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A SIMULATION MODEL OF THE NIGERIAN AGRICULTURAL ECONOMY

A Progress Report

Submitted to the Agency for International Development Under the Auspices of Contract No. AID/csd-1537, Agricultural Sector Models, by Michigan State University

November 1, 1969 - May 1, 1970

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INTRODUCTION

This report describes the progress made by the Michigan State University simulation team in developing a computer simulation model of the Nigerian agricultural economy during the period November 1, 1969-May 1, 1970. This report supplements earlier reports submitted to AID dated April 26, 1968, October 31, 1968, April 1, 1969, and November 1, 1969. To avoid duplication of previous reports, this discussion will be restricted to the recent accomplishments of the research team. Further, we shall briefly suggest the general direction of the research plan during the remainder of the contract.

RECENT ACCOMPLISHMENTS

Since the last progress report, the research team has engaged in three primary streams of activity: (1) a continued testing of the northern regional model, including some tentative policy explorations within the context of that model; (2) conceptualization and programming of the detailed structure of the southern regional model; (3) presenting the current model framework for examination and criticism to professional economists, systems scientists, and AID administrators in the U. S.

During the last six months, one major thrust has been directed toward refining and testing the model of the northern Nigerian agricultural economy, modifying structural relationships to make them more consistent with the northern Nigerian economy, and further exploring the credibility of the model and its ability to provide insights into relevant development questions.

This process is discussed in more detail in the attached paper entitled "Simulating a Developing Agricultural Economy: Methodology and Planning Capability " which was presented at a joint meeting of the American Agricultural Economics Association - Econometric Society in December, 1969 (this paper will be published in the May, 1970 American Journal of Agricultural Economics and in a book entitled Frontiers of Quantitative Economics to be published by the North Holland Publishing Co.) The project will also distribute reprints of this paper, an accompanying paper by T. Naylor, and discussion papers by Ed Holland, Glenn Johnson and Richard Day as partial fulfillment of our contractual obligation to investigate and evaluate alternative simulation efforts.

To facilitate any subsequent use of the model, project working papers have been developed which describe the computer program (Project Working Paper 69-2) and the format which a decision maker can use to explore various agricultural modernization alternatives in the north (Project Working Paper 70-1).

Some alternative modernization policies in northern Nigeria have been explored within the context of the tentative northern regional model. The resulting comparisons are not to be viewed as the highly accurate project analysis. Rather, they illustrate the flexibility of the model in comparing various types of policy alternatives and providing comparative performance results. These examples of how to use the model to make policy comparisons are described in detail in Project Working Paper 70-2 titled "Planning Capability of the Northern Nigerian Agricultural Model," attached as Appendix 1.

In addition to the testing of the simulation model, some alternative beef distribution policies were examined within a spatial equilibrium model. This research examined the payoffs associated with different combinations of slaughter, transportation, and health care facilities for the Nigerian beef industry. It will soon be presented by Mr. Earl Kellogg as a Ph. D. dissertation at Michigan State University.

Prior to the last progress report, some of the basic characteristics of the southern regional model had been determined, but the basic components had not been fully developed. The research team has subsequently been developing the conceptual framework much more thoroughly, and has now begun the initial programming of the complex production interrelationships involving components for both perennial tree crops and annual crops in the southern economy. The complexity of simulating farmer enterprise decisions where both perennials and annuals (or shorter term improvements of perennials) are among the alternatives for the south has used up more time than originally anticipated. While we are presently programming models for the southern region, more information about the behavioral factors affecting producer responses is necessary to develop a more satisfactory model. Further, the current alternatives being considered by policy makers concerned with southern region can suggest some currently useful trial policy runs. Thus, a trip to Nigeria is currently being planned which should lead to greater insights about both farmer behavior (where perennials are production alternatives) and the likely needs of policy makers. This kind of interaction between simulators and policy makers is crucial both in developing software and in putting it into actual use. Our contractual obligations under this

project is only that of developing software; however, we look forward to direct application possibly in Nigeria and elsewhere. Currently, there is a tremendous post-war rehabilitation and reconstruction pressure on Nigerian research agencies and her various ministries dealing with agriculture and economic development. As a consequence, there are critical questions of timing involved in sending project personnel to Nigeria and in planning for possible use of the models by Nigerian agencies. While the financial resources and time required to complete present contractual obligations remain unchanged from present plans for the period ending December 31, 1970, it appears increasingly advantageous to shift the completion date to March 31, 1971. This would permit better synchronization of the completion of our work with the likely easing of pressure on (and hence the availability of) Nigerian personnel. Since successful Nigerian applications and further development of this model requires thorough Nigerian acquaintance with the current technical apparatus, its capabilities and limitations, this synchronization of project completion with likely Nigerian personnel availability seems appropriate.

The level of living for the large farm population of both northern and southern regions is quite dependent upon the level of demand for the products which they produce. While prices received by farmers for export crops are determined by marketing board policies and by the level of demand in the world market for such crops as groundnuts, palm oil, cocoa, etc., the income potential from food crops is primarily dependent upon domestic demands. As a result, some effort is being expended to extimate the level of domestic demand for domestically produced food products at varying

levels of income and/or food prices. Further, level of demand is also contingent upon the size of the domestic consumer population (which in turn has a direct impact on the work force available for agricultural production). As a result, the population model which has been developed for the northern region is being adapted to the southern region, with somewhat greater attention being paid to migration patterns which may have some influence on the overall level of activity possible in agricultural enterprises in the southern region.

The third major area of activity has been the presentation of the Nigerian simulation model to various professional groups for discussion and criticism, so that major weaknesses may be spotted and eliminated prior to the completion of the project. As previously mentioned, a major paper was presented to the joint meeting of the American Agricultural Economics Association - Econometrics Society at the Allied Social Science Meetings. Presentations were also made at the Regional Meeting of the Midwestern Simulation Council, at the Workshop on System Science and Cybernetics at the Annual Meeting of the Institute of Electrical and Electronic Engineers, and at a seminar sponsored by the University of Iowa Center for Urban and Regional Planning. Further, a two-day seminar on the Nigerian Simulation model was held at Michigan State University for a group of AID administrators and AID-invited economists and agricultural economists working in the area of agricultural development. While this series of seminars and presentations took a substantial amount of time in preparation and presentation, the feedback from these meetings has been useful in correcting and directing our research efforts.

