. Thus seasonal variations in production, price or consumption are not treated.

The Model is solved for a planning horizon consisting of a number of one-year periods, and successive solutions can be used to reflect a sequence of planning horizons. The number of periods in a planning horizon is variable and determined by the user, but a practical limit imposed by model size seems to be four or five years. In general, production decisions are assumed to be made at the beginning of the planning horizon and remain unchanged through the

end of the planning horizon. These decisions are made with knowledge of product demand and factor supply conditions in each year of the specified horizon, and even more distant repercussion of decisions are reflected by a set of prices at which assets are "sold out" at the end of the planning horizon.

The Model is intended for use as an instrument in evaluation of alternative government policies and programs, changed technological possibilities, and modified factor and product market situations. It also has potential for identifying impediments to development of the cattle industry. It is not intended to design policies or programs and cannot choose a "best" policy from among alternatives. However, given a proposed modification in the system, it can provide insight into the likely effects. Like any other model it is no better than the data used in its construction. At present the available data is less than perfect, but nevertheless, model performance appears to be adequate to provide useful input into policy and program evaluation, and to provide a basis for further refinement and improvement.

In the following section of this paper, a brief overview of the Guyana cattle industry as characterized in the Model is presented. Then the results obtained with the base specification of the Model are summarized and implications drawn. This is followed by a description of several modifications in Model specifications to reflect policy, program, market and technological changes. Each modification is briefly described and its impact on industry behavior summarized.

Overview of the Guyana Cattle Industry as Modeled

A broad overview of the conceptualization of the cattle industry implicit in the Model is provided in Figure 1. The major industry components are indicated and one set of flows linking components are illustrated. Components to the left of the component labeled Beef Market constitute the supply side of the market. Arrows connecting the supply components indicate physical flows of goods and services. Each of these is paralleled by a reverse flow of payment and factor demand information. The components of domestic and foreign demand and import supply are outside the model (i.e. these market forces are determined outside the model but are themselves important components of the model).

The Herd

The national cattle herd (estimated at 151,000 head) is divided into four regional herds with the four regions being the Rupununi, the Northwest District, the Intermediate Savannahs and the Coast. Each of the regional herds is disaggregated into subherds on the basis of (1) performance capacity of the animals due to either genetic characteristics or prior treatment, or (2) ownership patterns which are not expected to change. In general animals in different subherds when confronted with similar treatments would be expected to react differently. The initial allocation of the national breeding herd among regions and subherds is presented in Table 1.

For each subherd one or more management systems are specified. A management system specifies the treatment of cattle in terms of inputs applied per animal unit (quantity and quality of pasture, labor, and purchased inputs and services), and the resulting performance (calving rate, death rate, theft rate, and rate of gain). Management systems also reflect strategies with

respect to age of sale of slaughter animals and whether all females are retained for breeding stock or sold for slaughter. The disaggregation of the national herd is illustrated in Figure 2.

In the base model management system one reflects the current method of production and marketing. Management system two differs from one in that slaughter animals are marketed one year younger. Management system three differs from one in that all heifers are sold at three years of age to provide a means of reducing herd size. The fourth system reduces sales age of steers and sells heifers. For two subherds, Amerindian of Rupununi and small non-commercial of the coast, only management system one is included in the base model to reflect the assumption that these producers do not respond to market stimuli. Other management systems specified to reflect changes in technology or marketing strategies are discussed later.

Markets

The Guyana markets for beef and milk are assumed to be located in the coastal area (Georgetown). Local consumption of beef in other regions is subtracted from the supply offered in the national market. Carcass beef at the slaughter house door is the product traded in the market (i.e. the retail distribution of beef is not treated by the model). An exogenously specified price-quantity schedule represents the demand for carcass beef. Beef and milk supplies to the coastal market are generated within the model in response to price incentives subject to restrictions imposed by the existing herd, available technology, resource and input supplies, and policy and institutional restrictions. The demand for milk is assumed to be perfectly elastic (i.e. the price is fixed).

Input supplies are either regional or national depending on the nature of the input. Land, labor, machinery services, and veterinary services are assumed to have regional markets. All other inputs are available through a national market located in the coastal region (Georgetown). Land and labor supplies are represented by price-quantity schedules. All other inputs are purchased at fixed prices.

Slaughter

Slaughter facilities are located in two regions, the Rupununi and Coast, only. Cattle produced in other regions must be shipped live to one of these areas for slaughter. Cattle produced in the Rupununi are slaughtered in that region and the carcass beef shipped to the coastal market.

Transportation

Since the four production regions are geographically separated, transportation is a key component of the production-marketing system, and thus, of the model. All transportation is assumed to occur between the coast and another region. That is, to transport an item from the Northwest District to the Rupununi, it would be shipped from the Northwest District to the coast and then from the coast to the Rupununi (Figure 3).

Three modes of transportation--boat, air, and truck--are assumed to exist, but not all are available between the coast and all other regions. Goods transported are segregated into three categories--live cattle, meat or inputs.

Development

Three types of development activities are available for expanding production capacity. They are land clearing, improved pasture establishment and improved pasture maintenance. All use resources and thus have a cost. Improved pasture, once established, must be maintained or else it reverts to either native range or cleared land, depending on the region.

The Model, specified to generally reflect production and demand conditions existing in the 1973-74 period, produced results that appear reasonable considering the adequacy of data used for specifications. The predicted price of beef ranged from $1.69 to $1.71 per pound over the four year run (Table 2). Price declined during the first three years and then increased in year four. These prices appear to be ten to fifteen percent higher than actual prices observed in the Georgetown market. There was, however, some indication that demand was exceeding supply at existing prices in late 1974 and early 1975, thus exerting pressure for higher prices.

The quantity of beef marketed is considerably smaller than the estimated total slaughter for 1974, but is reasonably close to the official slaughter estimate during that year (about six million pounds). Considering that local consumption was subtracted from supply for three regions, that official slaughter data constituted the principal source of reliable quantity data for specifying the model and that data on size and performance of the small non-commercial subherd on the coast was very inadequate, this can be considered acceptable performance.

The quantity of beef marketed, in the Model, increased throughout the period (Table 2). However, the increase between years 3 and 4 was considerably smaller than in earlier years. The decline in growth of beef marketings results primarily from the age distribution of the initial herd which produced larger increases in number of animals reaching slaughter age during the first two years than in subsequent years. Also two subherds, the Northwest and Intermediate Savannahs, were being liquidated. This produced larger beef supplies initially as females were slaughtered, but smaller supplies toward the end of the period as the size of these subherds declined.

The total number of head equivalents slaughtered(15,000 to 17,000) is reasonably close to the 20,974 head of official slaughter reported for 1974. The Model does seem to produce a larger proportion of total beef in the Rupununi than is the actual case. This may result in part from inaccurate estimates of regional herd size and off-take. It appears likely, however, that an important part of the underestimation of coastal production derives from a higher rate of female slaughter in the coast in reality than is produced by the Model. In the Model, the only female slaughter on the coast was of old cows. This would also account for the lower marketed quantity and higher prices produced by the Model.

Milk production of between 1.8 and 1.9 million gallons is approximately one-half the estimated actual production in 1973. However, the Model considers only milk which is marketed. Since a major portion of milk production occurs on small farms and is partially consumed on the farm, this result is probably acceptable. Milk is assumed to be sold at a fixed price of $2.40 per gallon. Therefore, the results provide no information on the adequacy of this price level except that it was sufficient to induce growth in the commercial dairy subherd. This subherd was allocated, by the Model, to the management system which retains all females in the herd, thus growing at the maximum rate.

The national herd increased consistently over the four-year run with the increase between years one and four being about five percent (Table 3). Herds in the Rupununi and on the coast increased throughout the period, while herds in the other two regions declined in size.

In the Rupununi and the Coast, the Model allocated all subherds to management systems which retain all females (except for a normal percentage of culls) in the breeding herd. This implies that, under the conditions assumed

in the model, production is economically viable in that resources earn higher returns in cattle production than in other available alternatives. It is important to recognize that, in these two regions, most of the resources used in cattle production--land and labor--have very limited alternative uses.

The results for the other two regions, Northwest and Intermediate Savannahs, were very different. The entire subherd in both regions was allocated, by the Model, to a management system that sells all heifers for slaughter, thus depleting the herd as rapidly as possible without selling the existing breeding herd (which is not allowed in the Model). This implies that cattle production is not economically viable given the production technology currently being employed. In both regions, the current technology is very intensive and requires large quantities of purchased inputs, especially fertilizer. This result would indicate that if the Government is going to be successful in stimulating production of cattle in these regions either a less intensive production technology will need to be developed or production will have to be heavily subsidized. Both of these alternatives are investigated later. These model results are supported by the absence of commercial production in the two regions.

Intensive Management Systems for Extensive Commercial Subherds

To evaluate the impact of improved management of the Extensive Commercial Subherd, a new set of production activities were introduced into the model to provide an intensive management alternative. The intensive management alternative introduced is essentially the same as that specified for the Intensive Commercial Subherd in the base model. It involves closer supervision of animals, keeping them out of flooded areas during the rainy season, providing more veterinary care and better pasture management. This results in higher calving rates, lower

death and theft losses, and faster rates of gain. It also requires more management input, more labor, more fencing, but less land per animal due to better pasture management.

Approximately one-tenth of the brood cows of this subherd are allocated to the intensive management system. Adoption of the intensive system is limited by an assumed constraint on the availability of qualified managers. An extension training program could relieve this constraint over time. An additional trained manager would have added almost $10,000 to industry income in year one. Thus, such a training program has a high potential payoff.

The model selects the intensive management system which sells heifers rather than building the breeding herd. This results from end-of-period sell-out prices for heifers which are below market value for slaughter, thus the model chooses to sell. This would be realistic producer behavior if the "low" sell-out price reflects a pessimistic producer expectation of future conditions.

The introduction of this intensive management system as an alternative results in a slightly larger meat supply, lower market price in year two, increased coastal slaughter and a slight increase in size of the coastal herd in spite of the sale of heifers. These impacts can be seen from a comparison of Tables 2 and 3 with Table 4. The impact of the new system on beef supply and thus in price was not large enough to affect the organization or production of other subherds or regions.

The introduction of an intensive management alternative for the Extensive Commercial Subherd had a small market impact, because its adoption is limited by a shortage of qualified managers. Given an adequate supply of managers,

the intensive system is clearly preferable (economically) to the extensive system and offers a means for stimulating beef supply from the coastal herd It is feasible because it requires relatively few purchased inputs. If producers had optimistic expectations, these would be reflected through higher sell-out prices and females would be retained rather than slaughtered. This would result in some reduction in short-run supply but an increase in long-run supply.

Subsidies on Pasture Development and Maintenance in Northwest and Intermediate Savannahs

Cattle herds are being reduced at the maximum rate allowable by the Model in the Northwest and in the Intermediate Savannahs when considered as a commercial venture. Recognizing the Government's interest in expanding cattle production in these regions as a means of regional development, the effect of a subsidy was evaluated. A subsidy equivalent to approximately one-half the fertilizer cost of establishment and maintenance of pasture was provided. This subsidy was inadequate, and the Model chose to continue depleting the herds in these areas, and the Model results were unchanged from the base situation.

Export of Beef from Northwest and Intermediate Savannahs

The effect of limited Guyanese participation in the world beef market was evaluated by introducing activities which allow beef from the Northwest and Intermediate Savannah subherds to be exported at a fixed price of $1.90 per pound. Herds in both regions were completely allocated to activities which produce beef for export and which sell all heifers for slaughter, thus depleting herd size. The impact on the domestic beef market was to reduce domestic beef supply, thus forcing up the domestic market price for beef (Table 5). Even

though the domestic prices for beef increased, the rise was insufficient to cause changes in management or production of herds in other regions of the country.

The choice of management systems which sell all heifers represents a short-run optimization but is self defeating in the long-run. The model selects this system because the high cost, intensive production system currently being used in the two areas remains economically unattractive even at the higher export price.

Long Feeding of Skinny Coastal Steers

It is widely recognized that many coastal cattle, especially those of small non-commercial producers, are marketed in very poor condition. A number of observers have suggested that these animals should be placed on improved pasture for a year or more to take advantage of compensatory gains as a means of increasing coastal beef supply.

Activities which purchase one- and three-year old steers from the small non-commercial subherd and grow them for one, two, or three years on improved pasture were added to the Model. These growing activities were made available in the Northwest, Intermediate Savannahs, and Coastal Regions. Growing out of Coastal cattle in the Northwest and Intermediate Savannahs required transport of live animals from the coast to the growing area and return transport to the coast for slaughter. These alternatives were run once with the assumption that animals were sold on the domestic market and once with the assumption that they could be sold on the export market. None of these alternatives were chosen, by the Model, over systems that slaughter skinny animals, and Model results were identical to the base run.

Failure of these growing-out activities to enter the solution implies that the gain from growing on improved pasture is less than the added costs. For growing out in the Northwest and the Intermediate Savannahs cost would include establishment and maintenance of improved pasture and two-way transport of animals. Growing on the coast would not involve interregional transportation, but would incur either the cost of establishment and maintenance of improved pasture or would have to be able to bid existing improved pasture away from the Commercial Dairy Subherd and then pay the cost of maintenance.

Removal of Transportation Subsidy for Rupununi Beef

The air transport of beef from the Rupununi to Georgetown is heavily subsidized. The effect of this subsidy on Rupununi production was evaluated by removing the subsidy and solving the Model. Removal of the transport subsidy is equivalent to an increase in production cost or a decrease in price received. Model results with and without the subsidy were identical implying that the subsidy has no effect. A broader implication is that Rupununi cattle production is relatively insensitive to changes in price of beef.

The insensitivity of Rupununi cattle production to changes in beef price is probably quite realistic given their system of production. Cattle production in the region utilizes primarily land and labor, and very few inputs purchased from outside the region or the subsector. Land and labor in the region have very few employment alternatives available. Therefore, it is economically rational to employ these resources in cattle production over a wide range of beef prices. This result is further supported by the finding of the Tuskegee Survey that a high proportion of producers are "unhappy" with the price of beef. However, they are continuing to produce.

Short Feeding of Skinny Coastal Steers

The economic infeasibility, as indicated by Model results, of long feeding of skinny coastal cattle caused us to look for an alternative method for taking advantage of compensatory gain as a way of increasing coastal beef production and productivity of the coastal herd. In other areas of the world, feeding of cattle for short periods of time has been a more economic means of obtaining compensatory gains than long feeding. Therefore, an activity was developed to represent a system which would feed three-year old steers on grass for 100 days.

It is assumed that three-year old steers from the small non-commercial subherd on the coast would be fed on improved pasture. They are fed molasses, free choice, with bone meal as a mineral supplement. A stocking rate of three animals per acre of improved pasture is assumed. Three batches per year can be put through the process. An average weight gain of 2.2 pounds per day is assumed. Veterinary services are provided at a level of .2 hours per head with supplies costing $4.50 per head.

With the short-feed alternative included in the Model, the entire Small Non-commercial Subherd was allocated to the management system that sells steers for finishing rather than for immediate slaughter. The effect was a dramatic increase in beef supply and a decrease in market prices of eleven percent in the first year.

The number of steers available for feeding in the second year is somewhat greater resulting in a further increase in beef supply. The increase in supply exceeds the increase in demand. resulting in a small decline in price relative to year one.

Even with the significant decline in beef price occurring as a result of the introduction of an economically viable alternative production technology, other

subherds in the region and the rest of the country continued to be produced under the same management systems as in the base run. This further illustrates the lack of price responsiveness of producers using essentially fixed resources and having few viable alternatives to present production practices. This indicates the need for research which will result in development of viable new alternatives if the performance of the Guyana livestock industry is to be markedly improved. These new technologies will also have to be extended to producers if they are to be adopted.

Introduction of Texas Model Data

The ultimate objective of the consortium is to integrate the Texas Herd Model with the Industry Model. To illustrate the potential for accomplishing this objective, five runs of the herd model were used to develop alternative management systems for the Rupununi and the Intermediate Savannahs. The management systems included were:

Rupununi

1. 12-month breeding season with improved managements to prevent baby-calf deaths by drowning, steady state herd,
2. 12-month breeding season without improved management, steady state herd,
3. 12-month breeding season, growing herd,

Intermediate Savannahs

1. 12-month breeding season
2. 4-month breeding season (November-February).

In runs with Texas data all original management systems were deleted and the entire regional herds were aggregated into a single subherd for each region. This was done because the Texas data are not fully comparable with base data. Therefore in the model run using Texas Model data the Industry Model selects among management systems all of which are based on Texas data.