FUTURE PLANS

Our current plans are to continue working on the southern model, putting a substantial amount of time on it between now and the end of the summer. The effort will involve a trip to Nigeria by two or more team members to develop a better conceptual base for this modeling effort. Subsequently, the northern and southern regional models will have to be tied together so that some basic questions concerning regional specialization and inter-regional trade can be adequately examined using the model. To the extent that time allows, a rudimentary model of the non-agricultural sector probably should be developed to provide a ballpark estimate of the competition or complementarity between agricultural and industrial development efforts of various sources. Finally, all three sectors--northern, southern and non-ag sectors--will have to be integrated and validated before some tentative policy explorations can be completed. While Earl Kellogg has completed the major portion of his Ph. D. work here at the University and has left, Dr. Albert Halter will be joining us for six months of full time effort beginning July 1 to assist us in final stages of research, modeling, and writing.

RECENT PUBLICATIONS

1. Halter, A. N., M. L. Hayenga, and T. J. Manetsch, "Simulating A Developing Agricultural Economy: Methodology and Planning Capability," to be in the American Journal of Agricultural Economics, May, 1970, and in Frontiers of Quantitative Economics, edited by Michael Intriligator, to be published by North-Holland Publishing Company.

2. Johnson, Glenn L., "Discussion of Two Papers: 'Simulating a Developing Agricultural Economy--', by Halter, et. al., and 'Policy Simulation Experiments with Macroeconometric Models: The State of the Art,' by Naylor," to be in the same publications as above(1).

3. Page, Gloria and Tom W. Carroll, A Programmer's Description of NISIM--The Executive Program for a Simulation Model of the Nigerian Agricultural Economy, Simulation Project Working Paper 69-2, December 31, 1969.

4. Manetsch, Thomas J., and Gloria Page, The Modernization Executive Component, Simulation Project Working Paper 70-1, February 9, 1970.

5. Manetsch, Thomas J., Marvin L. Hayenga, and Gloria Page, Planning Capability of the Northern Nigerian Agricultural Model, Simulation Project Working Paper 70-2, April, 1970 (Appendix 1 in this report).

6. Hayenga, Marvin L., "Simulating Macro Agricultural Adjustment," in Simulation Uses in Agricultural Economics, A Proceedings of Joint Conference of North Central Regional Farm Management Extension and Research, Michigan State University Agricultural Economics Report No. 157, February, 1970.

7. Manetsch, Thomas J., "Design, Development and Use of Simulation Models for System Planning and Management," in Simulation Uses in Agricultural Economics, A Proceedings of Joint Conference of North Central Regional Farm Management Extension and Research, Michigan State University Agricultural Economics Report No. 157, February, 1970.

APPENDIX

A SIMULATION MODEL OF THE NIGERIAN AGRICULTURAL ECONOMY

Contract No. AID/csd-1557

Planning Capability of the Northern Nigerian Agricultural Model

Project Working Paper 70-2

Prepared By:
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March 31, 1970
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INTRODUCTION

This paper has three objectives: 1) To describe in detail the types of planning questions this particular model is capable of addressing 2) To present the results of preliminary simulation runs which explore some alternative strategies for development of the agricultural sector of Northern Nigeria[1/] and 3) To provide an assessment of the work that remains in order to develop an operational planning model. The reader is cautioned to accept the results of the simulation runs discussed herein as tentative at this time since they are based upon a preliminary model with very rough estimates of many model parameters. Further work can make possible a refined simulation model with improved estimates of key model parameters and introduction of data uncertainties to produce statistical estimates of model outcomes including expected values and standard errors. With further work it may well be possible to compare the expected outcomes of alternative development strategies and estimates of the expected variations of these outcomes.

In what follows we will describe in detail two important sets of variables which, in essence, define the planning capability of the model:

a) A set of policy variables - those variables which planners at various levels might be interested in controlling in order to guide the development process, i.e. tax rates, marketing board price policies, investments in modernization alternatives, etc.

1/ The scope of the model is essentially the old Northern Region of Nigeria.

b) A set of criterion variables - those variables that planners might be interested in using as measures of the success or failure of development programs, i.e. per capita income, foreign exchange earnings, marketing board revenues, etc.

The paper concludes with a description of some of the more important policy simulations made with the current model and an assessment of further work required to operationalize the model.

POLICY VARIABLES OF THE NORTHERN NIGERIAN AGRICULTURAL MODEL

While the model is capable of generating an enormous volume of detailed information, at yearly intervals if desired, only a small fraction of this is relevant to decision makers. For this reason the model has been programmed to print summary tables of information that is most relevant to the model user (See Tables I - IV).1/ These summary tables enable the user to compare a number of simulation runs which embody the alternative development strategies he is exploring. The numbers down the left side of the tables are the values assigned to the policy variables for each of the simulation runs. Note that these values are identified with particular parameters by the headings at the top left of the table. Correspondingly, the values of the criterion variables at the end of each simulation run appear on the right side of the table.

Taken together, the parameters in the first two columns of these Tables determine what, if any, crop modernization programs are introduced during a given simulation run. The parameters RMAX, TO, T1, T2, and TF

1/ For a guide to the interpretation of these Tables see Appendix A.

define a "modernization" budget[1/] which can be allocated to production campaigns directed at various productive activities in Northern Nigeria. These parameters control budget values and timing.

This budget is allocated by the modernization executive component of the model to promotion, technical assistance, and subsidies (if any) for the activity of interest, i.e. modernization of groundnuts, introduction of draught animals, etc.

Figure 1 illustrates how these 5 parameters determine the modernization budget.

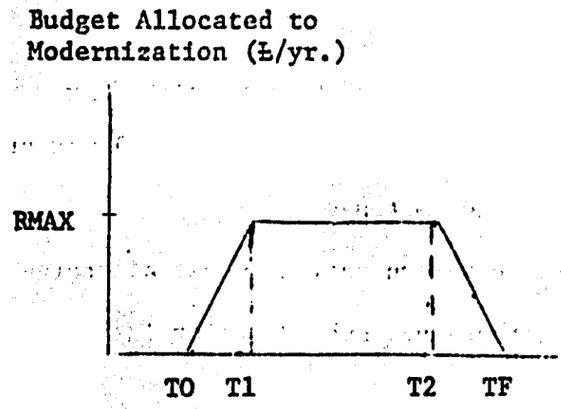

Figure (1)

1/ See Project Working Paper 70-1 for more details.

As shown, RMAX determines the maximum level of annual expenditure on modernization, TO the start of the modernization program, TF the conclusion and so forth.

Given the modernization budget and its distribution through time, the parameters PREV(1) through PREV(6) determine the proportion of the modernization budget that is allocated to each modernization alternative. Specifically:

PREV(1) = Proportion of modernization budget allocated to promotion, technical assistance and subsidies for modernization of groundnut production (a number between zero and one)

PREV(2) = Ditto for cotton production

PREV(3) = Ditto for food grown in competition with groundnuts and cotton

PREV(4) = Ditto for food (mainly in the middle belt) not grown in competition with groundnuts and cotton

PREV(5) = Proportion of the modernization budget allocated to promotion, technical assistance and subsidies for introduction of draught animals.1/

PREV(6) = Proportion of the modernization budget allocated to the eradication of tsetse flys in the middle belt (primarily to provide additional grazing for the cattle of Northern Nigeria).