The impact of Texas data was to greatly increase beef production and decrease price (Table 7). The increased beef supply results from 1), the assumption of a steady state herd which implies a high level of female slaughter, 2), animal weights somewhat higher than in the base data, and 3), somewhat different herd structure than in the base data.

In both regions the management system chosen utilized a 12-month breeding system and steady state herds were preferable to growth herds. The latter is due to the higher off-take rates of steady state herds.

None of the management systems require large quantities of purchased inputs as opposed to the existing technology in the Intermediate Savannahs. These results indicate the potential for cattle production in the Intermediate Savannahs with an extensive system which, based on the Texas Model, is technically feasible.

Failure of much lower beef prices to induce changes in beef production in the Coast and the Northwest again reflects the lack of available, viable alternative systems.

Summary

This paper contains a very brief description of the Guyana Cattle Industry Model and a summary of the more important model results for the base situation and a number of modifications reflecting changed policy, technological, and market conditions. While the absolute levels of production, prices and other outputs are not as close to existing estimates for the base period as one would like, they are not so bad as to make the Model useless. In addition, the behavior of the Model over time and in response to changes in the system seems to be reasonably consistant with what those knowledgeable of the industry would expect.

Model results provide important insights into industry behavior. These insights, and the Model, can be useful in the evaluation of alternative policy and program proposals. First, production in the major supply regions is based primarily on systems using land and labor and very few purchased inputs. This is a relatively low cost mode of production, and alternative technologies which require large quantities of purchased inputs are not competitive for beef prices reasonably close to those currently prevailing. Second, since existing production systems depend heavily on inputs with very limited alternative employment opportunities, beef supply is relatively insensitive to price changes. Third, economical expansion of beef production into new areas of the country will depend upon the development of less intensive and less costly systems of production than those currently being tried. Fourth, failure of the Model to accurately reflect behavior of those producers on the Coast who are going out of production seems to indicate a negative attitude toward cattle production, which is not a consequence of purely technical or economic considerations. High theft rates and impoundment laws, while they have economic consequences, are difficult to

capture in the model and could contribute to a negative attitude toward cattle production.

With the existing data for specification, the Model does not function adequately as a price forecaster. This was never its purpose. It does seem to be useful in evaluation of alternative interventions where direction and incidence of impact may be of more interest than magnitude. The Model can be improved and made more useful through further cooperative efforts involving the ultimate user--the Government of Guyana.

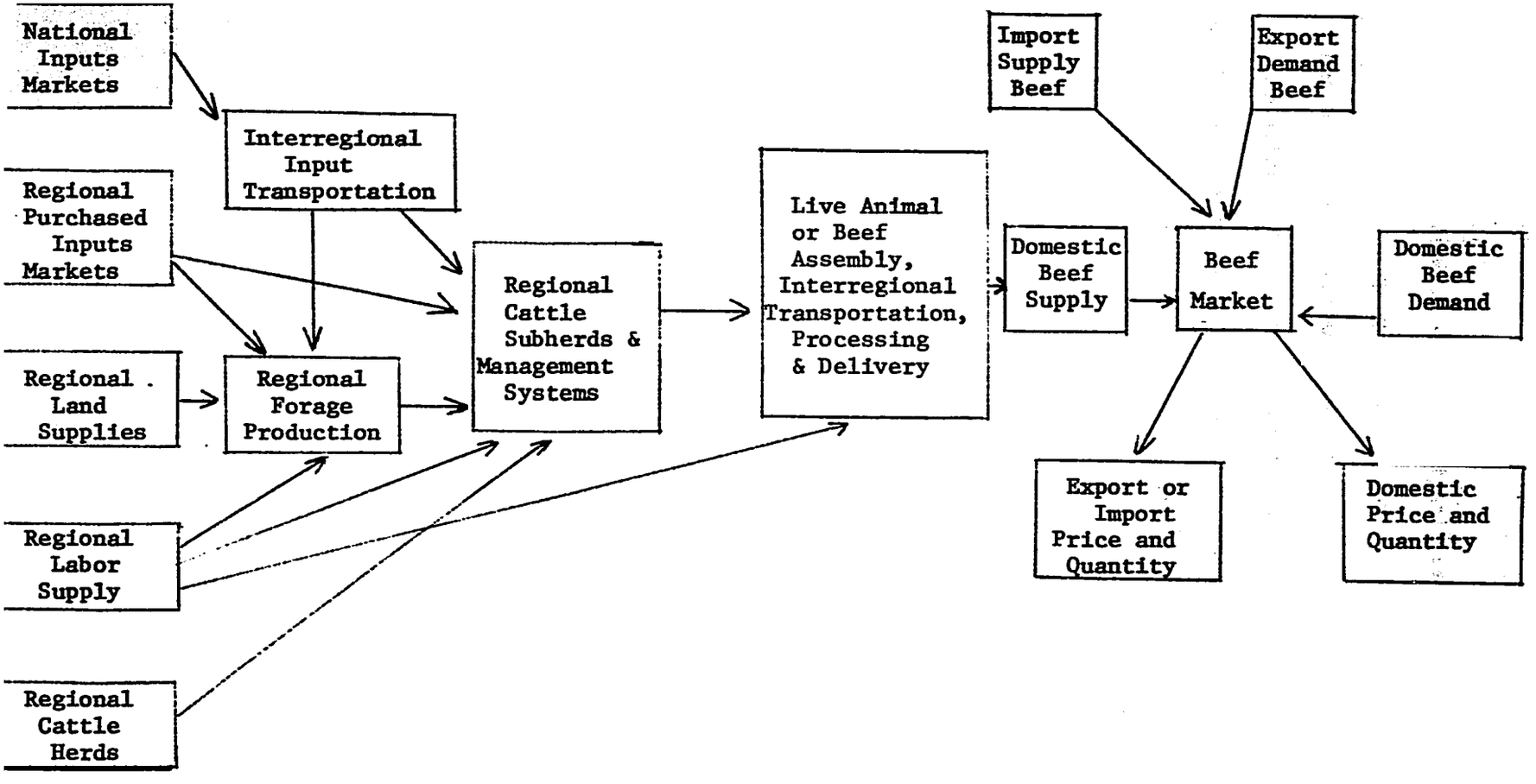

Figure 1. Simplified View of Guyana Cattle Sub-Sector.

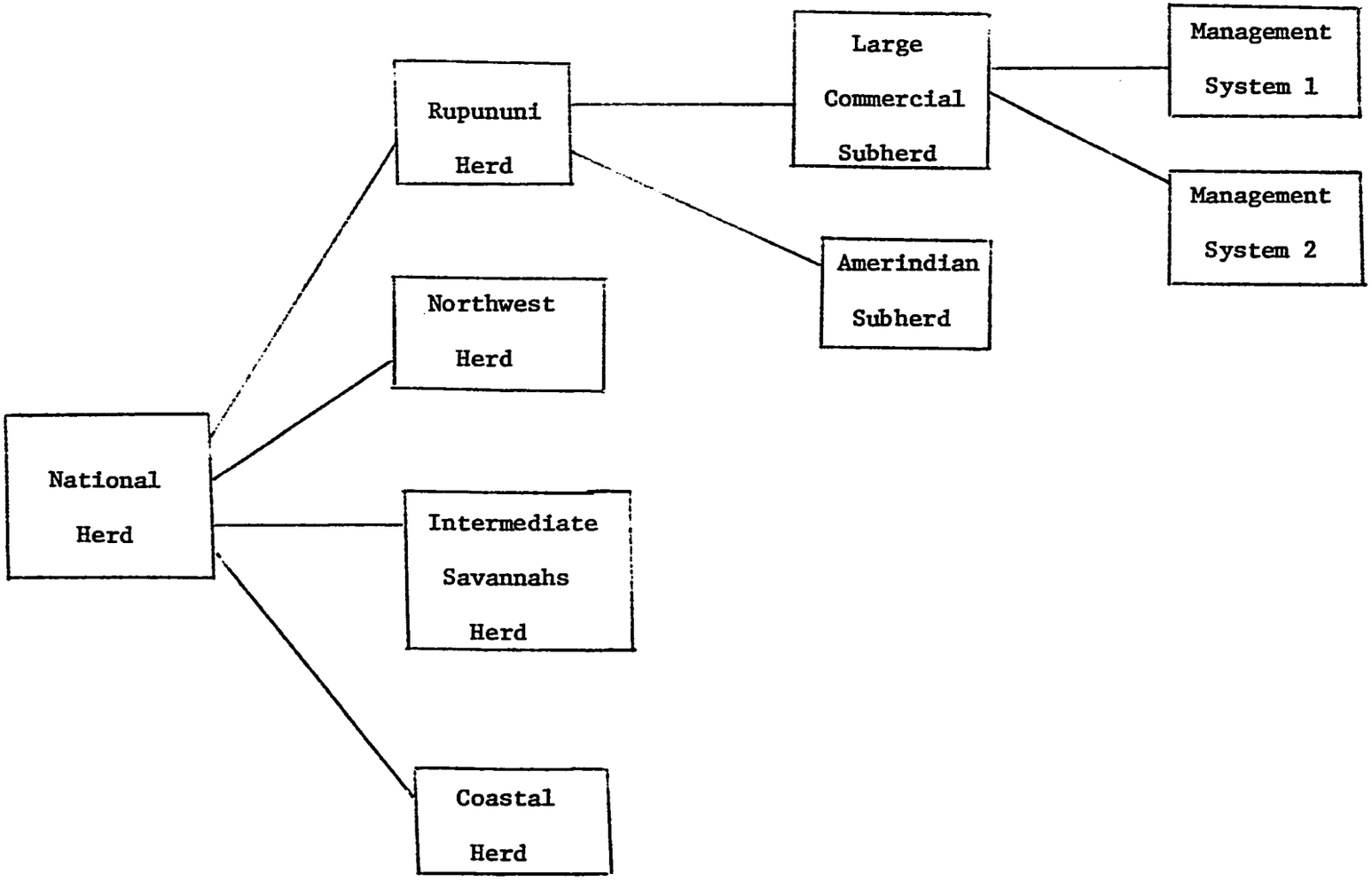

Figure 2. Disaggregation of Guyana Cattle Herd.

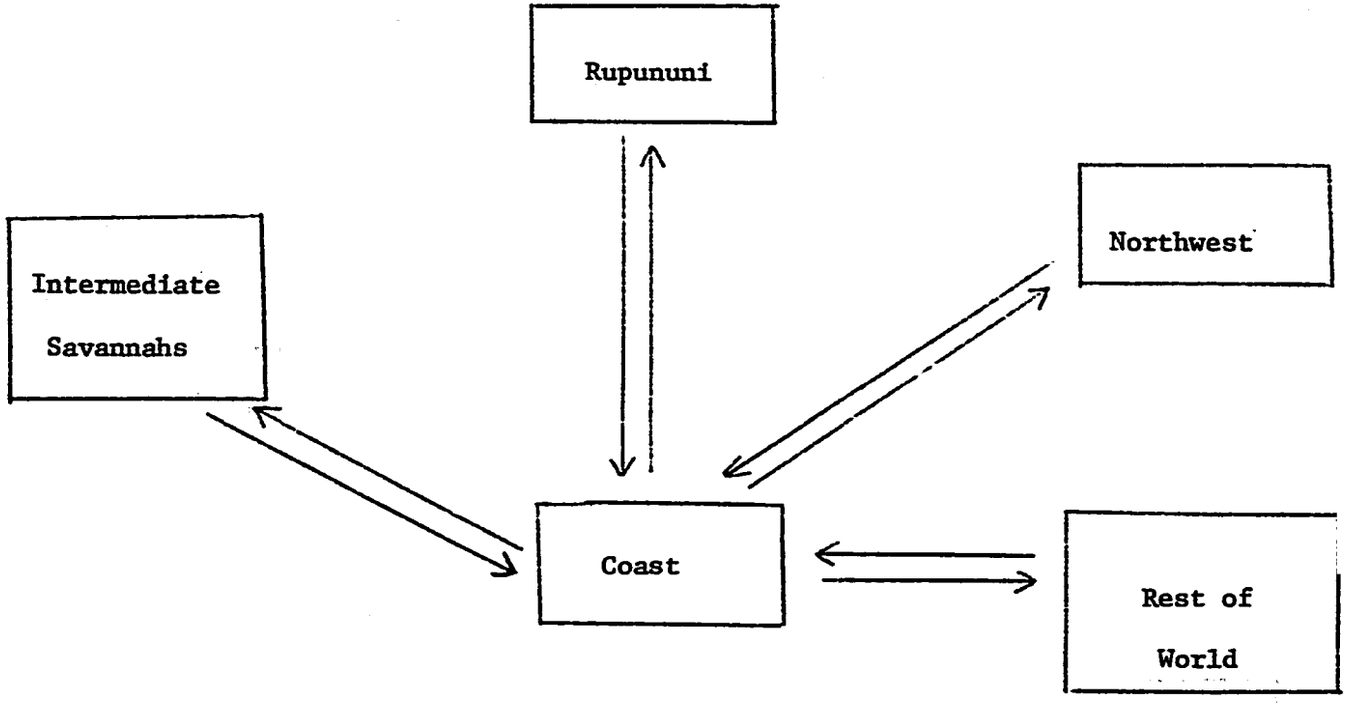

Figure 3. Simplified View of Interregional Transportation in the Model.

Table 1. Number of Cows by Region and Sub-herd--Base Data

Region		Sub-herd	Number
Rupununi	1.	Large Commercial	10,000
	2.	Small Commercial	10,000
	3.	Amerindian	4,000
	4.	World Bank	1,000
		Total	25,000
Northwest	1.	Matthews Ridge	480
Intermediate Savannahs	1.	Ebini	900
Coast	1.	Extensive Commercial	12,300
	2.	Small Non-Commercial	19,203
	3.	Commercial Dairy	1,818
	4.	Intensive Commercial	6,100
		Total	39,421

Table 2. Beef market, milk production and cattle slaughter -- Base Model

	Year			
	1	2	3	4
Price beef (domestic)$	1.71	1.70	1.69	1.71
Quantity beef (domestic) (1,000 lb.)	5,065.9	5,336.3	5,577.3	5,597.4
Quantity milk (1,000 gal.)	1,838.0	1,861.6	1,883.8	1,947.7
Head slaughtered (Head equivalent)*				
Rupununi	5,253	5,473	5,702	5,885
Coast	10,255	10,864	11,362	11,185

* Head equivalent = 400 lb. carcass for Rupununi
= 300 lb. carcass for Coast

Table 3. Herd size by region -- Base Model

	Year			
	1	2	3	4
Rupununi	63,215	64,016	64,902	65,930
Northwest	1,447	1,397	1,328	1,238
Intermediate Savannahs	2,489	2,324	2,108	1,852
Coast	88,999	91,573	93,186	94,801
National Total	156,150	159,310	161,525	163,821

Table 4. Beef market, cattle slaughter, and coastal herd size -- intensive management system for Extensive Sub-herd on Coast.

	Year			
	1	2	3	4
Price beef (domestic) $	1.71	1.69	1.69	1.71
Quantity beef (domestic) (1,000 lb)	5,083.5	5,359.4	5,605.1	5,643.2
Slaughter (Head Equivalent)				
Coast	10,314	10,941	11,455	11,338
Coastal herd (No. Animals)	89,143	91,776	93,382	94,869

Table 5. Beef Market and Herd Size for Northwest and Intermediate Savannahs--Export

	Year			
	1	2	3	4
Price (domestic) $	1.73	1.72	1.71	1.73
Quantity Beef (domestic) (1000 lb)	4,908.5	5,181.7	5,424.7	5,445.8
Price (export) $	1.90	1.90	1.90	1.90
Quantity beef (export) (1000 lbs)	157.4	154.6	152.6	151.6
Price (combined) $	1.79	1.77	1.76	1.79
Quantity Beef (combined)	5,065.9	5,336.3	5,577.3	5,597.4
Herd Size (number of head)				
Northwest	1,447	1,397	1,328	1,238
Intermediate Savannahs	2,489	2,324	2,108	1,852

Table 6. Comparison of Beef Production and Price with and without Short Feeding of Coastal Steers.

	Year 1	Year 2
Price Beef (domestic) $		
Base Run	1.71	1.70
Short Feed	1.52	1.48
Quantity Beef (domestic) 1000 lbs.		
National		
Base Run	5,065.9	5,336.3
Short Feed	6,462.2	6,876.8
Coast		
Base Run	3,076.6	3,259.2
Short Feed	4,472.9	4,799.7

Table 7. Comparison of Selected Model Results for Base Input and Texas Data.

	Year 1	Year 2
Price Beef (domestic) $		
Base Run	1.71	1.70
Texas Data	1.33	1.36
Quantity Beef (domestic) 1,000 lb.		
National Total		
Base Run	5,065.9	5,336.3
Texas Data	7,831.1	7,760.3
Rupununi		
Base Run	2,101.3	2,189.1
Texas Data	4,630.0	4,630.0
Herd Size		
National		
Base Run	156,150	159,310
Texas Data	176,846	178,674
Rupununi		
Base Run	63,215	64,016
Texas Data	85,165	85,165
Intermediate Savannahs		
Base Run	2,489	2,324
Texas Data	3,138	3,138

Herd Structure	Year 1	Year 2	Year 3	Year 4	Year 4 Weight (lbs.)
Bulls	45	45	45	45	
Brood Cows	900	900	900	900	
Bull Calves	238	238	238	238	
Heifer Calves	238	238	238	238	
Heifers (1 Yr.)	45	45	45	45	
Heifers (2 Yrs.)	130	130	130	130	
Steers (1 Yr.)	85	85	85	85	416
Steers (2 Yrs.)	329	329	329	329	545
Steers (3 Yrs.)	568	568	568	568	837
Total	2,578	2,578	2,578	2,578	
Meat Supply per Cow Unit (lbs)	166.2	166.2	166.2	166.2	

Herd Structure	Year 1	Year 2	Year 3	Year 4	Year 4 Weight (lbs)
Bulls	45	45	45	45	
Brood Cows	900	900	900	900	
Bull Calves	308	308	308	308	
Heifer Calves	308	308	308	308	
Heifers (1 Yr.)	119	119	119	119	
Heifers (2 Yrs.)	135	135	135	135	
Steers (1 Yr.)	304	304	304	304	404
Steers (2 Yrs.)	373	373	373	373	579
Steers (3 Yrs.)	646	646	646	646	920
Total	3,138	3,138	3,138	3,138	
Meat Supply per Cow Unit (lbs)	177.3	177.3	177.3	177.3	

Herd Structure	Year 1	Year 2	Year 3	Year 4	Year 4 Weight (lbs)
Bulls	1,250	1,575	1,471	1,594	
Brood Cows	25,000	31,504	29,415	31,880	
Bull Calves	6,255	7,882	7,359	7,976	
Heifer Calves	6,255	7,882	7,359	7,976	
Heifers (1 Yr.)	4,685	5,904	5,512	5,974	
Heifers (2 Yrs.)	3,969	5,001	4,669	5,061	
Steers (1 Yr.)	4,687	5,907	5,514	5,979	419
Steers (2 Yrs.)	3,660	4,613	4,309	4,669	583
Steers (3 Yrs.)	7,831	9,869	9,220	9,989	930
Total	63,592	80,137	74,828	81,098	
Meat Supply per Cow Unit (lbs)	160.4	137.5	165.5	165.7	

Herd Structure	Year 1	Year 2	Year 3	Year 4	Year 4 Weight (lbs)
Bulls	1,250	1,250	1,250	1,250	
Brood Cows	25,000	25,000	25,000	25,000	
Bull Calves	8,033	8,033	8,033	8,033	
Heifer Calves	8,026	8,026	8,026	8,026	
Heifers (1 Yr.)	3,608	3,608	3,608	3,608	
Heifers (2 Yrs.)	3,478	3,478	3,478	3,478	
Steers (1 Yr.)	8,550	8,550	8,550	8,550	446
Steers (2 Yrs.)	8,286	8,286	8,286	8,286	674
Steers (3 Yrs.)	15,998	15,998	15,998	15,998	1,039
Total	82,229	82,229	82,229	82,229	
Meat Supply per Cow Unit (lbs.)	164.2	164.2	164.2	164.2	

Appendix B

Selected papers presented at the Livestock

Modeling Workshop

Georgetown, Guyana

March 1 & 2, 1976

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Explanation of the Guyana Livestock Model

The Guyana livestock model is a multiyear decision model for analysis of the Guyana livestock sector. The model attempts to predict actions of the livestock subsector under development interventions. The behavior of producers is assumed to be determined by principles where all producers try to obtain maximum income over a multiyear period, each producer has no individual power over the country beef price, and producer groups do not attempt to affect price.

The model includes the following actions within the livestock sector: cow-calf production, steer finishing, animal marketing, intermediate sales, animal and input transport, theft, labor, input supply and consumption. The model does not attempt to incorporate functioning of the retail market. Within the model the demand for beef is explicitly responsive to the price of beef. Similarly variable labor and land quantities are available to the livestock industry and are dependent upon the wage or rental rate. Prices of imports such as fertilizer and gasoline are fixed at exogenously specified prices. Similarly prices of local by-products such as rice bran and wheat middlings are fixed at exogenously specified prices and quantities.

Thus the overall model predicts a pattern of production through consumption, given a situation. Through systematic alteration of the data situation policy alternatives can be tried out and sector response predicted.

This paper reviews in a general non-technical manner the structure of the Guyana livestock model. Interested readers may wish to consult companion papers on data specification and policy simulations.

Production

The basic production scheme within the model is developed to predict producer behavior in the first year of the model given current market situations and future expectations. Generally, within the model once a producer makes a production decision he stays with it throughout the multi-year period. The model explicitly includes four years worth of explicit pricing information along with estimates of the future value of animals after the period is over (ending inventory data).

Livestock are broken into 12 categories for the purpose of this model (Table 1).

Bulls
Brood Cows
Male Calves
Female Calves
Heifers 1 year
Heifers 2 years
Steers 1 year
Steers 2 years
Steers 3 years
Steers 4 years
Steers 5 years
Steers 6 years

Table 1. Breakdown of Cattle.

When aging the herd replacement bulls are drawn from the three year old steer categories and all 2 year old heifers go into the Brood Cow category. Other than these exceptions, the animals progress from calves through steers and heifers with animals retained equal to initial animals less sales, theft, and death loss. Weight of animals is independent of animal numbers and is calculated by taking initial weight then adding in the annual poundage of gain.

Animals within the model are separated into subherds. These subherds are differentiated because of either animal performance or ownership. Basically, a new subherd is introduced whenever two sets of animals are reasonably expected to react differently when presented with the same management system. The different reaction may be due to either the animal conditions (breed, health, etc.) or owner behavior (due to slowness to adopt new technology, operating capital, etc.).

On the resource side animal production uses land, labor, cash, machinery, minerals, fertilizer, feed supplements and veterinary services. These resource uses are all specified on the input form. Usage of these resource changes with time dependent upon herd size. In addition to the above usages of resources, production may also require additional animals dependent upon the retention-disposal strategy used.

Outputs from production include milk, meat and animals for intermediate sale (dependent upon retention-disposal systems). Production of these outputs depends upon the number of animals in the herd.

The production decision within the model involves which way to manage the existing subherds given the present and future output resource markets. Production alternatives may differ on all herd performance and

requirement parameters. Current specifications include such things as differences in age of animal sales, use of feed supplements and use of land.

Steer Finishing

Steer finishing is an activity which has a structure similar to the production activity. Steers from other production subherds are sold to the finishing activity. Animals can be either 1 or 3 years old. The animals progress through this subherd with retention defined by the initial animal less yearly sales, theft and death loss data. Weight gain is independent of the number of animals on hand with initial weight changing by a percentage specified in the input form.

The activity uses resources in the same manner as the production activities so this will not be discussed here. The sale output of the activity is meat.

The decision involved in steer finishing is how many steers to feed by each method each year given resource use and output demand. In addition the steer finishing activities do not have an initial herd endowment so the decision making involves whether or not to feed steers at all.

Animal Marketing

Animal marketing within the model consists of the transfer of live animals from the farm through slaughter to meat in Georgetown. The rate at which animals are marketed is dependent upon the management systems adopted and the derived demand the abattoirs have for farm level beef. Within the model there are two basic modes of meat marketing. Animals are slaughtered in the Rupununi and meat is transported to Georgetown, or the

animals are transported to Georgetown and then slaughtered. The only exception to this rule is the meat consumption outside of the Coastal-Georgetown region. This meat is slaughtered on location and does not go through the normal marketing channels.

In slaughtering the animals the only resources required are animals, labor and abattoir capacity. Outputs from the abattoir are carcass beef to meet demand. The cut out rate is assumed to be 50 percent, i.e., for each two pounds of live weight one pound of carcass beef is created.

Intermediate Sales

Within the Guyana model animals may be sold at either one year of age, three years of age or at slaughter. The slaughter sales are discussed above. Intermediate sales are caused as a consequence of the herd retention and disposal activities and the steer finishing activities. The steer-finishing activities are pure demanders of intermediate steers and the production activities act as both suppliers and demanders of intermediate animals.

Land Development

Land Development includes land clearing, pasture development and pasture maintenance. All of these activities use land of one form and transform it to another form, using resources in the process.

Land clearing is a one year process. Land is transformed from uncleared land not useful to the livestock sector into land classified as native grazing land. This process takes one year and uses land, labor, cash, and possibly fertilizer.

Pasture establishment is basicallv a one year process. However the acreage established is assumed to be 50 percent available in the first year and 100 percent in the second year. Pasture establishment uses cleared native grazing land and transforms it into improved pasture. In establishing pasture, labor, machinery, fertilizer and seed is used.

Pasture maintenance is an activity required to perpetrate improved pasture. Each year of the improved pasture use requires that it either be established or maintained the year before. If the pasture is not maintained it reverts to cleared native grazing in one year. Maintenance requires the same resources as establishment although in less quantities. The decision variables in this case are what to develop given the needs of the livestock industry versus the costs of development.

All the of the above development activities are limited by an annual maximum.

Animal and Input Transport

The model as specified involves four spatially separated production regions (Rupununi, Northwest, Intermediate Savannahs, and Coastal) and one principal demand region (Coast). Inherent in this separation is the need to transport goods back and forth. In the Guyana model due to geographic considerations all items are assumed to be passed through the Coastal region. Three modes of transport are available (boat, truck, and plane) although not all modes are available to each region due to existing infrastructure. Three types of goods are transported (inputs, live animals and carcasses) althought not all goods are shipped to all regions (due to considerations such as foot-and-mouth).

Transportation services are paid for on an as used basis. The cost however may be shared by the government in the form of subsidies. There is an upper limit on the trips in and out of each region set externally.

Theft

Theft considerations are included with respect to the Coastal beef production activities. Stolen beef does enter the market system in regular channels. However theft is penalized in the models consideration as it results in a direct loss of producer income.

Labor and Input Supply

Labor and input supply refer to those activities through which the livestock sector obtains its land, labor, feed supplements, fertilizer and other services and purchased inputs. The supply of these commodities is based upon the Guyanese situation. Most feed supplements and fertilizers are imported with Guyana purchasing a very small amount relative to the world market. These goods are purchased at a fixed price set by the world market. Several other Guyanese inputs and services are portrayed as available at a price up to a fixed quantity (such as rice bran) as these goods are available as byproducts of other industries.

The labor market, however, is one in which the cattle industry does exercise some effect on the wage rate. Thus as the cattle industry increases its demand for labor it may increase its available labor supply by increasing the wage rate.

The land market is also one in which the cattle industry faces a variable land supply dependent upon the amount of rent it is willing to pay. However this feature is only present on the coast where the land is

being drawn away from other productive uses (cropping). In the outlying districts land is made available at an exogenously specified rental rate up to a fixed quantity.

Consumption

Consumption is treated within the model for beef and milk. Beef consumption is broken into three parts: national, regional and export. National consumption is determined by a prespecified demand curve varying quantity consumed with price. Consumers are assumed to act in a way in which they pay the least amount possible for beef. Beef consumption in the model is consumption of carcass beef and is drawn from marketed beef without distinction as to source of the animal (theft or region does not affect consumption, just price). The only domestic exception to this is regional meat consumption where only local meat is consumed.

Export meat, however, is handled slightly differently. Exports are only from subherds which have export potential. Thus disease restrictions may be imposed on exports.

Milk is consumed at a uniform price of 2.40 independent of quantity consumed.

Appendix B-3

The Guyana Data

Within the Guyana model there is a large data base. This paper attempts to explain that data base. Sources of data are not stated with all the numbers.

The basic sources are the Ministry of Agriculture (through both interview and annual reports), the World Bank Guyana Loan Project, the Tuskegee Producer Survey, the many producers and marketing agents interviewed by Purdue and the members of the 211d Livestock Consortiuum.

This paper will proceed through the base data in its various groupings: Production, Inventory, Development, Resource Endowment, Transportation Supply and Demand, Purchased Services and Inputs, Animal Movement.

Production

Cattle production takes place in primarily four regions of the country, within each region, one or more subherds are defined. Each subherd may be managed under several alternative management systems.

Rupununi Region

The Rupununi region has four basic subherds: large commercial, small commercial, Amerindian and World Bank.

The large commercial subherd is typified by the Rupununi Development Corporation. About 42 percent of the animals in the area are in this herd. The herd is extensively managed. Within this land there are four management systems. Management system 1 is a portrayal of the current herd. Management system 2 allows steers to be slaughtered one year earlier. Management system 3 allows heifer slaughter, and management system 4 is heifer slaughter and early steer slaughter.

The small commercial herds are typified by the McTurk ranch. About 37 percent of the animals in the area are in this herd. This herd is managed more closely than the large herds. Under this herd the same four management systems appear as under the large commercial herds.

The Amerindian herds are typified by the village herds of the Amerindians. About 16 percent of the regional herd is in this subherd. This herd performs similarly to the small commercial herds. However the producers are seen as subsistence type producers.

About 5% of the cattle in the Rupununi area are in the World Bank sponsored herd. Production conditions and management systems are similar to those of the large commercial herds, however the World Bank herd is treated separately because it is assumed to have better access or potential access to information on advanced production techniques.

Northwest District Region

The Northwest District region has one subherd. It is a government owned ranch with about 1,500 head located near Matthews Ridge. Each of the four management systems described above are specified for this subherd.

Intermediate Savannahs Region

There is one subherd in this region at the Ebini Livestock Station. The herd is rather intensively managed and currently has about 2,500 head. Each of the four management systems described above are specified for this herd.

Coastal Region

There are four subherds specified on the Coast: extensive commercial ranches, intensive commercial ranches, small non-commercial producers, and a commercial dairy herd.

The extensive commercial ranches are typified by the Booker's operation. Approximately 34% of the Coastal herd is managed under this extensive production system. The four management systems described above are specified for this subherd.

The intensive commercial ranches are typified by the Fraser ranch. This more intensively managed herd has a higher calving percentage and lower death loss than the extensive ranches. Fourteen percent of the Coastal herd is in this subherd. The four management systems described above are specified for this herd, except that they are numbered 6, 7, 8, and 9, respectively.

About 47% of the Coastal herd is in the small non-commercial herds. Most of the herds are maintained by small farmers in herds ranging from 1-25 head and are kept primarily to produce milk for the household. These animals are assumed to attain a lower performance than either the extensive or intensive commercial ranches. There are three management systems specified for this subherd. Management system 1 is the current situation in which 30% of 1 year old steers, 50% of the 2 year old steers and 100% of the 3 year old steers are sold to slaughter.

Management system 2 does not allow for sale of steers until 3 years old, at which time all steers are sold. Management system 3 is the same as 1 except that all 3 year old heifers are sold. Due to clinical error, a fourth management system is specified, but is exactly the same as 1.

There is a small commercial dairy herd which accounts for 6% of the Coastal herd. Beef produced from this herd enters the Coastal meat supply, but milk production is the primary output. There are four management systems specified for this subherd. Management system 1

sells 10% of the 3 year old heifers, and 100% of 2 year old steers to slaughter. Management system 2 is similar to 1 except now 100% of 1 year old steers are sold to slaughter. Management system 3 is similar to 1 except now all heifers are slaughtered. Management system 4 sells all 1 year steers and all heifers to slaughter.

Inventory

Pricing of final inventory are activities which sell out the inventory of animals and land which the sector possesses in the last year of the model. In the base data, cattle are sold out by subherd in each region. Steers are sold on a per pound basis, all other animals are sold on a per head basis. Prices are specified in the pricing of animal inventory section of the input form. Currently, all land in the model is sold for zero.

Development

Three types of land development activities can be carried on within the model. Land which is jungle may be cleared to yield unimproved pasture. Native pasture or cleared land may be improved through a pasture establishment activity. Once an improved pasture has been established, it must be maintained each year through a pasture maintenance activity. In the base data, development activities have been specified for the Northwest District, Intermediate Savannahs, and the Coast.

Northwest District

A land clearing activity is specified for this region. It is subsidized by the government at the rate of $150 per acre and can at most clear 1,000 acres per year. A pasture establishment activity is

specified. It is subsidized by the government at the rate of $65.72 per acre and can at most establish 2,000 acres per year. A pasture maintenance activity is also specified. It is subsidized at the rate of $65.72 per acre and can at most maintain 9,000 acres per year.