1/ If the variable MECH is set equal to one the mechanization takes place in the middle belt if the variable MECH is set equal to zero the mechanization takes place in the grain-groundnut-cotton zones of Northern Nigeria.

It should be pointed out that there are some restrictions which limit the range of modernization alternatives that can be explored with this model. An obvious and necessary one is that PREV(1) . . . . . PREV(6) must sum to one. A general rule to follow in designing simulation runs is that the model (in its present form) may yield questionable results if more than one modernization program is initiated <u>in a given geographical area</u>. At the present time the model doesn't necessarily consider all important interactive effects between modernization programs. For example, if modernization of groundnut and food grain production are programmed simultaneously the model will not include reduced extension service costs which would probably result from simultaneously, rather than independently, promulgating the two modernization packages. The model would, however, approximate the effects of higher food yields upon groundnut acreage.

The parameters K3(1) . . . . . K3(5), also related to the modernization programs, are defined as follows:

K3(1) = Proportion of fertilizer price <u>not</u> subsidized during a groundnut production campaign (a number between zero and one)

K3(2) = Ditto for cotton

K3(3) = Ditto for food grains grown in competition with groundnuts and cotton

K3(4) = Ditto for food <u>not</u> grown in competition with groundnuts and cotton

K3(5) = Proportion of maximum cash subsidy (E141(5)) <u>not</u> paid during a campaign to introduce draught animal level mechanization.

By assigning various values to these parameters, a wide range of fertilizer subsidy schemes can be simulated. As an example, if K3 is .5 for a given modernization program, one-half the cost of required fertilizer will be paid for by the modernization budget.

Also related to modernization programs are the policy parameters S1(1) . . . . . S1(5) of Tables I - IV. These parameters are set equal to either zero or one at the beginning of a simulation and they determine whether or not the modernization program must pay for the distribution of inputs required to sustain the given program. Inclusion of this feature was motivated by the realization that input distribution activities could substantially reduce the effectiveness of an extension service as a promulgator of modern methods and that it might be important to investigate payoffs from marketing system developments that would eliminate the need for extension service involvement in this area. More specifically, if S1 is zero for a particular commodity the modernization program must pay the cost of distributing inputs if that commodity undergoes modernization through a production campaign. If S1 is one, the model assumes that the private marketing system is able to distribute inputs necessary for modern production. The numbers in brackets, i.e., S1(1), S1(2) . . . S1(5) refer to the five modernization alternatives defined above in connection with the parameter K3.

Another important set of model policy variables are the various tax rates in columns 2-5 of the tables. These are defined as follows:1/

1/ As presently constructed, the model assumes that regulatory policies such as taxes, marketing board price policies, etc., are constant throughout a given simulation run. This can be changed to permit time varying policies when it is relevant to do so.

TAXJ = "Jangali" cattle tax - £/animal-year

TAXRP(1) = ad valorem producer tax on groundnuts sold - % x 100

TAXRP(2) = ad valorem producer tax on cotton sold - % x 100

TAXRP(3) = ad valorem producer tax on food grain sold - % x 100

TAXRP(4) = ad valorem producer tax on root crops sold - % x 100

TAXRM(4) = ad valorem marketing tax on root crops sold - % x 100

TAXRM(3) = ad valorem marketing tax on food grain sold - % x 100

TAXRM(2) = ad valorem marketing tax on cotton sold -% x 100

TAXRM(1) = ad valorem marketing tax on groundnuts sold - % x 100

Normally TAXRM(1) and TAXRM(2) are zero because these taxes (if any) are assumed to be combined with any revenue that is withheld from producers by the marketing boards for groundnuts and cotton.

Marketing board price policies are determined by the policy parameters PMB(1) and PMB(2) in column 5 of the summary tables.

PMB(1) = Proportion of total groundnut sales value withheld from producers <u>in excess of marketing board operating costs</u>.

PMB(2) = Ditto for cotton.

Thus, if the PMB parameters are set to zero, marketing boards break even.

CRITERION VARIABLES OF THE NORTHERN MODEL

We will now turn our attention to a description of the criterion variables appearing in the summary table of the model. These appear in columns 6-10 of Tables I-IV. Beginning with column 6 these variables are defined as follows:

CFICNA = Disposable cash farm income from crops (groundnuts, cotton and cash food) in Northern Nigeria accumulated over the length of a given simulation run - ₦ x 1000

TAXTNA = Total taxes (from crop production, marketing and livestock including marketing board revenues) accumulated over the length of the given simulation run - ₦ x 1000

VANA = Value added (from crops, livestock and related marketing) accumulated over the given simulation run - ₦ x 1000

FOREXNA = Foreign exchange earnings from livestock and cash crops accumulated over the given simulation run - ₦ x 1000

CFIN = Annual cash farm income from crops and livestock in Northern Nigeria in the last year of a simulation run - ₦ x 1000/yr.

CFICN = Annual cash farm income from crops in Northern Nigeria at the last year of a simulation run - ₦ x 1000/yr.

The criterion variables in Column 7 of the summary table are defined as follows:

CFIPC = Total annual cash income from crops and livestock (CFIN) per person in agriculture in Northern Nigeria in the last year of asimulation run - ₦/person-year

FARMIN = Total annual income from livestock in the last year of a simulation run - ₦ x 1000/yr.

VAN = Total annual value added (from crops and livestock) in the last year of a simulation run - ₦ x 1000/yr.

1/ The model in its current form does not discount variables which are accumulated over the duration of simulation runs. Future versions of the model can compute discounted variables where desired.

FOREXN = Total annual foreign exchange (from crops and livestock) in the last year of a given simulation run - ₤ x 1000/yr.

TAXTN = Total annual taxes from cash crop production, marketing (including marketing board revenues), and livestock in the last year of a given simulation run - ₤ x 1000/yr.

ENFI = Total expenditures on non-farm agricultural inputs (for groundnuts, cotton and food production) in the last year of a simulation run - ₤ x 1000/yr.

The criterion variables in column 8 of the summary table are defined as follows:

TAXPT = Total annual taxes from crop production in the last year of a simulation run - ₤ x 1000/yr.

TAXMT = Total annual taxes from marketing (less marketing board revenues) in the last year of a simulation run - ₤ x 1000/yr.

TAXA = Total annual taxes from animals in the last year of a simulation run - ₤ x 1000/yr.

TDCRDT = Total annual demand for credit in the last year of a simulation run - ₤ x 1000/yr.

TDFERT = Total annual demand for fertilizer in the last year of a simulation run - lbs x 1000/yr.

TDINV = Total investment demand (for productive capital) in the last year of a given simulation run - ₤ x 1000/yr.