Intermediate Savannahs

The land clearing activity in this region is subsidized at the rate of $75 per acre and can at most clear 2,000 acres per year. The pasture establishment activity is subsidized at the rate of $87.62 per acre and can at most establish 2,000 acres per year. The pasture maintenance is subsidized at the rate of $87.62 per acre and can at most maintain 9,000 acres per year.

Coastal Region

No land clearing activity is specified for the Coast. Both pasture establishment and pasture maintenance are specified but are not subsidized by the government and have limits of 300 acres and 15,000 acres per year, respectively.

Supply or Demand

Land and labor supply and beef demand are specified to the model through these activities. Land is classified by quality. The classifications are: Type I and II - good to moderate agricultural land, Type IIIf - poor land with severe fertility limitations but with fertilization possibility, Type III - poor land which should be left in its natural condition, and Type IV - non-agricultural land with severe limitations for general agricultural use. Land is supply by land type to each region.

In the base data, land is supplied to the Rupununi, Northwest District and Intermediate Savannahs through perfectly elastic supply curves (constant price). Labor is specified to each region in one of three classifications: permanent labor, temporary or hired labor, and skilled labor. Skilled labor is supplied only to Rupununi and the Coast and is assumed to be used only for slaughter. All beef is assumed to be sold through the Coastal market so that a single beef demand schedule is specified.

Resource Endowments

Initial endowments of cattle, land, feedlot capacity, and transportation capacity may be specified through these activities. Since all beef is assumed to be sold on the Coast, regional meat demand may be specified for the Rupununi, Northwest District, and Intermediate Savannahs. This regional meat demand is substracted from the supply by the region to the Coastal beef market.

Transportation

Transportation is assumed to be available to the cattle sector in three forms: air, boat, and truck. All routes are either to or from the Coastal area. For example, if one wished to travel from the Northwest District to the Rupununi, one must first travel from the Northwest District to the Coast and then from the Coast to the Rupununi. The transportation activities "transport" beef from the outlying regions to the Coast and inputs from the Coast to the outlying regions. Air transport from the Rupununi to the Coast is subsidized by the government at the rate of $.145 per pound for each trip.

Purchased Services and Inputs

The following purchased inputs are imported at a fixed world price and have a fixed availability: salt, minerals, mixed feed, corn, bone meal, supplement for horses, nitrogen, phosphate, potassium, and fencing materials. Rice bran, wheat middlings, urea, molasses, and copra meal are by-products of other sectors in Guyana and may be purchased at a fixed availability. All purchased inputs are purchased on a country-wide basis. Farm managers, farm machinery, veterinary services, artifical insemination, and slaughter services are purchased services which are purchased at a fixed price and availability on a regional basis. Slaughter services are purchased only the Coast and the Rupununi. Capital is treated on a national basis. The cattle sector may borrow needed cash at a 9% per annum charge and may level excess cash at a 7% rate.

Trial Interventions in the Livestock Sector:

Changes in the Base Data

Following the creation of the base model, many livestock interventions were imposed on the industry model. The changes to these interventions are the subject of this note.

Intensive Coastal Management

Under the intensive coastal management system, four new management systems were added to the coastal large commercial producer subherd. These new management systems were the same management systems as employed by the small commercial producers on the coast. Essentially these new management systems provide the opportunity to closer control the cattle by using more labor and gaining improvements in theft and death losses.

Export from Northwest and Intermediate Savannahs

In the export runs new management systems were added to the Northwest and Intermediate Savannahs subherds from the base model. The new management systems were identical to the existing management systems except the producer is allowed to sell up to 60% of output to the export market. An export demand curve is also entered which reflects demand in the world market for beef. The quantity produced by Guyana is assumed to be small enough that the world price is not affected.

Rupununi Air Transportation Subsidies

Two runs were done simulating the Rupununi air transportation subsidies. Due to clerical difficulties one of the runs is not summarized in the final tables in this report. One run was with complete subsidy of all beef transport costs from the Rupununi, the other run removed the subsidy completely.

Steer Finishing

Several runs were made on steer finishing possibilities. All of these runs involved the introduction of new management systems for the coastal small producers. Each of the existing small non commercial producer management systems received the additional felxibility wherein all one year old or three year old steers are sold for additional finishing.

Short Steer Feeding

In the short feeding activity a new subherd technology was introduced which feeds 3-year old steers a short time obtaining a quick gain. Animal movement and final inventory data are also included.

Coastal Young Steer Feed

Two Coastal long feed runs were made. They both purchased steers from small non commercial herds at one year of age and feeds them for 3 years. The two runs were different by export potential. The export run has an export curve and 60% of finished steers were allowed to be sold to the export market.

Northwest and Intermediate Savannahs Young Steer Finishing

These interventions involve the feeding of young non commercial coastal steers in the outlying areas. A new subherd is introduced with three management systems. Animals must be moved by transportation means to get them to these areas.

Texas A & M Data

Data from the Texas A & M Herd Model were used to generate an alternative base model. In the Texas data, only one subherd was specified for the Rupununi (all Rupununi base subherds were removed). Texas data were also used for the Intermediate Savannahs (again with all of the above Intermediate Savannahs base data removed). Texas data were not used for the Northwest District or the Coastal herds. The alternative management systems specified for the Rupununi and the Intermediate Savannahs were:

Rupununi

1. 12-month breeding season with improved management to prevent baby-calf deaths by drowning, steady state herd,
2. 12-month breeding season without improved management, steady state herd,
3. 12-month breeding season, growing herd.

Intermediate Savannahs

1. 12-month breeding season
2. 4-month breeding season (November-February).

Appendix B-5

Feb. 25, 1976

Summary

by

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We have discussed the basic physical systems involved in the livestock sector:

Forage, its production, management, digestability, protein content.

Cattle herds, producing milk and calves, consuming the seasonally available forage supply, gaining weight, loosing weight, and compensating gain.

Animal health and its effect on production. Here our data on the physical relationships is still a little weak.

Phosphate supplememtation

The livestock producers and their labor force.

The Veterinary Service and its delivery system.

The Livestock Extension Service and its delivery system.

This includes a National policy framework.

Development of the livestock sector and increase of the meat supply

Diversification of the sector geographically

Equity for the producers.

Increasing employment opportunities.

Exploiting the export potential of the sector.

We have then used a first model to feed the forage to the cattle, allowing for the seasonal change in its quality, and simulated the resulting production. With this basis we have used a second model to indicate the economic outcome including the effect on the price of meat using the supply/demand relationships which we have estimated for Guyana.

Furthermore, we have only tested a specific number of possible strategies. However, we are pleased to be training Mr. Deep Ford of your country, and expect that with him and through him it will be possible to test other strategies which will be of interest to the Government of Guyana. Our models will point out restrictions, but the conception of the strategies to be tested must come from the human brain and will not come from the computer.

What will the Models Do?

Given a conception of the government's priorities the models can provide information on the following:

Where should production be centered in the short and medium term and in the long term?

What are the likely effects of price, subsidy and tax policies?

What would be the likely economic payoff from a veterinary program which would reduce death loss by X percent?

What systems of production should be used and in what areas? This includes the effects of improved management and the spectacular possibilities of finishing cattle on coastal pastures with a molasses supplement for 100 days.

What is the potential for export?

What will the price and consumption of meat be under given conditions?

The models will not, in their present state, explain changes in the coastal herd apart from those caused by economic and technical reasons. Social and socio-political variables are not quantified for this purpose.

While the models help to evaluate the results of plans, they do not themselves plan and they will not indicate how the technical package is to be implemented and delivered by the extension service, nor what are the training needs in order to deliver a program.

We have tested a number of alternatives in terms of

Location for livestock development,

Specialization by zone (e.g. cow herds in one place, growing and/finishing in another),

Intensive management systems with and without large quantities of purchased inputs,

Subsidies related to meat transport and inputs for pasture improvement,

Supplemental feeding of steers on improved pasture, and

Limited participation in the export market for beef.

The effect of these "interventions" or strategies on the economic and physical output and on the "efficiency" of the sector in the use of the available forage-water resources. We attempt to explain the reasons why we get certain results. It must be remembered that this whole process provides solutions based upon economics but that in reality the result is based upon economics and government policies. For example, the government may influence meat prices, it may decide to charge for various services performed at a reduced rate or at the full cost, and so on.

We do not propose that we have reached a final stage; the models need further "tuning" and adjustment and there are relationships which should be quantified but have not yet been quantified. For example, the effects of government investment in more research, in improved veterinary service, and in strengthened extension on livestock production, the effect of farm record keeping on extension and so on have not been quantified.

In Conclusion

We are happy to be able to deliver to you two new models in operation and to have the opportunity to instruct one of your countrymen in their use, so as to make them more accessible to you. We have appreciated your assistance in the past and your interaction with us at this seminar and look forward to further discussion tomorrow.

We look forward to helping you to test your ideas for development of the sector and to interpret the results of those tests.

Appendix C

Report of "Survey of Beef Consumption In Guyana"

REPORT OF "SURVEY OF BEEF CONSUMPTION IN GUYANA" *

The questionnaire on which this survey was based appeared as Appendix B, in the 211(d) Annual Report, Purdue Universtiy, June 30, 1975. It was circulated among respondents during the six months prior to this date. The questionnaire is attached at the back of this report.

INTRODUCTION

The sample on which this survey is based is made up of a total of 137 respondents, distributed geographically into two groups, urban (58%) and rural (42%). Urban includes Georgetwon and New Amsterdam, while rural would be anywhere else. This would be in keeping with the breakdown of the population in Guyana, which is a rural based country. This is an important facet in an analysis of this nature because of the absence of markets and the presence of household production of meat in the rural areas.

It should also be pointed out that eighty percent of the respondents have at least a primary school education. The literacy rate in Guyana is unusually high because of the concentration of the population in the coastal belt and the deliberate educational bias of government policy. Sixty-five percent of the sample classified themselves as either skilled, sub-professional, or professional. Job classification categories might be hazy because of the wide definition of what a skilled or a sub-professional job is. Seventy-seven percent were classified in middle income and upper income households ($2,500 plus per annum). Household incomes tend to be high because of the presence of the extended family system which is still fairly common in Guyana.

Finally, thirty percent of the sample were Hindus (part of the sixty percent East Indians in the sample) whose presence need to be mentioned because their religious beliefs do not permit the consumption of beef. Their failure to respond to parts of the survey that were not relevant to them should be noted and treated with the indifference it implies. It should also be noted that per capita estimates are influenced by their presence, for instance, per capita consumption of beef would be higher than indicated.

Consumption Patterns

The results of the survey point to three characteristics that describe the meat consumption patterns of the Guyanese population. Firstly, the survey suggests that meat is bought as a homogeneous product, despite recognition of it as a differentiated product. Secondly, Guyanese consume meat based on a purchase made once per week. Thirdly, poultry is the most popular meat consumed, followed by beef.

Seventy-three percent of the respondents recognize that beef is a differentiated product, although the survey suggests that when they make their purchase of meat this differentiation is not reflected. It is felt however, that there is a failure on the part of the marketing mechanism to communicate this because of the way in which the sale is conducted. Normally sales take place in a butcher shop or public market and buyers dictate to the butcher (there and then) where their cut must come from and how it should be. The label on the cut of meat is not specifically placed, but it is almost always bought with a particular cooking purpose in mind. Stew beef which is very popular reflected this in that most respondents claimed they bought this type of meat the previous week.

Ninety-four percent of the respondents claimed that they had electricity in their area while only sixty-three percent claimed they owned refrigerators. This is expected because of the policy of rural electrification that has been a favorite of the government for a long time. It is questionable that it is the presence of refrigerators that leads to the weekly purchasing of meat. Undoubtedly their presence would facilitate this. However, in the markets in the rural areas, meat is normally for sale only on Saturday's, therefore, this pattern may be more dictated by the marketing mechanism than by consumer choice. This pattern is also evidenced in Georgetown, although meat is available on a daily basis there. In Georgetown however, it is felt that both convenience and habit cause most people to make the purchase once per week.

Finally, the survey points out clearly that the main substitute for beef in Guyana would be poultry. When meats were ranked in order of preference, poultry and then beef were preferred to all other meats. Sixty-seven percent of the sample (another seventeen percent did not respond to this question) stated that they would resort to poultry if the price of beef was to rise. Tables I and II present these results* The development of the poultry industry in Guyana in recent years may well be an indication of this.

Purchasing Patterns

Purchasing patterns treated by the questionnaire yielded information primarily on the sales outlet. Generally the conclusions to be drawn were that most meat is purchased from village butcher shops and municipal markets and that purchasers were satisfied with the sanitation of the premises and the quality of the meat. Failure on the part of most of the respondents to answer the questions concerning prices and cuts of meat greatly limited the conclusions that could be drawn from this section.

Fifty-eight percent of the respondents claimed that they purchased meat either from a municipal market or a butcher. This has been used to point out the preference for 'hot' beef and to show up one of the traditional sides of Guyana's beef marketing system. Frozen meat is available in local supermarkets from which seventeen percent of the respondents claim they obtain their beef. It is felt that it is not so much a preference for hot beef as it is the fact that this is the form in which beef has been presented (traditionally) on a daily basis. There is nothing to suggest that the demand for 'hot' beef is greater than the demand for frozen beef

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* All Tables are in the appendix.

Both the sanitation of the dealers' facilities and the quality of the beef he offered for sale were judged satisfactory by approximately sixty-eight percent of the respondents, (see Tables III and IV). This satisfaction by the consumers however, should not be considered to reflect that in these areas there does not need to be a lot of improvement. Quoting from the Elmers' report, John Dukhia suggests methods, tools, and techniques are primitive and that the industry standards of sanitation and disease inspection are totally inadequate.* These contradictory statements are not surprising when one realizes that in most cases the only frame of reference for the Guyana consumer is what he has traditionally been accustomed to.

Beef Consumption over Geographic Location, Ethnic Origin, Religious Persuasion and Income Group

Broken down between urban and rural, it was found that on the average four pounds of meat was consumed in the urban area to two pounds in the rural area per household per week. This result is very interesting as it reflects perhaps not only the availability of meat in the urban area, but also the higher consumption in the higher income area. Beef consumption based on ethnic origin suggests further reason for high urban consumption (or explanation why rural consumption is low). Among the East Indian respondents only two pounds of meat was consumed, while among the Africans it was found to be three and one-half pounds. It must be remembered that the Hindus in the population, who are primarily East Indians, would bias the consumption of the East Indians as a group downwards. This effect of the Hindus' is seen clearly when their consumption as a religious group is looked at. In comparison with the four pounds average of the Christians and the three pounds average of the Moslems, the Hindus' consume a little over one - half pound of meat per week. Finally, consumption of

* See Appendix C, 211(d) Annual Report, Purdue University June 30, 1975.

beef per week increases with income class. Table V presents all these results. These facets are considered to be important because as development takes place and the population continues to grow, its nature may change to emphasize any one of the above units which in turn would signal particular changes in the demand for meat.

Prices of Beef by Outlet

The three outlets looked at were supermarkets, butcher shops and municipal markets. It was observed that the price in general varied between $1.60 per pound and $2.15 per pound. The supermarkets were reported as having the highest prices, the average price in this outlet being $1.90 a pound. There was much more variation of prices at the municipal markets where equal numbers of respondents quoted $1.70, $1.80 and $1.90 as the price per pound. Butcher shops showed a similar variation to the municipal markets. These figures are summarized in Table VI. A number of suggestions can be put forward to explain the variation cited. Firstly, the higher prices at the supermarket might reflect their own transportation of animals to the city abbatoir plus the extra benefits in sanitation facilities that they are reputed to offer. The variation among butcher shops and municipal markets may reflect location and clientele served. Butchershops and market stalls are very small, personal and community oriented, and butchers are known to discriminate based on their own evaluation of the client at hand. Finally, there may be some distortion in the apparent price variation based on beef being considered a homogeneous product but bought as a differentiated product.

Conclusions

The results cited above in no fashion or manner treat all the information that is in the survey. A close look at the questions in the survey would indicate the other types of information that might be extracted. There is the intention to treat these elsewhere.

Table 1

If Price of Beef is too High, Which Meat Resorted to:

Type of Meat Resorted To	Percentage of Respondents
None*	17
Pork	10
Mutton	7
Poultry	66

*No response.

Table 2

Percentage of Population Ranking Particular Meat Highest on Preference List

Meat	% of Population Choosing Particular Meat as #1
Beef	30
Pork	7
Mutton	28
Poultry	35

Table 3

Level of Sanitation of Dealer's Premises

Dealer	Percentage of Respondents		
	Very Satisfied	Satisfied	Unsatisfied
Meat Centre*	20%	80%	-
Supermarket**	39	53	8%
Grocery*	50	50	-
Municipal Market**	13	71	16
Butcher Shop**	9	82	9

*5 and 2 respondents, in that order.
**23, 35 and 44 respondents, respectively.