The criterion variables in column 9 of the summary table are defined as follows:

VAPT = Total annual value added from production (crops and livestock) in the last year of a simulation run - £ x 1000/yr.

VAMT = Total annual value added from marketing (including marketing boards) in the last year of a simulation run - £ x 1000/yr.

PCNNA = Per capita nutrition of persons consuming cash food (dominantly in urban areas) in the last year of a given simulation run-- calories/person-year

TREVMB = Total annual marketing board revenue (from groundnuts and cotton) in the last year of a simulation run - £ x 1000/yr.

REVMBA(1) = Accumulated marketing board revenue from groundnuts over the length of a given simulation run - £ x 1000

REVMBA(2) = Accumulated marketing board revenue from cotton over the length of a given simulation run - £ x 1000

The variables in the last column of the summary table (column 10) provide a measure of how well the model compares with actual behavior of the Northern Nigerian agricultural economy over the period 1952-1965. (For a more complete description of these variables and related model tests see the Project Progress Report dated November 1, 1969 pp. 68, 69.) It should be noted that these variables (SS(1), SS(2), SS(3) and TSS) are only relevant when the model is run under the same conditions (i.e. producer prices, extension programs, etc.) that actually prevailed in Nigeria from 1952 to 1965.

These variables are defined as follows:

SS(1) = Total normalized sum of squared deviations between actual and simulated staple food prices in Northern Nigeria over the period 1952-1965

SS(2) = Total normalized sum of squared deviations between actual and simulated groundnut sales in Northern Nigeria over the period 1952-1965

SS(3) = Total normalized sum of squared deviations between actual and simulated cotton sales in Northern Nigeria over the period 1952-1965

TSS = Total squared deviations (SS(1) + SS(2) + SS(3))

A perfect model fit would result in a TSS value of zero and a "worst" model fit would correspond to a TSS value of about 40. Again, it must be emphasized that these criteria are meaningless if model conditions do not match actual conditions over this time period.

DESCRIPTION OF PRELIMINARY POLICY RUNS OF THE NORTHERN MODEL

We will now turn our attention to a discussion of some typical simulation runs involving alternative development policies. The purpose of this discussion is to illustrate how such a simulation model <u>might</u> be used as an aid to planning and to further explicate the planning capability of the model.

As discussed in the recent progress report (dated November 1, 1969) the current model contains "ballpark" estimates of many key parameters and many of the structural assumptions of the model require careful review. In spite of these limitations one can use such a model to develop deeper

insights into complex development processes, to raise relevant questions regarding advantages and disadvantages of alternative development strategies, etc.

In what follows, the results of some forty simulation runs will be presented. These results are summarized in Tables I, II, III and IV. The many detailed assumptions upon which these runs are based are fully described elsewhere.1/ All values in Tables I-IV are those prevailing at the end of a 30-year simulation run.

Runs 1-5 in Table I explore the impact of production modernization campaigns upon the four major commodities of Northern Nigeria. Run I is a standard run (with no modernization) against which modernization alternatives can be compared. In Runs 2-5, it is assumed that 10 million pounds per year (RMAX) are allocated to commodity modernization over a 10-year time horizon (TF minus TO). In Run 2 of Table I, this amount is allocated to modernization of groundnut production (PREV(1) = 1), in Run 3 to cotton (PREV(2) = 1), in Run 4 to food grown in competition with groundnuts and cotton (PREV(3) = 1), and in Run 5 to food, mainly in the middle belt, not grown in competition with groundnuts and cotton (PREV(4) = 1).

1/ For these details consult the Project Progress Report (Revised) dated 3/15/70 and the detailed simulation run outputs (identified by the "CS" numbers referenced on each table.)

TABLE I

SUMMARY TABLE OF OUTPUT FROM ALL RUNS AT TIME T= 30.00 YEARS

RUN	POLICY PARAMETERS					CRITERION VARIABLES				
	PREV(1)	RMAX	K3(1)	S1(3)	TAXRM(1)	CFICNA	CFIPC	TAXPT	VAPT	SS(1)
	PREV(2)	T0	K3(2)	S1(2)	TAXRM(2)	TAXTNA	PARMIN	TAXMT	VAMT	SS(2)
	PREV(3)	T1	K3(3)	S1(3)	TAXRM(3)	VANA	VAN	TAXA	PCNNA	SS(3)
	PREV(4)	T2	K3(4)	S1(4)	TAXRM(4)	FORFXNA	FORFXN	TDCRDT	TREVMR	ISS
	PREV(5)	TF	K3(5)	S1(5)	PMB(1)	CFIN	TAXTN	TDFERT	REVMBA(1)	
	PREV(6)	TAXJ	TAXRP(1)	TAXRP(3)	PMB(2)	CFICN	ENFI	TNDIRV	REVMBA(2)	
			TAXRP(2)	TAXRP(4)						
1	0.	.1000E+05	.5000E+00	0.	0.	.4798E+07	.1323E+02	0.	.4531E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	.5277E+05	.2720E+05	0.	.1205E+06	.1038E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1051E+08	.5736E+06	.1849E+04	.8815E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.3567E+05	-.2545E+05	0.	-.8731E-10	.3507E+01
	0.	.1100E+02	.5000E+00	0.	0.	.3153E+06	.1849E+04	0.	.3031E+04	
	0.	.4333E+00	0.	0.	0.	.2881E+06	.6487E+03	0.	-.6831E+04	
			0.	0.						
2	.1000E+01	.1000E+05	.5000E+00	0.	0.	.6377E+07	.1881E+02	0.	.6071E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	.5202E+05	.2657E+05	0.	.1779E+06	.9684E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1302E+08	.7849E+06	.1803E+04	.8815E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.1718E+07	.1140E+06	.2205E+05	.1077E-08	.1215E+02
	0.	.1100E+02	.5000E+00	0.	0.	.4483E+06	.1803E+04	.1013E+07	.2810E+04	
	0.	.4333E+00	0.	0.	0.	.4217E+06	.9317E+04	.1415E+04	-.6831E+04	
			0.	0.						
3	0.	.1000E+05	.5000E+00	0.	0.	.5395E+07	.1531E+02	0.	.5002E+06	.1877E+00
	.1000E+01	.1000E+01	.5000E+00	0.	0.	.4654E+05	.2725E+05	0.	.1400E+06	.1037E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1133E+08	.6402E+06	.1853E+04	.8815E+06	.5485E+02
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.9339E+06	.4741E+05	.1347E+05	-.2910E-10	.5408E+02
	0.	.1100E+02	.5000E+00	0.	0.	.3648E+06	.1853E+04	.1356E+07	.3036E+04	
	0.	.4333E+00	0.	0.	0.	.3375E+06	.1131E+05	.9139E+03	-.1304E+05	
			0.	0.						
4	0.	.1000E+05	.5000E+00	0.	0.	.4911E+07	.1337E+02	0.	.457[illegible]E+06	.1881E+00
	0.	.1000E+01	.5000E+00	0.	0.	.5122E+05	.2698E+05	0.	.1221E+06	.1497E+01
	.1000E+01	.3000E+01	.5000E+00	0.	.2000E+00	.1070E+08	.5792E+06	.1834E+04	.8815E+06	.5210E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.1866E+06	-.2124E+05	.6231E+03	.4075E-09	.6895E+01
	0.	.1100E+02	.5000E+00	0.	0.	.3187E+06	.1834E+04	.6231E+05	.3069E+04	
	0.	.4333E+00	0.	0.	0.	.2917E+06	.1107E+04	.1607E+03	-.7895E+04	
			0.	0.						
5	0.	.1000E+05	.5000E+00	0.	0.	.4484E+07	.1228E+02	0.	.3439E+06	.8565E+00
	0.	.1000E+01	.5000E+00	0.	0.	.5196E+05	.2635E+05	0.	.1175E+06	.1038E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.9182E+07	.4615E+06	.1787E+04	.1897E+07	.2281E+01