Table 4

Quality of Beef Offered for Sale by Outlet

Outlet	Percentage of Respondents		
	Very Satisfied	Satisfied	Unsatisfied
Meat Centre	20%	40%	40%
Supermarket	17	74	9
Grocery	50	--	50
Municipal Market	11	60	29
Butcher Shop	9	82	9

Table 5

Beef Consumption per Week

Nature of Group	Average No. of Pounds
Urban	4.02
Rural	2.32
Africans	3.57
East Indians	2.13
Christians	4.27
Hindus	0.85
Muslims	3.08
Low Income (< $2,500)	1.56
Middle Income ($2,500-$6,000)=	2.49
Upper Income ($6,000+)	4.97

Appendix D

Some Notes on the Use of Sugarcane for Animal Feed

Some Notes on the Use of Sugarcane For Animal Feed

Pete Wenstrand

December, 1975

Preparation of sugarcane before feeding. Only in the last few years has sugarcane been recognized as having the potential as the basis for intensive feeding of ruminants. Sugarcane does offer an alternative crop for animal feed production in the tropics and subtropics, due to the remarkable photosynthetic ability of the plant. However, the heavily lignified outer rind layer is a major limitation in using the cane as feed. The rind necessitates processing the cane before feeding. Cane may be fed one of the following three ways:

1) Derinded whole cane
2) Derinded cane stalk & chopped (ground) cane tops
3) Ground whole cane

The derinding is accomplished mechanically, while grinding may be done either by hand or machine. In 1974 a derinder with a 3 tn/hr. capacity cost US $35,000.00, while a 2 tn/hr. chipper cost US $700.00. Apparently, there are no differences in voluntary intake between whole sugarcane chopped by hand to a particle size of 2 cm. and that which has been passed through a grinder in such a way as to give a smaller particle size. Also, there seems to be no nutritional advantages from removing the rind as long as the particle size is mostly in the range of 2 mm to 5 mm. Since grinding is less expensive than derinding, it is probably advantageous to grind the whole cane whenever possible. See exhibit 1. Sometimes it is

difficult to pass whole cane through a derinder. This problem may be alleviated by separating the tops of the plants and grinding them separately, before adding them back to the derinded stock. Evidence indicates that animal performance is improved by mixing the ground derinded stalk with ground cane tops.

Although the tops are inferior in nutritive value as compared to the ground derinded stalk, their inclusion in the ration has led to increased live weight gains. Feed efficiency is not improved and in fact may be reduced. This indicates that the effect of the cane tops is almost certainly due to increased voluntary intake, by giving a better physical structure to the total ration. See exhibit 2. However, it should be remembered that separate grinding of the cane tops requires additional operations and expense.

Nitrogen (Protein Supplementation)

Since sugarcane has a low protein content, supplementation is extremely important. See exhibit 3 for the composition of sugarcane. A combined supplement of urea with various forms of vegetable protein, so that the urea contributes about one-half of the total N in the ration has been found successful. The supplemental protein should provide approximately 50 g of true protein per 100 Kg body weight. The urea provides a cheap source of N for the growth of rumen microorganisms, however supplementary protein N is

necessary. (Results show that if only NPN is added to the ration, gains will not exceed 300 g/day).

Most studies have indicated that vegetable protein is superior to animal protein. One of the most successful supplements is rice polishings. Rice polishings not only contain 13% crude protein, but 9% fat as well. Apparently, rice polishings are providing some essential nutrient or are having some positive interacting effect on performance when sugarcane is the basis of the ration. See exhibits 4 and 5 to compare performance with different levels of rice polishing supplement.

Carbohydrate Supplementation

Because of the high fiber content of sugarcane, performance is improved with supplemental carbohydrates. Both molasses and maize equally increase voluntary intake. However, maize improves rate of gain more than molasses and improves feed efficiency, while molasses decreases conversion. See exhibit 6.

Ensiling of Sugarcane

In certain situations it might be preferable to ensile sugarcane harvested during the traditional dry-season period. Advantages of ensiling sugarcane are:

1) Elimination of daily cutting and grinding, especially in the wet season when use of mechanical equipment is more difficult.

2) Reduction of labor costs.

There are however, inherent difficulties when ensiling sugarcane. Because of its high soluble sugar content, sugarcane is very labile, especially when finely ground. The spontaneous fermentation leads to a drastic reduction in pH and excess acetic acid production and consequently a reduction in voluntary intake. This problem may be alleviated by buffering the silage with ammonia. The ammonia maintains the pH of the material at a higher level during the first few days of the ensiling process. This allows more lactobacilli activity. The addition of .4% of ammonia on a fresh matter basis is adequate. The ammonia is easier applied if dissolved in a mixture of water and molasses. However, performance with sugarcane silage has not matched performance with fresh cane. See exhibit 6.

Miscellaneous Items

The feeding value of mature cane does not decline with age, but immature cane is nutritionally inferior to mature cane.

Trace minerals should be fed as well as salt, calcium, and phosphorous, but additional fat soluble vitamins are not needed.

Most sugarcane varieties have been developed for maximum sucrose yield. For sugar production nonsucrose soluble carbohydrates and protein are considered detrimental, because they interfere with sugar processing. It may be that the rejected varieties would have higher total soluble carbohydrate yields and thus provide a higher quality feedstuff.

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Productivity and Power Consumption of Derinding and Grinding Sugarcane.

	Chetumal Grinder[1]		Canadian Separator[2]	
	Productivity[3]	Power Consumption	Productivity[3]	Power Consumption
Mean Values (February-May)	434 Kg/hr	4.72 KWhr/Mg[4]	3169 Kg/hr	6.17 KWhr/Mg[4]

[1]Prototype model 5 hp motor with 2 knives: commercial machine (Siderurgica Nacional, SA) has 4 knives and productivity of 1000 to 2000 Kg/hr, and power consumption of 3 KWhr/Mg.

[2]Model C4: Canadian Cane Equipment, Edmonton, Canada.

[3]Refers to fresh weight of product for animal feed purposes.

[4]Mg = 1000 Kg.

Source: CIEG 1974 Informe anual. Centro de Investigacion y Experimentacion Ganadero, Chetumal, Q. R., Mexico.

Exhibit 1

Effect on Performance of Holstein Steers of Adding Chopped Cane Tops to Derinded Cane Stalk.

	Ground Derinded Cane Stalk	Ground Derinded Cane Stalk Plus Tops
Liveweight, Kg		
Initial	105	102
Final	257	271
Daily Gain	0.58	0.66 (12% increase)
Feed Intake, Kg/d		
Derinded Stalk	12.8	10.9
Tops		4.3
Protein Supplement	1.1	1.1
Total DM	4.72	5.63 (19% increase)
Conversion, Kg DM/Kg Gain	8.0	8.5 (6% increase)

Note: The two groups were fed ad libitum for 246 days. The derinded cane stalk and cane tops were combined to give a 70:30 ratio which is similar to the proportions found in whole cane. Both groups received a supplement in which urea contributed 62% of the crude protein content with the remainder being supplied by coconut and linseed meals.

Source: E. Donefer, L. A. James, and C. K. Laurie, "Use of a Sugarcane-Derived Feedstuff for Livestock", Barbados, West Indies.

Exhibit 2

Composition of Sugarcane Fractions (% Fresh Basis)
From June to December 1974 in Mauritius.

Date	Matter	Fiber	Protein	Sucrose	Total Sugars	Ether Extract	Ash	Sulphur
Derinded cane stalk								
5-31	27.9	11.2	.53	12.4	13.35		.95	.04
6-7	23.6	10.0	.48	9.75	12.39		.57	.07
6-14	27.2	10.0	.58	8.41	10.21		.69	.055
6-26	23.1	8.7	.55	10.8	12.9	.04	.57	.042
8-9	22.7	7.6	.88	12.5	13.32	.15	.71	.02
8-30	25.3	7.6	.60	16.2	16.58		.45	.085
9-28	24.4	7.9	.39	13.5	14.7	.067	.78	.063
10-4	27.9	7.7	.39	15.2	16.26	.04	.62	.056
10-18	26.9	6.7	.92	15.8	16.63	.189	.46	.05
11-8	32.5	7.7	.94	14.4	15.09	.1	.47	.07
11-14	39.2	8.8	.98	14.6	15.37	.08	.86	.092
11-21	26.0	9.6	.44	16.9	17.28	.05	.47	.04
Chipped whole cane								
8-2	25.9	13.5	1.18	7.91	8.81	.29	1.27	.087
10-14	32.6	17.5	1.26	8.64	10.11	.28	.89	.055
10-16	20.8	17.3	1.05			.30	1.51	
11-6	28.0	9.6	1.05	12.3	13.1	.41	.69	.08
11-22	29.9	16.8		8.46	10.19			
Cane tops								
6-26	26.9	15.3	.73	6.53	7.22	.32	1.42	.107
11-7	26.7	18.9	1.59	2.33	3.76	.28	1.44	.09
Rind								
6-28	39.1	27.2	.84	8.4	9.24		.73	.097
8-9	33.9	21.6	1.06	8.62	9.52	.41	.82	.04

Composition of cane stalk (8-9-74)

Rind 29.8%
Pith 70.2%

Source: T. R. Preston, "Milk and Beef from Sugarcane and its By-products", December 19, 1974.

Exhibit 3

Mean Live Weight Gains of Zebu Steers Fed a Basal Diet of Ground Derinded Whole Cane and Ground Whole Cane and Different Levels or Rice Polishings.

Treatment Effects	Mean Values Kg/d	Significance Level
Processing		
Whole	0.615	
Derinded	0.502	P < .10
Rice Polishings, g/d		
0	0.225	
300	0.456	
600	0.617	P < .001
900	0.808	
1200	0.896	

Source: Preston, T. R., Alvarez, F., Carcano, C., and Gutierrez, "Derinded and Ground Whole Sugarcane with Different Levels of Rice Polishings for Fattening Cattle, 1974.

Exhibit 4

Effect on Performance of Zebu Steers at Low Levels of Supplementation with Ground Ear Maize of Rice Polishings.

	Ear Maize	Rice Polishings	SE of Mean	Level of Significance
Initial Weight, Kg	230	226		
Daily LW Gain, g,	328	514	±1.7	P < .01
Feed Intake, Kg/d				
Fresh Cane	12.7	14.7	±0.07	P < .05
Molasses	.415	.480		
Urea	.144	.167		
Ear Maize	.600	0.0		
Rice Polishings	0.0	.300		
Total DM	4.83	5.23		
DM Conversion	14.70	10.19	±0.20	P < .05
Added True Protein, g/Kg DM[1]	9.70	6.94		
Added Lipids, g/Kg MM[1]	4.11	7.40		

[1]Protein/lipids provided by the supplement and expressed as concentration in total ration.

Source: CIEG 1974 Informe anual. Centro de Investigacion y Experimentacion Ganadera, Chetumal, Q. R., Mexico.

Exhibit 5

Forage: Sugar-Fith/Canetops.

Form:	Fresh			Ensiled		
Energy Supplement	None	Mol.	Corn	None	Mol.	Corn
Ave. Daily Gain, Kg.	.88	1.00	1.09	.31*	.87	.94

This trial lasted 95 days with Holstein steers initially averaging 320 Kg.

*After a 42-day period with low gains (0.3 Kg/day) this group was then fed a molasses supplement after which a threefold increase in gains was observed for the remainder of the period.

Source: E. Donefer, L. A. James, and C. K. Laurie, "Use of Sugarcane-Derived Feedstuff for Livestock", Barbados, West Indies, 1973.

Exhibit 6

Most of the sugarcane produced in Guyana is grown on the coast. Yields of cane average 30 tn./acre. Prices received by farmers have fluctuated considerably in recent years. In 1973 producers received $16.65 per ton of cane while in 1974 they received $27.40. Therefore, we are uncertain as to what sugarcane yields might be in the Northwest District and what the cost of feeding cane would be.

Since the Northwest District is a rainforest area, inherent problems are associated with feeding sugarcane in this region. The constant rainfall would make daily cutting, grinding, and immediate feeding necessary. Apparently, the mechanical equipment used to process sugarcane is more difficult to use during a wet season than a drier period. Also, there is some indication that the sugar content of cane decreases during a wet season, which would decrease animal performance.

In the following two tables, results from Preston's research in Mexico are used to estimate potential liveweight gains and feed costs in Guyana.

Table 1 presents a high energy, high protein ration. As can be seen, daily gains are impressive, but due to the inclusion of maize and bone meal, the ration is expensive.

Table 2 presents a low supplement ration. The rice polishings appear to be superior to maize. The cost per Kg. of liveweight gain is considerably lower than any of the previous rations.

Results from Preston's Work in Mexico, 1974 (Zebu Cattle)

Ration/day	
Sugarcane, Kg.	22.9
Maize, Kg.	1.0
Bone Meal, Kg.	.300
Urea, Kg.	.229
Molasses, Kg.	.82
Salt and Minerals	--

Liveweight gain, g/day

Bulls - 952 g.
Heifers - 758 g.

Annual Cost Using Guyana Cost Estimates

Sugarcane, 8358 Kg.	$125.40
Maize, 365 Kg.	$153.30
Transportation	$ 6.42
Bone Meal, 110 Kg.	$ 55.00
Transportation	$ 1.94
Urea, 84 Kg.	$ 18.50
Transportation	$ 1.48
Molasses, 300 Kg.	$ 15.00
Transportation	$ 5.28
Salt and Minerals	$ 1.00
TOTAL COST	$383.32

Cost Estimates

Sugarcane	$ 15/tn.	
Maize	$420/tn.	(FOB Georgetown)
Bone Meal	$500/tn.	"
Urea	$220/tn.	"
Molasses	$ 50/tn.	"

Transportation: From Coast to the Northwest District: $.008/lb.

Total Annual Gain

Bulls:	.952 Kg/d. x 365 d. = 347 Kg.	(763#)
Heifers:	.758 Kg/d. x 365 d. = 277 Kg.	(610#)

Feed Cost Per Kg.(lb.) Gain

Bulls:	$1.10 / Kg. gain	$ .50 / lb. gain
Heifers:	$1.38 / Kg. gain	$ .63 / lb. gain

Total Cost Per Kg.(lb.) Gain

If overhead costs are estimated at one-third of feed costs, then total cost of liveweight gain is $509.80.

Bulls:	$1.47 / Kg. gain	$ .67 / lb. gain
Heifers:	$1.84 / Kg. gain	$ .84 / lb. gain

Note: If the price of sugarcane is $20/tn, feed cost per Kg.(lb.) gain becomes:

Bulls:	$1.23 / Kg. gain	$ .56 / lb. gain
Heifers:	$1.54 / Kg. gain	$ .70 / lb. gain

If the price of sugarcane is $25/tn, feed cost per Kg.(lb.) gain becomes:

Bulls:	$1.35 / Kg. gain	$ .61 / lb. gain
Heifers:	$1.69 / Kg. gain	$ .77 / lb. gain

Effect of Performance of Zebu Steers with Low Levels of Supplementation (CIEG 1974)

Ear Maize Supplementation

Ration/day		Liveweight gain, g/day
Fresh Sugarcane, Kg.	12.7	
Molasses, Kg.	.415	
Urea, Kg.	.144	328 g.
Maize, Kg.	.600	
Salt and Minerals	—	

Annual Cost Using Guyana Cost Estimates

Sugarcane, 4636 Kg.	$ 69.54
Molasses, 152 Kg.	$ 7.60
Transportation	$ 2.68
Urea, 53 Kg.	$ 11.66
Transportation	$ .93
Maize, 219 Kg.	$ 92.00
Transportation	$ 3.85
Salt and Minerals	$ 1.00
TOTAL COST	$ 189.26

Total Annual Gain

.328 Kg./d. x 365 = 120 Kg. (264 lb.)

Feed Cost Per Kg.(lb.) Gain

$1.58 / Kg. gain $ .72 / lb. gain

Rice Polishing Supplementation

Ration/day		Liveweight gain, g/day
Fresh Sugarcane, Kg.	14.7	
Molasses	.480	
Urea	.167	514 g.
Rice Polishings	.300	
Salt and Minerals	—	

Annual Cost Using Guyana Cost Estimates

Sugarcane, 5365 Kg.	$ 80.48
Molasses, 175 Kg.	$ 8.75
Transportation	$ 3.21
Urea, 61 Kg.	$ 13.42
Transportation	$ 1.08
Rice Polishings, 110 Kg.	$ 16.50
Transportation	$ 1.93
Salt and Minerals	$ 1.00
TOTAL COST	$126.37

Total Annual Gain

.514 Kg./d. x 365 = 188 Kg. (413 lb.)