	.1000E+01	.9000E+01	.5000E+00	0.	.2000E+00	.3033E+05	-.2587E+05	.1456E+05	-.8731E-10	.4175E+01
	0.	.1100E+02	.5000E+00	0.	0.	.2928E+06	.1787E+04	.2005E+07	.3031E+04	
	0.	.4333E+00	0.	0.	0.	.2664E+06	.1550E+05	.9396E+03	-.6830E+04	
			0.	0.						
6	0.	.1000E+05	.5000E+00	0.	0.	.5839E+07	.1661E+02	0.	.5504E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	-.4621E+06	.2449E+05	0.	.9654E+05	.1038E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1145E+08	.6409E+06	.1798E+04	.8815E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.5781E+06	.1718E+05	0.	-.3992E+05	.3507E+01
	0.	.1100E+02	.5000E+00	0.	-.2500E+00	.3960E+06	-.3812E+05	0.	-.3766E+06	
	0.	.4333E+00	0.	0.	-.2500E+00	.3495E+06	.6769E+03	0.	-.1415E+06	
			0.	0.						
7	.1000E+01	.1000E+05	.5000E+00	0.	0.	.3928E+07	.2875E+02	0.	.8840E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	-.1279E+07	.2557E+05	0.	.1083E+06	.9684E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1519E+08	.9923E+06	.1733E+04	.8815E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.2994E+07	.2376E+06	.3444E+05	-.1188E+06	.3215E+02
	0.	.1100E+02	.5000E+00	0.	-.2500E+00	.6852E+06	-.1171E+06	.1604E+07	-.1193E+07	
	0.	.4333E+00	0.	0.	-.2500E+00	.6597E+06	.1421E+05	.2054E+04	-.1415E+06	
			0.	0.						
8	0.	.1000E+05	.5000E+00	0.	0.	.6969E+07	.2030E+02	0.	.6320E+06	.1877E+00
	.1000E+01	.1000E+01	.5000E+00	0.	0.	-.7811E+06	.2663E+05	0.	.9576E+05	.1037E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1255E+08	.7278E+06	.1810E+04	.8815E+06	.5485E+02
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.1815E+07	.1114E+06	.1751E+05	-.6525E+05	.5608E+02
	0.	.1100E+02	.5000E+00	0.	-.2500E+00	.4838E+06	-.6344E+05	.1873E+07	-.3377E+06	
	0.	.4333E+00	0.	0.	-.2500E+00	.4571E+06	.1514E+05	.1004E+04	-.4993E+06	
			0.	0.						
9	0.	.1000E+05	.5000E+00	0.	0.	.6376E+07	.1813E+02	0.	.5938E+06	.1881E+00
	0.	.1000E+01	.5000E+00	0.	0.	-.6053E+06	.2531E+05	0.	.9762E+05	.1497E+01
	.1000E+01	.3000E+01	.5000E+00	0.	.2000E+00	.1211E+08	.6914E+06	.1715E+04	.8815E+06	.5210E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.1050E+07	.4744E+05	.3032E+04	-.5013E+05	.6895E+01
	0.	.1100E+02	.5000E+00	0.	-.2500E+00	.4322E+06	-.4841E+05	.3026E+06	-.4704E+06	
	0.	.4333E+00	0.	0.	-.2500E+00	.4069E+06	.3064E+04	.2628E+03	-.1898E+06	
			0.	0.						
10	0.	.1000E+05	.5000E+00	0.	0.	.5525E+07	.1567E+02	0.	.4611E+06	.8565E+00
	0.	.1000E+01	.5000E+00	0.	0.	-.4630E+06	.2562E+05	0.	.9361E+05	.1038E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1012E+08	.5547E+06	.1735E+04	.1897E+07	.2281E+01
	.1000E+01	.9000E+01	.5000E+00	0.	.2000E+00	.5726E+06	.1675E+05	.1456E+05	-.3992E+05	.4175E+01
	0.	.1100E+02	.5000E+00	0.	-.2500E+00	.3734E+06	-.3818E+05	.2005E+07	-.3766E+06	
	0.	.4333E+00	0.	0.	-.2500E+00	.3478E+06	.1522E+05	.9396E+03	-.1415E+06	
			0.	0.						

TABLE I

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TABLE II

SUMMARY TABLE OF OUTPUT FROM ALL RUNS AT TIME T= 30.00 YEARS

RUN	POLICY PARAMETERS					CRITERION VARIABLES				
	PREV(1)	RMAX	K3(1)	S1(1)	TAXRM(1)	CFICNA	CFIPC	TAXPT	VAPT	SS(1)
	PREV(2)	T0	K3(2)	S1(2)	TAXRM(2)	TAXTNA	FARMIN	TAXMT	VAMT	SS(2)
	PREV(3)	T1	K3(3)	S1(3)	TAXRM(3)	VANA	VAN	TAXA	PCNMA	SS(3)
	PREV(4)	T2	K3(4)	S1(4)	TAXRM(4)	FOREXNA	FOREXN	TDCRDT	TPEVMB	TSS
	PREV(5)	TF	K3(5)	S1(5)	PMB(1)	CFIN	TAXTN	TDFERT	REVMBA(1)	
	PREV(6)	TAXJ	TAXRP(1)	TAXRP(3)	PMB(2)	CFICN	ENFI	TNDINV	REVMBA(2)	
			TAXRP(2)	TAXRP(4)						
1	0.	.1000E+05	.5000E+00	0.	0.	.4798E+07	.1323E+02	0.	.4531E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	.5277E+05	.2720E+05	0.	.1205E+06	.1938E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1051E+08	.5736E+06	.1849E+04	.8815E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.3567E+05	-.2545E+05	0.	-.8731E-10	.3507E+01
	0.	.1100E+02	.5000E+00	0.	0.	.3153E+06	.1849E+04	0.	-.3031E+04	
	0.	.4333E+00	0.	0.	0.	.2881E+06	.6437E+03	0.	-.6831E+04	
			0.	0.						
2	.1000E+01	.1000E+05	.5000E+00	0.	0.	.6377E+07	.1881E+02	0.	.6871E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	.5202E+05	.2657E+05	0.	.1779E+06	.9484E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1302E+08	.7849E+06	.1803E+04	.8815E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.1718E+07	.1140E+06	.2205E+05	.1877E-08	.1215E+02
	0.	.1100E+02	.5000E+00	0.	0.	.4483E+06	.1803E+04	.1013E+07	.2816E+04	
	0.	.4333E+00	0.	0.	0.	.4217E+06	.9317E+04	.1415E+04	-.6831E+04	
			0.	0.						
3	.6700E+00	.1000E+05	.5000E+00	0.	0.	.6793E+07	.2073E+02	0.	.6527E+06	.1878E+00
	.3300E+00	.1000E+01	.5000E+00	0.	0.	.4902E+05	.2654E+05	0.	.1961E+06	.5582E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1359E+08	.8489E+06	.1801E+04	.8815E+06	.1985E+02
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.2367E+07	.1789E+06	.3317E+05	-.4875E-09	.2562E+02
	0.	.1100E+02	.5000E+00	0.	0.	.4941E+06	.1801E+04	.2159E+07	.2839E+04	
	0.	.4333E+00	0.	0.	0.	.4475E+06	.1827E+05	.2131E+04	-.9874E+04	
			0.	0.						
4	.1000E+01	.5000E+04	.5000E+00	0.	0.	.6194E+07	.1875E+02	0.	.6855E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	.5216E+05	.2660E+05	0.	.1773E+06	.3848E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1273E+08	.7827E+06	.1805E+04	.8815E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.1520E+07	.1126E+06	.2198E+05	-.3201E-09	.6317E+01
	0.	.1100E+02	.5000E+00	0.	0.	.4469E+06	.1805E+04	.1006E+07	.2864E+04	
	0.	.4333E+00	0.	0.	0.	.4203E+06	.9272E+04	.1421E+04	-.6831E+04	
			0.	0.						
5	.6700E+00	.5000E+04	.5000E+00	0.	0.	.6568E+07	.2064E+02	0.	.6504E+06	.1877E+00
	.3300E+00	.1000E+01	.5000E+00	0.	0.	.5044E+05	.2658E+05	0.	.1952E+06	.2472E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1324E+08	.8456E+06	.1804E+04	.8815E+06	.9893E+01

	0.	.9000E+01	.5000E+00	0.	.2000E+00	.2109E+07	.1767E+06	.3307E+05	.7567E-09	.1255E+02
	0.	.1100E+02	.5000E+00	0.	0.	.4920E+06	.1804E+04	.2145E+07	.2897E+04	
	0.	.4333E+00	0.	0.	0.	.4454E+06	.1918E+05	.2142E+04	-.8591E+04	
			0.	0.						
6	0.	.1000E+05	.5000E+00	0.	0.	.5839E+07	.1461E+02	0.	.5504E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	-.4623E+06	.2449E+05	0.	.9454E+05	.1038E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1145E+08	.6469E+06	.1798E+04	.8819E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.5781E+06	.1718E+05	0.	-.3992E+05	.3507E+01
	0.	.1100E+02	.5000E+00	0.	-.2500E+00	.3960E+06	-.3812E+05	0.	-.3764E+06	
	0.	.4333E+00	0.	0.	-.2500E+00	.3695E+06	.6769E+03	0.	-.1415E+06	
			0.	0.						
7	.1000E+01	.1000E+05	.5000E+00	0.	0.	.8928E+07	.2875E+02	0.	.8840E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	-.1279E+07	.2557E+05	0.	.1083E+06	.9684E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1519E+08	.9923E+06	.1733E+04	.8815E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.2994E+07	.2376E+06	.3444E+05	-.1188E+06	.1215E+02
	0.	.1100E+02	.5000E+00	0.	-.2500E+00	.6852E+06	-.1171E+06	.1604E+07	-.1193E+07	
	0.	.4333E+00	0.	0.	-.2500E+00	.6597E+06	.1421E+05	.2054E+04	-.1415E+06	
			0.	0.						
8	.6700E+00	.1000E+05	.5000E+00	0.	0.	.9771E+07	.3190E+02	0.	.9590E+06	.1878E+00
	.3300E+00	.1000E+01	.5000E+00	0.	0.	-.1531E+07	.2557E+05	0.	.1083E+06	.5582E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1599E+08	.1067E+07	.1732E+04	.8815E+06	.1985E+02
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.3911E+07	.3140E+06	.4693E+05	-.1403E+06	.2562E+02
	0.	.1100E+02	.5000E+00	0.	-.2500E+00	.7603E+06	-.1386E+06	.3035E+07	-.1159E+07	
	0.	.4333E+00	0.	0.	-.2500E+00	.7348E+06	.2507E+05	.2623E+04	-.4273E+06	
			0.	0.						
9	.1000E+01	.5000E+04	.5000E+00	0.	0.	.8651E+07	.2866E+02	0.	.8815E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	-.1218E+07	.2560E+05	0.	.1082E+06	.3488E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1483E+08	.9898E+06	.1735E+04	.8815E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.2763E+07	.2360E+06	.3443E+05	-.1182E+06	.6317E+01
	0.	.1100E+02	.5000E+00	0.	-.2500E+00	.6830E+06	-.1165E+06	.1597E+07	-.1132E+07	
	0.	.4333E+00	0.	0.	-.2500E+00	.6574E+06	.1418E+05	.2076E+04	-.1415E+06	
			0.	0.						
10	.6700E+00	.5000E+04	.5000E+00	0.	0.	.9424E+07	.3178E+02	0.	.9557E+06	.1877E+00
	.3300E+00	.1000E+01	.5000E+00	0.	0.	-.1448E+07	.2560E+05	0.	.1082E+06	.2472E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1557E+08	.1064E+07	.1735E+04	.8815E+06	.9893E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.3610E+07	.3118E+06	.4692E+05	-.1395E+06	.1255E+02
	0.	.1100E+02	.5000E+00	0.	-.2500E+00	.7574E+06	-.1378E+06	.3024E+07	-.1091E+07	
	0.	.4333E+00	0.	0.	-.2500E+00	.7318E+06	.2503E+05	.2653E+04	-.4123E+06	
			0.	0.						