Feed Cost Per Kg.(lb.) Gain

$ .67 / Kg. gain $ .31 / lb. gain

Cost Estimates

Sugarcane	$ 15/tn.	
Maize	$420/tn.	(FOB Georgetown)
Rice Polishings	$150/tn.	"
Urea	$220/tn.	"
Molasses	$ 50/tn.	"

Transportation: From Coast to the Northwest District: $ .008/lb.

Appendix E

An Application of Capital Theory in A Dynamic Linear Programming Model of the Cattle Sub-sector of Guyana

An Application of Capital Theory in A Dynamic
Linear Programming Model of the Cattle Sub-sector of Guyana

A Thesis Proposal
by
Thomas Spreen

INTRODUCTION

The motivation for studying livestock production in the Tropics has been discussed among others by Lattimore (1974), May (1975) and Mauer (1975). I see no need to repeat those points here, only to say that it has been recognized that some tropical countries do have potential for large scale livestock production and up to now, have failed to achieve their potential. Thus USAID has funded, under the 211d Tropical Livestock grant, a four institution consortium to study the problem of tropical livestock production.

The broad objective of the 211d consortium, under whose funding this research is conducted, is to strengthen the participating institutions' capabilities through an integrated multidisciplinary approach to:

a) indentify opportunities for significant ruminant livestock production,

b) identify and analyze constraints to such development,

c) design programs to overcome these constraints and thereby stimulate livestock production where the potential for such production exists (Mauer 1973).

The members of the consortium and their designated areas of concentration are:

University of Florida - Animal Nutrition and Forages

Tuskeegee Institute - Rural Sociology and Extension

Texas A & M University - Animal Science and Veterinary Medicine

Purdue University - Economics

The consortium selected Guyana, S.A., as the country in which to focus its study. Since the smaller ruminants are not particularly important in Guyana, the consortium centered its effort on cattle production. Guyana has a herd of approximately 150,000 head and also possesses large tracts of undeveloped land capable of sustaining cattle production. Hence, Guyana clearly has potential for significant cattle production which it has, up to now, failed to attain.

Problem Statement

The problem is to analyze the impact of interventions into the cattle industry of Guyana. The interventions may take the form of a new production technology, development of new pasture, or a change in the marketing patterns by producers. These interventions may be termed firm level interventions and the problem is to determine their economic viability. That is, it is assumed that the technical feasibility or proposed change in production has been determined. Thus the economist's problem becomes one of determining whether the proposed change can compete favorably, in an economic context, with current production techniques. Other interventions may be at an industry level such as a price ceiling or floor for beef, the impact of exports or imports of beef, or the impact of price change of a factor of production. For these types of interventions, the economist's problem is somewhat different than for the firm level interventions. In this case the economist wishes to determine how producers react to changes in their economic environment.

The proposed methodology is a linear programming model of the cattle sub-sector of Guyana. This model has the capability of determining the viability of a new production technique or analyze the impact of policy intervention by the government.

Related Studies

This study is essentially a refinement and extension of May (1975) In May's thesis, the data were collected and a linear programming model of the Guyana with sub-sector was built. Some policy interventions were analyzed. In this paper, substantial revision in May's model will be detailed and a broader range of policy interventions will be discussed. In other words, May's data base and the basic framework of his model will be retained.

Due to a time constraint, an extensive literature review will not be made here. Let it suffice to say that I am aware of other studies and have convinced myself that this proposal is not a duplication of past work.

Conceptual Model

This section will propose and explain a conceptual model of the beef sub-sector for a country. The emphasis of this section and the entire paper is to explain producer response to outside stimuli. The stimulus may be the availability of new production techniques or some policy action taken by the government. The focus, however, is on producer response.

With this focus in mind, consider first a single firm engaged in cattle production. The outputs of the firm may be slaughter cattle, feeder cattle, breeding stock, and milk. The production process for the firm may be expressed as

$$S = F(H, D, V, Z, C, M)$$

where

S = output of cattle production process

H = herd consisting of bulls, brood cows, steers, heifers, calves

D = land input

V = labor input

Z = other purchased inputs used such as feed supplements, veterinary services, machinery, etc.

C = capital input

M = management input

A cattle producer may have more than one production process from which he may choose. These production processes may vary according to the relative use of inputs or herd retention-disposal schemes. In other words, it is more appropriate to specify the kth of production process available to the producer as:

$$S_k = F_k(H, D, V, C|M_k).$$

That is, the particular management input or management system determines the relative use of the other inputs.

To clarify the analysis, define a unit of production as a cow unit. Suppose a herd consists of 10 bulls, 100 brood cows, and 50 steers. A cow unit is a vector representing the herd structure normalized on brood cows, in this example (.1, 1, .5). Furthermore assume that resource use is specified on a per year basis. Thus the resource requirement for one cow unit, in this example, will be resources required for .1 bull plus 1 brood cow plus .5 steers for one year.

Redefine the production process in terms of cow units:

$$s_k = f_k(1,^{1/} d, v, z, c|M_k)$$

where

s_k = output of the kth production process per cow unit per year

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Since the production process has been normalized on cow units, then

v = labor requirement per cow unit per year

z = purchased input use per cow unit per year

c = capital requirement per cow unit per year.

Assume the producer's sole goal is to maximize profit and the producer operates in competitive markets for both his inputs and outputs, i.e. the prices of those inputs and outputs are fixed and known to the producer. It is further assumed that the production processes exhibit constant returns to scale. Then the problem the producer faces is to select the production process or combination of production processes available to him which maximizes his profit.

Let the cattle producer have p independent production processes, hereafter referred to as activities, from which he may choose. An activity is defined as a particular way of combining a maximum of m variable factors with a maximum of n fixed factors to yield a unit of output. A fixed factor is defined as any factor which is fixed in availability to the cattle producer in the current year. Thus assume that the herd structure is fixed, in the current year, to the cattle producer. Specifically, the number of brood cows constrains that number of cow units which can be brought into production. Assume that all other factors, land, labor, purchased inputs, and capital, are available in unlimited quantities to the firm. Then define

q_k = the level of the kth activity ($k=1, \ldots p$)[2/]

X_{ik} = the total quantity of the ith variable input required by the kth activity ($i=1, \ldots, m$, $k = 1, \ldots p$)

Y_{jk} = the total quantity of the jth fixed factor required by the kth activity, ($j=1, \ldots, n$, $k=1, \ldots, p$)

2/ This notation follows Naylor, 1966 .

P_k = the market price per unit of the hth activity (h=1, ..., H)

r_i = the market price per unit of the rth variable input (i=1, ..., m)

K_{jk} = the cost of converting one unit of the fixed factor for use in kth activity (j=1, ..., n; k=1, ..., p)

Using the above notation, an expression for the profit or net revenue for the producer is

$$\sum_{k=1}^{p} P_k q_k - \sum_{k=1} \sum_{i=1} r_i X_{ik} - \sum_{k=1} \sum_{j=1} K_{jk} Y_{jk}$$

Levels of factor use and output supply are on a per year basis. Thus the above expression is the yearly net revenue for the cattle producer.

Cattle production, by its nature, is a multi-year process. Thus production decisions made by producers will have an impact not only in the current year but several years into the future. Thus, the producer must broaden his horizon, and attempt to maximize not only the current year's profit, but also future years' profits.

The concept of profit for the cattle producer is complicated by the fact that cattle are simultaneously an investment good and a consumption good (See Lattimore, Jarvis, or Yver). That is, in contrast to most other production processes, the primary input into cattle production is the animal itself.[3/] This fact implies that the producer has an indefinite planning horizon. His goal now can be expressed as maximizing the present value of the expected income stream from cattle production. Mathematically, yearly profit can be expressed as:

3/ Jarvis 1975.

$$\Pi_t = \sum_{k=1}^{p} P_{kt} q_{kt} - \sum_{k=1} \sum_{r=1} r_{it} X_{ikt} - \sum_{k=1} \sum_{j=1} K_{jkt} Y_{jkt}$$

where

Π_t = profit or net revenue in year t

p_{kt} = market price of hth output in year t[4/]

q_{kt} = level of the kth activity in year t

and similarly for r_{it}, X_{ikt}, K_{jkt} and Y_{jkt}.

Then the present value of the expected income stream for the cattle producer (PV) can be expressed as:

$$PV = \sum_{t=0}^{\infty} \frac{\Pi_t}{(1+r)^t}$$

where r is the discount factor.

An infinite planning horizon cannot be modeled. What one may do is to select some appropriate number of years in which he explicitly calculates yearly net revenue. Then at the end of this period, he attempts to account for all future income he expects to receive from the herd in inventory. In other words, he breaks the future into the next T years and all years beyond T. Then he attempts to maximize explicitly the present value of the income stream for the next T years and then implicitly maximize the present value of the income for all years beyond T. Mathematically,

$$PV_o = \sum_{t=0}^{T-1} \frac{\Pi_t}{(1+r)^t} + F_T$$

where

F_T = discounted expected income stream from all years beyond T.

Accounting for the expected income beyond year T is conceptually not difficult, however, devising a scheme to actually measure F_{T+1} is very

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4/ This can be taken as an expected price or assume that the producer possesses perfect knowledge.

difficult. One way is to "sell out" the herd in year T. It is assumed that the producer has an expected price at which he values bulls, brood cows, steers, heifers, and calves in inventory. This expected price can be looked upon as the producer's expectation of the discounted value of the income stream that will be derived from these animals. For steers and possibly heifers,[5] this will be the producer's estimate of what the discounted value of their meat will yield. For bulls, brood cows, and possibly heifers, the producer forms an expectation of the future income that will be generated by their offspring. In other words, the producer possesses an inventory demand for breeding stock and this demand is a derived demand based upon his expectation of the future income that can be derived from their offspring.

Define W_h = sell-out price of animal in category h.

where

h = 1 bull

h = 2 brood cow

h = 3 steer

h = 4 heifer

h = 5 calf

Further define F_{kh} to be the number of animals in class h left in inventory from activity k. Thus

$$F_T = \sum_{h=1}^{5} W_h F_{kh}$$

and substituting into the expression for PV_o

$$PV_o = \sum_{t=0}^{T-1} \frac{\Pi_t}{(1+r)^t} + \sum_{h=1}^{5} W_h F_{kh}$$

5/ The producer always has the choice of selling a heifer for meat or bring-it into the breeding herd.

Following the assumption that the production process exhibits constant returns to scale,[6/] define

a_{ik} = the quantity of the ith variable factor required by one unit of the kth activity (i=1, ..., m; k=1, ..., p).

b_{jk} = the quantity of the jth fixed factor required by one unit of the kth activity (j=1, ..., n; k=1, ..., p)

c_{hk} = the number of animals in category h left in inventory in year T by one unit of the kth activity (h=1, ..., 5, k=1, ..., p)

and let

Y_{jt} = the total quantity of the jth fixed factor available to the producer in year t.

From the definitions, the constraints are

1) $X_{ikt} = a_{ik}q_{kt}$ (i=1, ..., m; k=1, ..., p; t=0, ..., T)

2) $Y_{jkt} = b_{jk}q_{kt}$ (j=1, ..., n; k=1, ..., p, t=0, ..., T)

3) $F_{hk} = C_{hk}q_{kT}$ (h=1, ..., 5; k=1, ..., p)

4) $\sum_{k=1}^{p} Y_{jkt} \leq Y_{jt}$ (j=1, ..., n; k=1, ..., p)

So that the LP formulation of the profit maximization problem is to

$$\text{Max} \quad PV_0$$

$$\text{Subject to} \quad \begin{array}{ll} X_{ikt} = a_{ik}q_{kt} & (i=1, \ldots, m;\ k=1, \ldots, p;\ t=1, \ldots, T) \\ Y_{jkt} = b_{jk}q_{kt} & (j=1, \ldots, h;\ k=1, \ldots, p;\ t=1, \ldots, T) \\ F_{hk} = C_{hk}q_{kT} & (h=1, \ldots, 5;\ k=1, \ldots, p) \\ \sum_{k=1}^{p} Y_{jkt} \leq Y_{jt} & (j=1, \ldots, n;\ t=0, \ldots, T) \end{array} \qquad (\ )$$

6/ This assumption may be relaxed somewhat. See [ ].

$$q_{kt}, X_{ikt}, Y_{jkt} \geq 0 \qquad \begin{array}{l}(i=1, \ldots, m;\\ j=1, \ldots, n;\\ k=1, \ldots, p;\ t=1, \ldots, T)\end{array}$$

There are several levels of assumptions which must be made in order to assert that the solution to the above problem will solve the profit maximization problem for the firm. The technical assumption is that the firm's production activities can be expressed as a linear function. The economic assumptions include that the sole goal of the firm is profit maximization and its profit can be expressed as above. It is assumed that the firm acts as a perfect competitior in both its input and output markets. That is, the firm takes as given the prices of its inputs and outputs and cannot affect those prices by its actions.

Policy makers are usually concerned more with industry (or sectoral) actions rather than the actions of individual firms. Suppose that the industry of interest can be characterized as competitive, i.e., it is composed of a number of firms, none of which can affect the market price of inputs or outputs individually. How can the linear programming model above be modified to describe the actions of the industry?

First, consider the optimal solution to the linear programming problem. The Lagrangian formulation of this problem is

$$L = PV_o + \sum_{t=0}^{T-1}\left[\sum_{j=1}^{n} \lambda_{jt}(Y_{jt} - \sum_{k=1}^{p} Y_{jkt}) + \sum_{i=1}^{m}\sum_{k=1}^{p} \nu_{ikt}(X_{ikt} - a_{ik}q_{kt}) + \sum_{j=1}^{m}\sum_{k=1}^{p} \omega_{jkt}(Y_{jkt} - b_{jk}q_{kt})\right] + \sum_{k=1}^{p}\sum_{h=1}^{s} \sigma_{hk}(C_{hk}q_{kT} - F_{hk})$$

The Kuhn-Tucker conditions give the necessary and sufficient conditions for a constrained maximum at q^o_{kt}, X^o_{ikt}, Y^o_{ikt}, λ^o_{it}, ν^o_{ikt}, and ω^o_{ikt}. There

are eight conditions but only four are relevant to the current discussion.[7/] The conditions are:

5a) $$\frac{\partial L}{\partial q_{kt}} = \frac{P_{kt}}{(1+r)^t} - \sum_{i=1}^{m} \nu_{ikt} a_{ik} - \sum_{j=1}^{n} \omega_{jkt} b_{jk} \leq 0,$$

5b) $$\frac{\partial L}{\partial Y_{ikt}} = \frac{-r_{it}}{(1+r)^t} + \nu_{ikt} \leq 0 ,$$

5c) $$\frac{\partial L}{\partial F_h} = \frac{W_h}{(1+r)^t} - \sigma_{hk} \leq 0,$$

5d) $$\frac{\partial L}{\partial Y_{jkt}} = \frac{K_{jkt}}{(1+r)^t} + \omega_{jkt} - \lambda_{jt} \leq 0 .$$

Rewriting 5a) gives

6a) $$\frac{P_{kt}}{(1+r)^t} \leq \sum_{i=1}^{m} \nu_{ikt} a_{ik} + \sum_{j=1}^{n} \omega_{jkt} b_{jk}$$

It is known from the complementary slackness condition that q^o_{kt} will be non-zero only if equation 6a) holds as strict equality. The right hand side of equation 6a) can be interpreted as the marginal cost of producing one more unit of q_{kt}.[8/] Thus equation 6a) can be interpreted as the profit maximization condition for a competitive firm, i.e., produce up to the point where price of the output equals the marginal cost of producing one more unit of that output. Similarly 5b can be written as

6b) $$\frac{r_{it}}{(1+r)^t} \geq \nu_{ikt},$$

7/ The other Kuhn-Tucker conditions insure a non-negative solution for the primal variables, feasibility of the solution and the complementary slackness conditions. For a further discussion see Naylor.

8/ See Naylor.

which can be interpreted as continues to apply a variable input until its price equals the value of its marginal product.

Equation 5c) refers to the inventory of animals which can be rewritten to give

6c) $$W_h \leq \sigma_{hk}$$

which can be interpreted as animals should be retained in inventory until their "sell-out" price equals the marginal value imputed to animals kept in inventory.