TABLE II

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TABLE III

SUMMARY TABLE OF OUTPUT FROM ALL RUNS AT TIME T= 30.00 YEARS

RUN	POLICY PARAMETERS					CRITERION VARIABLES				
	PREV(1)	RMAX	K3(1)	S1(1)	TAXRM(1)	CFICNA	CFIPC	TAXPT	VAPT	SS(1)
	PREV(2)	T0	K3(2)	S1(2)	TAXRM(2)	TAXTNA	FARMIN	TAXMT	VAMT	SS(2)
	PREV(3)	T1	K3(3)	S1(3)	TAXRM(3)	VANA	VAN	TAXA	PCNNA	SS(3)
	PREV(4)	T2	K3(4)	S1(4)	TAXRM(4)	FOREXNA	FOREXN	TDCRDT	TREVMR	TSS
	PREV(5)	TF	K3(5)	S1(5)	PPB(1)	CFIN	TAXTN	TDFFRT	REVMBA(1)	
	PREV(6)	TAXJ	TAXRP(1)	TAXRP(3)	PPB(2)	CFICN	ENPT	TNDINV	REVMBA(2)	
			TAXRP(2)	TAXRP(4)						
1	0.	.1000E+05	.5000E+00	0.	0.	.4309E+07	.1165E+02	0.	.4081E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	.3020E+06	.2753E+05	0.	.1323E+06	.1038E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1009E+08	.5405E+06	.1873E+04	.8815E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	-.2143E+06	-.4511E+05	0.	.1904E+05	.3507E+01
	0.	.1100E+02	.5000E+00	0.	.2500E+00	.2777E+06	.2091E+05	0.	.1910E+06	
	0.	.4333E+00	0.	0.	.2500E+00	.2502E+06	.6365E+03	0.	.5418E+05	
			0.	0.						
2	.1000E+01	.1000E+05	.5000E+00	0.	0.	.4929E+07	.1332E+02	0.	.4534E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	.6132E+06	.2738E+05	0.	.1841E+06	.9684E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1152E+08	.6375E+06	.1862E+04	.8815E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.7934E+06	.2226E+05	.1219E+05	.4313E+05	.1215E+02
	0.	.1100E+02	.5000E+00	0.	.2500E+00	.3174E+06	.4499E+05	.5632E+06	.5024E+06	
	0.	.4333E+00	0.	0.	.2500E+00	.2900E+06	.5434E+04	.7747E+03	.5418E+05	
			0.	0.						
3	.6700E+00	.1000E+05	.5000E+00	0.	0.	.5042E+07	.1380E+02	0.	.4449E+06	.1878E+00
	.3300E+00	.1000E+01	.5000E+00	0.	0.	.6989E+06	.2737E+05	0.	.2002E+06	.5582E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1179E+08	.6651E+06	.1861E+04	.8815E+06	.1985E+02
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.1129E+07	.5069E+05	.1771E+05	.5113E+05	.2562E+02
	0.	.1100E+02	.5000E+00	0.	.2500E+00	.3289E+06	.5300E+05	.1134E+07	.4863E+06	
	0.	.4333E+00	0.	0.	.2500E+00	.3015E+06	.9891E+04	.1127E+04	.1559E+06	
			0.	0.						
4	.1000E+01	.5000E+04	.5000E+00	0.	0.	.4830E+07	.1331E+02	0.	.4532E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	.5846E+06	.2739E+05	0.	.1839E+06	.3848E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1132E+08	.6371E+06	.1863E+04	.8815E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.6520E+06	.2198E+05	.1218E+05	.4302E+05	.6317E+01
	0.	.1100E+02	.5000E+00	0.	.2500E+00	.3172E+06	.4469E+05	.5618E+06	.4738E+06	
	0.	.4333E+00	0.	0.	.2500E+00	.2898E+06	.5426E+04	.7764E+03	.5418E+05	
			0.	0.						
5	.6700E+00	.5000E+04	.5000E+00	0.	0.	.4929E+07	.1379E+02	0.	.4444E+06	.1877E+00
	.3300E+00	.1000E+01	.5000E+00	0.	0.	.6413E+06	.2739E+05	0.	.1998E+06	.2472E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1156E+08	.6444E+06	.1862E+04	.8815E+06	.9893E+01

	0.	.9000E+01	.5000E+00	0.	.2000E+00	.9491E+06	.5017E+05	.1769E+05	.5095E+05	.1255E+02
	0.	.1100E+02	.5000E+00	0.	.2500E+00	.3286E+06	.5281E+05	.1131E+07	.4550E+06	
	0.	.4333E+00	0.	0.	.2500E+00	.3012E+06	.9871E+04	.1130E+04	.1494E+06	
			0.	0.						
6	0.	.1000E+05	.5000E+00	0.	0.	.4553E+07	.1244E+02	0.	.4307E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	.1677E+06	.2737E+05	0.	.1254E+06	.1038E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1029E+08	.5561E+06	.1861E+04	.8815E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	-.1013E+06	-.3625E+05	0.	.8804E+04	.3507E+01
	0.	.1100E+02	.5000E+00	0.	.1000E+00	.2964E+06	.1067E+05	0.	.8928E+05	
	0.	.4333E+00	0.	0.	.1000E+00	.2690E+06	.6422E+03	0.	.2168E+05	
			0.	0.						
7	.1000E+01	.1000E+05	.5000E+00	0.	0.	.5651E+07	.1600E+02	0.	.5287E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	.3427E+06	.2495E+05	0.	.1838E+06	.9484E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1228E+08	.7125E+06	.1831E+04	.8815E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.1262E+07	.6896E+05	.1733E+05	.2387E+05	.1215E+02
	0.	.1100E+02	.5000E+00	0.	.1000E+00	.3614E+06	.2570E+05	.7976E+06	.2647E+06	
	0.	.4333E+00	0.	0.	.1000E+00	.3545E+06	.7457E+04	.1109E+04	.2168E+05	
			0.	0.						
8	.6700E+00	.1000E+05	.5000E+00	0.	0.	.5925E+07	.1724E+02	0.	.5582E+06	.1878E+00
	.3300E+00	.1000E+01	.5000E+00	0.	0.	.3955E+06	.2493E+05	0.	.2035E+06	.5582E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1273E+08	.7617E+06	.1829E+04	.8815E+06	.1985E+02
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.1784E+07	.1190E+06	.2599E+05	.2949E+05	.2562E+02
	0.	.1100E+02	.5000E+00	0.	.1000E+00	.4110E+06	.3132E+05	.1691E+07	.2549E+06	
	0.	.4333E+00	0.	0.	.1000E+00	.3841E+06	.1444E+05	.1667E+04	.8428E+05	
			0.	0.						
9	.1000E+01	.5000E+04	.5000E+00	0.	0.	.5499E+07	.1596E+02	0.	.5275E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	.3252E+06	.2698E+05	0.	.1838E+06	.3848E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1202E+08	.7105E+06	.1833E+04	.8815E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.1078E+07	.6769E+05	.1727E+05	.2368E+05	.6317E+01
	0.	.1100E+02	.5000E+00	0.	.1000E+00	.3804E+06	.2551E+05	.7912E+06	.2471E+06	
	0.	.4333E+00	0.	0.	.1000E+00	.3534E+06	.7417E+04	.1115E+04	.2168E+05	
			0.	0.						
10	.6700E+00	.5000E+04	.5000E+00	0.	0.	.5742E+07	.1718E+02	0.	.5564E+06	.1877E+00
	.3300E+00	.1000E+01	.5000E+00	0.	0.	.3732E+06	.2696E+05	0.	.2024E+06	.2472E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1241E+08	.7587E+06	.1831E+04	.8815E+06	.9893E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.1545E+07	.1170E+06	.2589E+05	.2921E+05	.1255E+02
	0.	.1100E+02	.5000E+00	0.	.1000E+00	.4094E+06	.3104E+05	.1678E+07	.2357E+06	
	0.	.4333E+00	0.	0.	.1000E+00	.3824E+06	.1436E+05	.1676E+04	.8111E+05	