Equation 5d can be rewritten as

6d) $$\frac{\omega_{jkt}}{(1+r)^t} - K_{jkt} \leq \lambda_{jt},$$

Since it deals with fixed factors, it has no analogue in the marginal approach with which we are familiar. It can be interpreted as the marginal value of the jth fixed factor used in the kth activity minus the marginal cost of converting one unit of that factor for use in the kth activity must be less than or equal to the marginal value imputed to the jth fixed factor. If $\lambda_{jt} = 0$, then the jth fixed factor is in disposal, and the marginal value of the jth fixed factor used in the kth activity is less than or equal to the marginal cost of converting one unit of that factor for use in the kth activity. That is, it is not profitable for the producer to acquire more of the jth fixed factor.

With appropriate modification, the above formulation can be used to model the cattle sub-sector. Define $q_{\ell kt}$ = output of the ℓth firm of the kth activity in year t.

Then

$$q_{kt} = \sum_{\ell=1}^{f} q_{\ell kt}$$

where f = number of firms in the sector.

Similarly define $X_{i\ell kt}$; $Y_{j\ell kt}$, $F_{\ell kt}$, and $K_{j\ell kt}$ and let

$$X_{it} = \sum_{k=1}^{p} \sum_{\ell=1}^{m} X_{i\ell kt}$$

be the industry use of input i in year t and let

$$F_h = \sum_{\ell=1}^{f} F_{\ell h}$$

be the sector's inventory of animals in year T. Furthermore, the assumption of exogenously determined prices for all inputs and outputs is no longer tenable. If the sector is a significant supplier of a product, then the price of that product will be partially determined by the interaction of demand and sectoral supply. Suppose the inverse demand relation in year t for outputs of the industry is given by

$$\underset{p\times 1}{P_t} = \underset{p\times 1}{G_t} - \underset{p\times p}{H_t}\,\underset{p\times 1}{q_t}$$

where H is assumed to be diagonal.[9/]

Similarly if the industry is a significant purchaser of one of its inputs, then the price of that input will be partially determined by the interaction of the supply and the sectoral derived demand for that input. Let the inverse supply of variable inputs faced by the industry be given by

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9/ Assuming H_t is diagonal implies that the price of q_{kt} does not depend upon $q_{k't}$ for all $k' \neq k$. Suppose the demand function of q_{kt} could be written as $q_{kt} = f(P_{kt}\alpha)$. It is assumed that α is exogenous to the system and that we can solve for P_{kt}.

The assumption of diagonality is not necessary for the theoretical model, but is required for the linear approximation of the quadratic objective function. For further discussion see Duloy and Norton 1975.

$$\underset{m\times 1}{R_t} = \underset{m\times 1}{C_t} + \underset{m\times m}{D_t}\ \underset{m\times 1}{X_t}$$

where D_t is assumed to be diagonal.10/

Assume that the conversion costs schedule faced by the industry is the same for each firm and is invariant with respect to quantity.

Equation 2a) now becomes

7a) $$(g_{kt} - h_{kkt}\, q_{kt})/(1+r_m)^t \leq \sum_{i=1}^{m} \nu_{i\ell kt}\, a_{i\ell k} + \sum_{j=1}^{n} \omega_{j\ell k} b_{j\ell k}$$

where g_{kt} is the kth element of G_t and h_{kkt} is the kth diagonal element of H_t (k=1, ..., p).

Equation 6b) now becomes

7b) $$(C_{it} + d_{iit}\, X_{it})/(1+r)^t \geq \nu_{i\ell kt}$$

where C_{it} is the ith element of C_t and d_{iit} is the ith diagonal element of D_t. Equation 6d) reamins unchanged.

7d) $$\nu_{j\ell kt} - \frac{K_{j\ell kt}}{(1+r)^t} \leq \lambda_{jt}$$ 11/

It is also reasonable to consider a demand schedule for the "sell-out" of the herd in inventory for the entire sub-sector. If the sub-sector can affect P_{kt}, then it follows that the sub-sector can affect W_{ht}, the "sell-out" prices. Let

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10/ See footnote 2 for diagonality of D.
Similar to the demand functions, it is assumed that all parameters in the supply function except current price are exogenous to the system. If the sector cannot influence the price of an input, then the appropriate diagonal element of D_t is zero.

11/ The fixed factors are assumed to be fixed to the sector and the alternative production activities are competing for the fixed factors. The model, however, could be formulated so that certain factors are fixed to the sector and other factors are fixed at the firm level.

$$\underset{5x1}{W} = \underset{5x1}{G_T} - \underset{5x5}{H_T}\ \underset{5x1}{F}$$

be the demand schedule for the herd in inventory. This can be looked upon as the producers' aggregate demand for inventory in year T. Substituting into equation 6c gives

7c) $$g_{hT} - h_{hhT} F_h \leq \sigma_{hk}$$

where g_{hT} is the hth element of G_T and h_{hhT} is hth diagonal element H_T.

The constaint optimization problem which is 7a, 7b, 7c, and 7d as its first order conditions is

$$\text{Max} \sum_{t=0}^{T-1} \left[q_t' G_t - \tfrac{1}{2} q_t' H_t q_t' - X_t' C_t - \tfrac{1}{2} X_t' D_t X_t - \sum_{\ell=1}^{f} \sum_{j=1}^{n} \sum_{k=1}^{p} K_{j\ell k} Y_{j\ell k} \right] /(1+r)^t + F' G_T - \tfrac{1}{2} F' H_T F$$

s.t.

$$X_{i\ell kt} = a_{i\ell k} q_{\ell kt} \qquad (i=1, \ldots, m;\ \ell=1, \ldots, f;\ k=1, \ldots, p;\ t=0, \ldots, T)$$

$$Y_{j\ell kt} = b_{j\ell k} q_{\ell kt} \qquad (j=1, \ldots, n;\ \ell=1, \ldots, f,\ k=1, \ldots, p;\ t=0, \ldots, T)$$

$$F_{\ell h} = C_{hk}\, q_{\ell hT} \qquad (\ell=1, \ldots, f;\ k=1, \ldots, p)$$

$$\sum_{\ell=1}^{f} \sum_{h=1}^{p} Y_{j\ell kt} \leq Y_{jt} \qquad (k=1, \ldots, p;\ t-0, \ldots, T)$$

$$\sum_{\ell=1}^{f} q_{\ell kt} = q_{kt} \qquad (k=1, \ldots, p;\ t=0, \ldots, T)$$

$$\sum_{\ell=1}^{f} F_{\ell h} = F_h \qquad (h-1, \ldots, \ )$$

$$\sum_{k=1}^{\bar{k}} \sum_{\ell=1}^{\bar{\ell}} X_{i\ell kt} = X_{it} \quad (i=1, \ldots, m;\ t=D, \ldots, T)$$

$$X_{i\ell kt},\ Y_{j\ell kt},\ F_{\ell h} \geq 0 \text{ for all } i, j, k, \ell, h.$$

The objective function no longer represents profit. It now is a measure of a consumer's plus producer's surplus which is defined as the area between the demand and supply curves to the left of their intersection. For a proof of this, see Samuelson 1952.

This is now a quadratic programming problem. The quadratic objective function can be approximated by a linear function. For a further explanation, see Duloy and Norton 1975.

The linear programming model takes as data production coefficients ($a_{i\ell k}$ and $b_{j\ell k}$), availability of fixed factors, demand schedules for the sector's output (G-HQ) supply schedule for the sector's variable inputs (C+DX), and conversions costs for the fixed factors ($K_{j\ell k}$). The solution of the programming model generates an equilibrium supply of outputs, price of those outputs, use of variable and fixed inputs, and price of variable inputs.

In the derivation of the model, a major assumption is that the sector is competitive, i.e., none of the producers can influence output or input prices individually. Each producer wishes to supply according to price of product equal to the marginal cost of producing one more unit of that product. Thus the sector output supply schedule will be an "aggregate"

marginal cost schedule.[12/] Similarly, each producer wishes to use variable inputs according to price of an input equal to its marginal value product. Thus the sectoral derived demand for input schedule will be an aggregate marginal value product schedule. However, the model does not explicitly derive the supply of output or demand for input schedules. The model selects the supply of output at that point at which the marginal cost curve intersects the demand for that output curve. The price of the outputs then can "read off" the demand schedule. The supply of output schedule generated by the model is then an implicit supply, and this implicit supply schedule corresponds to a marginal cost schedule. This marginal cost schedule, in turn, depends directly upon the production coefficients, and supply of input schedules inputed to the model. Similarly an implicit derived demand for inputs schedule is generated and corresponds to a marginal value product schedule.

The model is seen not as an optimizing model in the sense that it chooses the least cost formulation or profit maximizing product mix, rather it simulates the action of the industry. The technical assumptions concerning the production coincide with those made in the firm level model discussed before. The economic assumptions are now that the industry consists of a number of firms, each of which act independently and are profit maximizers and none can affect the prices of inputs or outputs individually. That is, assume the industry competitively bids for its inputs and competitively sells its outputs. Hence, the solution to the LP model can be characterized as a simulation of industry behavior under the assumptions of perfect competiton.[13/]

12/ The aggregate marginal cost curve is a schedule which represents the change in total cost to the sector incurred when the sector supplies one more unit of output.

13/ This should be qualified somewhat. It is assumed an atomistic market, resources and products are divisible, no external economies or diseconomies, and perfect knowledge. The assumption is not necessarily that of free entry or exit.

Thesis Proposal

The proposed thesis can be broken down into four major sections. The first consists of the conceptual model. This view of the programming approach to sector model, i.e. viewing the approach as an aggregation of micro-uhits, is original and, in the view of the author, lays a strong economic foundation for the model. The second section is essentially the revisions of the programming model by May. These will be detailed later. The third section will be reformulating the model into a recursive model. The motivation for the recursive model will be given later. The fourth section will consist of using the model to analyze policy interventions and discussion of the model's output.

Revisions in Current Model

May's model was a linear programming model of the cattle sector of Guyana. A description of his model and the data base used can be found in Ford 1976. Revisions in his model have been carried out. These, in general terms, consisted of revision of the herd accounting scheme, the steer finishing activity, the definition and handling of land and the land development activities, and the definition and accounting of capital or cash requirements. A "picture" of the LP has been extracted.

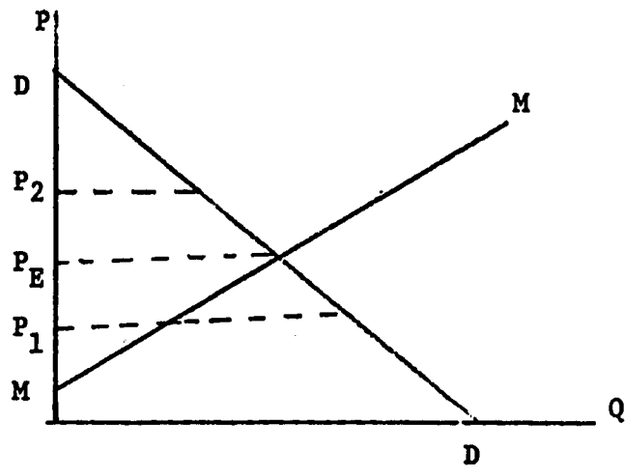
I do not propose to repeat in detail the data base of the model. I view the compilation of these data as May's major contribution. A description of the data can be found in May, 1975.

Further revisions in the LP have been proposed. These are described next. Throughout the discussion, the reader will be referred to the conceptual model and the attached "picture" of the linear programming model.

Sell-out Activity

The conceptual model that was laid out, a demand schedule, $G_T - H_T F$, was specified. This implied that the sector, through its actions, could affect this "sell-out" price for animals in inventory in year T. In the current version of the LP model, an exogenous fixed "sell-out" price is specified, which is independent of the number of cattle in inventory in year T.

The problem with a fixed "sell-out" price can be illustrated by considering a simple graph. Consider the beef demand schedule (DD), the aggregate marginal cost for beef (MM) given below.



The equilibrium price for beef will be P_E. If the "sell-out" price is P_1, the model will tend to "slaughter" additional animals because their current value exceeds their future value. This additional slaughter will tend to shift MM to the right. A similar argument can be made if the "sell-out" price is specified at P_2. Now the future value of the animal exceeds its current value and the model will "withhold" animals, thus shifting MM to the left. In either case, the model will push the

equilibrium meat price towards the "sell-out" price. One can see, by inputing the "right sell-out" price, the model could be manipulated to generate practically any solution. This is inconsistent with the "what if" view the model is supposed to take.

Specifying a "sell-out" demand schedule, which depends upon the number of animals in inventory, is much more realistic. Thus I propose to incorporate this into the model.

Resource Utilization

In the derivation of the conceptual, a unit of production was defined to be a cow unit. Thus the transformation coefficients ($a_{i\ell k}$ and $b_{j\ell k}$) were defined on a per cow unit basis. A cow unit was defined to be a brood cow and the associated bulls, steers, heifers, and calves. Thus resource utilization is defined on basis of animal numbers.

A small digression may be appropriate now. The current operational model consists of an input form, matrix generator, linear programming solver, and report writer. In the input form, resource use is specified for an entire herd. The matrix generator takes these resource requirements and transforms them to a per cow unit basis.[14/]

To specify resource use strictly on the basis of animal numbers may be appropriate for land use or veterinary services. However, for such inputs as feed supplements, a more appropriate basis is herd weight, or in this terminology, cow unit weight, which might be defined as the total weight of a brood cow and the associated other animals.

14/ For a further explanation of the matrix generator and report writer see May, 1975.

The proposal is to determine which resources should be utilized on the basis of animal numbers, animal weight, or some other statistic, then to modify the matrix genertor appropriately

There also exists a problem in the use of cow units. An initial herd structure is specified on the input form. Suppose, for the sake of argument that this initial herd structure is 10 bulls, 100 brood cows, 50 steers. Thus a cow unit will consist of .1 bull, 1 brood cows, and .5 steer. Let the herd above require 30 hours of temporary labor per year, the per cow unit temporary labor requirement for the first year would be .3 hours. Suppose that in the second year of the run, the herd consists of 11 bulls, 110 cows, 50 steers. The resource utilization is changed by the transformation

$$\text{resource utilization} \times \frac{\text{\# of brood cows year 2}}{\text{\# of brood cows year 1}}$$

Hence in the example above, the per cow unit requirement for temporary labor in year 2 would be .3 x 1.1 = .363. That is, it increased by 10%. Note however, that the total herd only increased by 171/160 = 1.06875. Thus, if the temporary labor requirement should be reflected by the total number or head, the requirement should have gone up by only 6.875%. The current version of the matrix generator does not account for a change in herd structure. Therefore it is proposed that the appropriate revision be made.

Land Use

In the current model, land may be one of four types and within each type may be one of three qualities--jungle. native or unimproved pasture, or improved pasture (for a discription of the land types, see May 1975.

In the input form, land requirements by land type and land quality (native or improved) are specified for each sub-herd in the input form.

The model does not allow substitution of one land type for another or one land quality for another. For example, in the hypothetical herd above, consisting of 10 bulls, 100 cows, and 50 steers, suppose that 1000 acres of native Type III land and no other land had been specified. The land use requirement then would be 10 acres of Type III--native per cow unit per year.

The model has what is called land development activities. These activities transfer land from a lower quality to a higher one, e.g. from unimproved to improved pasture.

The problem is that the model cannot make use of this improved pasture. A production activity is "locked in" to land requirement specified on the input form and cannot substitute one land type or quality for another.

There are two possible solutions to the problem of land substitution. One is specify several production activities which differ only through their land requirements. The second is one which I prefer conceptually but is more difficult to operationalize. The idea is to create a forage requirement constraint. Land supplies forages and production activities demand or require forage. The conversion coefficient ($a_{i\ell k}$) for land no longer will represent land requirement per cow unit but rather forage requirement per cow unit. Thus alternative land types or qualities can supply forages. The problem now becomes one of obtaining the data required for this sort of scheme.

Texas Herd Model

The animal scientists at Texas A & M, as a part of their role in the Consortium, have developed a herd model based primarily upon biological factors. The Texas model essentially plays the same role as the herd

accounting scheme or herd simulator in the matrix generator portion of the Purdue model. However, the Texas model is much more detailed and focuses directly upon biological factors.

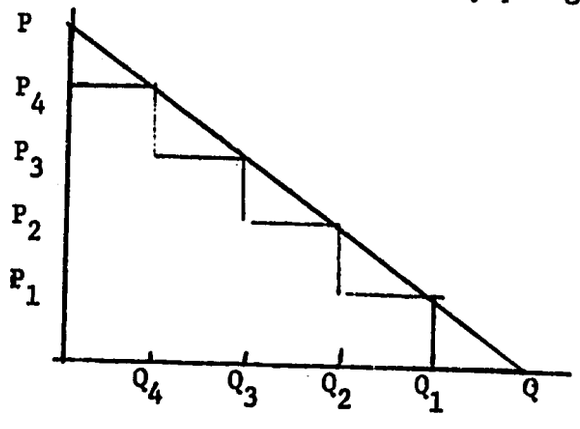
An attempt was made to integrate the Texas model into the Purdue model. This was done through using output from a run of the Tedas model as input in the Purdue model to generate a production activity. The results were not entirely satisfactory and work will be done to better link up the two models.

Area Approximation

The current model, through separable programming, is a linear approximation of a quadratic programming problem. The advantage of the linear approximation for a large scale model such as this one has been well-documented. The approximation is described in Appendix A of the attached paper.

The proposed change is to approximate the area under the curve with integrals rather than rectangles. The current approximation for demand curves is:

Let the curve be defined by $p = g - hq$.



Let $A_1 = P_4 \times q_4$

$A_2 = A_1 + P_3 (q_3 - q_4)$

$A_3 = A_2 + P_2 (q_2 - q_3)$

$A_4 = A_3 + P_1 (q_1 - q_2)$

Then approximate the area under the curve up to a (P, Q) point by a convex combination of A_1, A_2, A_3, and A_4. The proposed change is to let

$$B_1 = \int_0^{q_4} (g-hq)\, dq$$

$$B_2 = B_1 + \int_{q_4}^{q_3} (g-hq)\, dq$$

$$B_3 = B_2 + \int_{q_3}^{q_2} (g-hq) \cdot dq$$

$$B_4 = B_3 + \int_{q_2}^{q_1} (g-hq)\, dq$$

and then approximate the area under the curve up to a (p, q) point by a convex combination of B_1, B_2, B_3, and B_4. It is clear that the proposed approximation will be more precise than the current one and easy to implement.

Recursive Model

The proposed revision to make the model recursive is the most difficult to explain and will be the most complex to implement.

The current model is simultaneous in nature. A length of time, say four years, is selected, and the model solves simultaneously for equilibrium prices and quantities in each year for all four years. If particular production activity comes into solution, then that activity will be carried to a non-zero level for every year of the run. In other words, once a production decision is made, the producer is locked into that decision for four years.

A more appropirate scheme would be to still allow producers to see four years into the future and solve the model simultaneously for four years, but to use the solution to the first year to update the model's input, and then solve for years two through five. Continue to carry out their process for the number of years desired and then examine the path of adjustment. This method would allow producers to "change their mind" in say, the second or third year of the run.

Policy Interventions

The goal of Purdue's role in the 211d project has been to develop a model capable of analyzing the impact of policy interventions. After the above revisions have been made, it is proposed that the model be used to analyze some specific policy interventions that either have been put forward by the Government of Guyana or have come from the Consortium. Here, only a list of these interventions will be given. For a discussion of some of these interventions see J. R. Ford, et al., 1976.

The proposed interventions to be analysed are:

a) Short feeding of skinny steers

b) Longer term feeding of steers

c) Viability of production at Mathew's Ridge and Ebini

d) Impact of exporting beef

e) Viability of an intensive production technology on the Coast

f) Removal of transport subsidies

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Appendix F

An Application of A Large Scale Linear Programming Sector Model To The Cattle Economy of Guyana

AN APPLICATION OF A LARGE SCALE LINEAR PROGRAMMING SECTOR MODEL TO THE CATTLE ECONOMY OF GUYANA

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ABSTRACT

This paper describes a subsector model of the Guyanese livestock industry. The basic approach taken is price responsive linear programming modeling.

This paper describes the structure of the model and its use as a policy tool for decision makers. Data collected in Guyana are used to give specific empirical application of the model. The results of those applications are presented and their implications to policy makers are discussed.

I. INTRODUCTION

Guyana is a small country located north of Brazil and shares a western border with Venezuela. The population and development of the country is concentrated in a small strip of land along its coast. Its agricultural economy is based primarily on rice and sugar. Traditionally, cattle production has taken place among the Coastal peasants and in an interior region known as the Rupununi. The Guyanese government views cattle production as a means to settle its interior and as a possible export commodity to generate foreign exchange.

The problem is to formulate and implement a model which would assist policy makers in Guyana in its attempt to stimulate cattle production. The tool which has been chosen is price-responsive linear programming.

The Guyana model is a sector level model. It attempts to explain the actions of all producers in a sector simultaneously. The usual LP assumption of fixed factor and output prices is no longer tenable since the sector's actions will influence prices.1/ Takayama and Judge incorporated explicit output demand and factor supply schedules into the classical LP model, but transformed the problem into a quadratic programming problem. Duloy and Norton, through separable programming, have formulated a linear approximation and applied it to a model of the Mexican agricultural sector (see [2]). For a further discussion of the approximation technique see [1].

The model uses micro data which are transformed to provide coefficients and aggregate data for the supply and demand curves required for the solution of the LP problem. The objective function can be considered as a measure of the area between the demand and supply for beef schedules which has been called consumer's plus producer's surplus. For a further discussion see [6]. The constraints are the resource and institutional constraints upon the cattle sub-sector.

The major economic assumption of the model is that the cattle industry is competititve in both its output and input markets, i.e., none of the producers can influence output or input price individually. Note that the model generates an aggregate supply of output schedule, which under the assumptions of competitive markets corresponds to the aggregate marginal cost schedule for the industry.2/

II. DESCRIPTION OF THE MODEL

The formulation of the linear programming problem is given below. Following is a further explanation of the constraints and variables used in the model.

Maximize

$$-FD + \alpha P - SZ - \beta W - \gamma R$$

Subject to

$$-AD + \alpha Q \leq 0$$

$$CD - IZ \leq 0$$

$$ED - \beta L \leq 0$$

$$SD - \gamma K \leq 0$$

$$HD \leq b$$

$$T\alpha \leq 1$$

$$T\beta \leq 1$$

$$T\gamma \leq 1$$

where

- F is a vector per unit of production costs which do not vary with production level
- D is a vector of production activities disaggregated by region, subherd and management system

1/ The sector may influence certain prices and have no effect on other prices. The model can be formulated so some prices are endogenous while other prices are exogenous.

2/ The aggregate marginal cost curve is a schedule which represents the change in total cost to the sector incurred when the sector supplies one more unit of output.

Proceedings, Midwest AIDS Conference, Detroit, May 6-8, 1976.

α is a vector of separable programming step variables for the demand function approximation (see [1]).

P is a vector of areas under the demand function by step and year (see [1]).

S is a vector of purchased input prices by good and year

Z is a vector of purchased input quantities

β is a vector of separable programming step variables for labor supply

H is a vector of areas under the supply function by step and year

γ is analogous to β for land supply

R is analogous to w for land supply

A is a matrix of output quantities by production activity and year

Q is a matrix of demand quantities by step and year

C is a matrix of purchased input requirements by production activity and year

I is the identity matrix

E is a matrix of labor requirements per unit of each production activity

L is a vector of labor supplies by step and year

S is a matrix of land requirements by production activity per unit of each production activity

K is a vector of land supplies by step and by year

T is a matrix which sums the separable programming variables

H is a matrix of fixed factor requirements per unit of each production activity

b is the vector of endowments of fixed factors.

The activities can be divided into production type and supply-demand type activities. Production type activities include cattle production and steer finishing. Supply-demand activities include the demand for beef and the supply of land, labor and purchased inputs such as fertilizer, minerals, and farm machinery, and veterinary services.

By its nature, cattle production is a multi-year process. Thus production decisions made by the producers must necessarily be multi-year decisions. These decisions are based upon the current structure of the sector (e.g., current herd structure, land availability, etc.) and current and future expectations of prices of inputs and outputs.

A time frame is selected by the user to determine how many years he wishes the model to run. The model equilibrates supply and demand in each modeled year in every market. Thus output demand and supply schedules must be specified for each year. These demand and supply schedules can be looked upon as an aggregate expectation of the sector of what future demand for their output and future supply for their inputs will be. In other words, the model assumes that producers make multi-year production decisions based upon their aggregate expectations and the current structure of the sector. Thus a production activity will require inputs and supply output in each year of the model. Demand and supply activities, however, will supply or demand products in only one year.

Guyana is divided into four regions known as the Coast, Matthew's Ridge (or Northwest District), Ebini, and the Rupununi. These regions are either current cattle production areas or where the Guyanese government is interested in expanding cattle production.

Each region is thought of as possessing a herd which consists of a set of sub-herds. These sub-herds are based upon the genetic characteristics of the cattle and sociological considerations. If two animals within a region on the same management system (i.e., same ration, veterinary services, etc.) would perform approximately the same, then they belong in the same sub-herd. However, certain producers are less likely to adopt new technology and are treated separately. Up to nine management systems may be specified within each sub-herd. The management systems refer to purchased input usage, use of veterinarian services, etc., and the buying and selling schemes employed by the operator. A particular management system, sub-herd and region defines a cattle production activity in the linear programming model. The optimal level of these production activities determines the quantity of output (beef in this case) supplied and level of input usage.

A herd structure for each production activity is inputed to the model. The herd includes brood cows, bulls, steers, heifers and calves. A cow unit is defined to be a vector representing the herd structure normalized on the number of brood cows.

The production activities are one set of activities in the model. The other set of activities are those which specify the demand for outputs (beef and milk) and the supply of inputs. In the model, it is assumed the price of milk is exogenous but that the price of beef is endogenous. Thus milk is "sold" by the model in a single activity under one price while beef is sold per the stepped demand schedule (see [1] for a further discussion of the stepped demand curve). In both of these activities, the activity uses output and gives a receipt in the objective function. It is also assumed that the price of all inputs except land and labor are exogenous. Similar to milk activity, transportation and purchased inputs (minerals, fencing, veterinary services, farm machinery, etc.) are each supplied by a single activity (one for each input). Land and labor are supplied through stepped supply curves. It should be noted there are labor and land supply curves for each region. Labor can be temporary or permanent. Land is classified into four categories according to soil type and land may be uncleared, cleared but not improved or improved pasture.

It is assumed that all beef is sold on the coast. Hence beef consumed in the other three regions

is subtracted "off the top" of the regional supply by the regional meat demand activity. The regional meat demand row insures that the regional demand is met.

Theft is a significant problem in Guyana and cannot be ignored. Stolen meat enters the national beef supply, but the receipts do not accrue to the livestock producers. The theft activity adjusts the objective function to account for this loss in revenue.

The model is a multi-year model but does have a finite planning horizon. It must be given some way of valuing the inventory of cattle and improved pasture. Otherwise it will try to deplete the herd to improve the objective function in the time-frame of the model. The ending inventory of animals and pasture activities price out the inventory in the last year of the model. The prices of animals and land in inventory are assumed to be exogenous to the system. This assumption should be reformulated and another pricing scheme should be devised.

The other rows in the model are either accounting rows such as the subsidy row, which is simply adding up the amount of subsidy paid or institutional constraints such as regional feedlot capacity or regional slaughter capacity. For a more complete description of the input form and data used see [3] [5].

III. USE AS A POLICY TOOL

The model, as stated above, is not an optimization model in that it does not select a best policy or maximize the welfare of some group. Rather the model takes the "what if" view. That is, if a particular policy action is proposed, then the model simulates the actions of the participants in a sector. The model is seen then to take the "conditional normative" view. It takes as given a set of conditions, namely the current structure of a sector and the assumption that the sector is competitive and the firms in the sector are profit maximizers, and then it traces out quantitatively the impact of some policy action.

The following are some policy questions which a model of this type is capable of attacking. These problems are not necessarily related to the Guyana model, but are presented to demonstrate the model's versatility. In addition, some specific problems are presented which have been explored by the Guyana model. Then in the last section of the paper, a specific question is analyzed with specific numerical results presented.

In Guyana, cattle could receive more veterinary services. Death losses for cattle, especially young animals, are high and outbreaks of foot-and-mouth disease have occurred. Suppose the government of Guyana wanted to undertake an extensive health program, and given the infrastructure of health services, wanted to know the additional costs and benefits of such a program. The Guyana model can handle such a problem. First, some assumptions must be made on what effects the proposed program will have on death rates, calving rates, or weight gains, then a new production activity could be generated using the improved veterinary services. The simulation would be run and the analyst could see if the new production activity came into solution (i.e., was it profitable?).

Consider another problem related to cattle in Guyana. Large sections of Guyana are unsettled jungle land. Suppose the government wishes to investigate the possibility of clearing jungle land, establishing pasture, and grazing cattle on the pasture. This question could be handled by the model by creating a development activity. This could be done through a production activity. It uses uncleared land and yields pasture available for cattle. It requires certain purchased input usage (such as fertilizer, machinery) and requires labor. Then by running the simulation, the analyst can see if land development is a profitable alternative to the cattle sector. This type of government intervention may be termed a macro or sector level intervention.

Other problems which the Guyana model could investigate include the profitability of a steer finishing type operation, the profitability of building roads out to the interior regions of the country to facilitate the transport of inputs and beef, the profitability of alternative production techniques, or the impact of exports or imports of beef upon the cattle sector.

IV. SPECIFIC RESULTS FROM THE GUYANA MODEL

A base data set was collected and run in order to simulate the current situation as close as possible. This is necessary to validate the model and also to give us a point of reference with which to compare the results of the interventions.

The computerized version of the model consists of a matrix generator, linear programming solver, and a report writer. The matrix generator takes the information recorded on an input form and generates the coefficients required to solve the linear programming problem. A copy of the input form and a listing of the matrix generator can be found in [3] and [5]. The report writer takes the solution of the linear programming problem and presents it in labeled easy-to-read tables. In the current version of the report writer, a report is given for year of a run.

The solution of the model yields the equilibrium price and quantity of beef, labor and land for each year of the run. Also reported are the sector's use of and value to the sector of purchased inputs, production patterns, and the distribution of the herd for each modeled year. For a complete copy of the reports from the base run see [3].

The predicted price of beef ranged from $1.69 to $1.71[3/] over the four year run of the base model. The quantity of beef ranged from approximately 5 million to 5.6 million pounds. The prices are ten to fifteen percent higher than the actual prices observed in the Georgetown market but the total slaughter is reasonably close to the official slaughter estimate of 1974 (about six million pounds). Remember that regional consumption is subtracted from supply for three regions and when this regional consumption is added back in, the model simulates the actual situation quite well.

Several interventions have been run. A complete list and discussion of these interventions are given in [3]. One is presented here because of limited space.

In the base model, no import or export of beef was allowed. The Guyanese government is interested in developing export markets for beef, especially exporting beef from the experimental ranches at Matthew's Ridge and Ebini. Alternative management systems were specified for each subherd in these two regions which sold 60% of its slaughter animals to the export market. A perfectly elastic export demand schedule was specified at a fixed world price of $1.90 per pound.

The impact of exports on the domestic market is the expected one. Meat sold on the domestic market is less each year as compared to the basic run and price is higher. This result is summarized below.

	Base		Export	
Year	Quant. (1000 lb.)	Price ($/lb.)	Quant. (1000 lb.)	Price ($/lb.)
1	5,065.9	1.71	4,908.5	1.73
2	5,336.3	1.70	5,181.7	1.72
3	5,577.3	1.69	5,424.7	1.71
4	5,597.4	1.71	5,445.8	1.73

However, the total supply of beef remains unchanged. Now 60% of the beef supply from Matthew's Ridge and Ebini is being diverted to the export market. The introduction of exports did not alter the production pattern of the sector. Hence the export potential of beef from the experimental herds appears to be limited in the short run.

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3/ All monetary units are Guyanese dollars. The current exchange rate is approximately 2½ Guyanese dollars for each U.S. dollar.

Appendix G

1975-1976 211(d) Books

1975 - 1976 - 211d Books

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Niger Livestock Sector, by W. H. M. Morris, revised June 1975, originally prepared with Rex Otley for USAID/AFR/CWR,DAP Nov. 1974

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Appendix H

List of Seminars

Seminars Sponsored by Purdue 211(d) Team

September 19, 1975		Dr. Roger Norton, Chief Development Planning Division Development Research Center World Bank
	Topic:	Approaches to Agricultural Development Planning
February 18, 1976		Dr. Wilfred Candler, Director Farm and Rural Development Division Economics Branch Canada Department of Agriculture
	Topic:	Behavioral Programming
April 14, 1976		Dr. T. Kelley White Department Purdue University
	Topic:	Modeling the Livestock Industry of Guyana
May 11, 1976		Mr. Thomas H. Spreen Department of Agricultural Economics Purdue University
	Topic:	Application of A Large Scale Linear Programming Sector Model to the Cattle Economy of Guyana
May 19, 1976		Dr. P. B. R. Hazell Development Research Center World Bank
	Topic:	Introducing Risk Into Sectoral Models
May 26, 1976		Dr. T. Takayama Department of Economics University of Illinois
	Topic:	The Eight Agricultural Commodity and Twenty Region World Food Economy Model