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TABLE IV

SUMMARY TABLE OF OUTPUT FROM ALL RUNS AT TIME T= 30.00 YEARS

RUN	POLICY PARAMETERS					CRITERION VARIABLES				
	PREV(1)	RMAX	K3(1)	S1(1)	TAXRM(1)	CFICNA	CFIRC	TAXPI	VAPT	SS(1)
	PREV(2)	T0	K3(2)	S1(2)	TAXRM(2)	TAXTNA	FARMIN	TAXMT	VAMT	SS(2)
	PREV(3)	T1	K3(3)	S1(3)	TAXRM(3)	VANA	VAN	TAXA	PCNMA	SS(3)
	PREV(4)	T2	K3(4)	S1(4)	TAXRM(4)	FOREXNA	FOREXN	TDCRDT	TREVMR	TSS
	PREV(5)	TF	K3(5)	S1(5)	PMB(1)	CFIN	TAXTN	TDFERT	REVMBA(1)	
	PREV(6)	TAXJ	TAXRP(1)	TAXRP(3)	PMB(2)	CFICN	ENFI	TNDINV	REVMBA(2)	
			TAXRP(2)	TAXRP(4)						
1	0.	.2500E+04	.5000E+00	0.	0.	.4309E+07	.1165E+02	0.	.4081E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	.3020E+06	.2753E+05	0.	.1323E+06	.1038E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1009E+08	.5405E+06	.1873E+04	.8815E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	-.2143E+06	-.4511E+05	0.	.1904E+05	.3507E+01
	0.	.1100E+02	.5000E+00	0.	.2500E+00	.2777E+06	.2091E+05	0.	.1910E+06	
	0.	.4333E+00	0.	0.	.2500E+00	.2502E+06	.6365E+03	0.	.5419E+05	
			0.	0.						
2	.1000E+01	.2500E+04	.5000E+00	0.	0.	.4745E+07	.1329E+02	0.	.4528E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	.5510E+06	.2740E+05	0.	.1835E+06	.1898E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1114E+08	.6363E+06	.1863E+04	.8815E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.5230E+06	.2140E+05	.1216E+05	.4282E+05	.4367E+01
	0.	.1100E+02	.5000E+00	0.	.2500E+00	.3168E+06	.4468E+05	.5590E+06	.4401E+06	
	0.	.4333E+00	0.	0.	.2500E+00	.2894E+06	.5409E+04	.7798E+03	.5418E+05	
			0.	0.						
3	.6700E+00	.2500E+04	.5000E+00	0.	0.	.4826E+07	.1376E+02	0.	.4639E+06	.1877E+00
	.3300E+00	.1000E+01	.5000E+00	0.	0.	.6159E+06	.2740E+05	0.	.1999E+06	.1456E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1134E+08	.6628E+06	.1863E+04	.8815E+06	.5253E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.7748E+06	.4906E+05	.1766E+05	.5057E+05	.6897E+01
	0.	.1100E+02	.5000E+00	0.	.2500E+00	.3279E+06	.5243E+05	.1124E+07	.4184E+06	
	0.	.4333E+00	0.	0.	.2500E+00	.3005E+06	.9829E+04	.1136E+04	.1407E+06	
			0.	0.						
4	.1000E+01	.1250E+04	.5000E+00	0.	0.	.4665E+07	.1326E+02	0.	.4519E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	.5128E+06	.2742E+05	0.	.1825E+06	.1283E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1096E+08	.6344E+06	.1864E+04	.8815E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.3966E+06	.2016E+05	.1213E+05	.4237E+05	.3751E+01
	0.	.1100E+02	.5000E+00	0.	.2500E+00	.3161E+06	.4423E+05	.5529E+06	.4018E+06	
	0.	.4333E+00	0.	0.	.2500E+00	.2886E+06	.5373E+04	.7873E+03	.5418E+05	
			0.	0.						
5	.6700E+00	.1250E+04	.5000E+00	0.	0.	.4727E+07	.1370E+02	0.	.4623E+06	.1877E+00
	.3300E+00	.1000E+01	.5000E+00	0.	0.	.5650E+06	.2742E+05	0.	.1973E+06	.1155E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1111E+08	.6594E+06	.1864E+04	.8815E+06	.3471E+01

	0.	.9000E+01	.5000E+00	0.	.2000E+00	.6019E+06	.4476E+05	.1759E+05	.4970E+05	.4814E+01
	0.	.1100E+02	.5000E+00	0.	.2500E+00	.3265E+06	.5164E+05	~~.1110E+07~~	~~.3784E+06~~	
	0.	.4333E+00	0.	0.	.2500E+00	.2991E+06	.9742E+04	.1150E+04	.1298E+06	
			0.	0.						
6	0.	.2500E+04	.5000E+00	0.	0.	.4553E+07	.1244E+02	0.	.4307E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	.1677E+06	.2737E+05	0.	.1254E+06	.1038E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1029E+08	.5561E+06	.1861E+04	.8815E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	-.1013E+06	-.3425E+05	0.	.8804E+04	.3507E+01
	0.	.1100E+02	.5000E+00	0.	.1000E+00	.2964E+06	.1067E+05	0.	.8028E+05	
	0.	.4333E+00	0.	0.	.1000E+00	.2690E+06	.6422E+03	0.	.2168E+05	
			0.	0.						
7	.1000E+01	.2500E+04	.5000E+00	0.	0.	.5353E+07	.1569E+02	0.	.5255E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	.3049E+06	.2702E+05	0.	.1819E+06	.1898E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1176E+08	.7074E+06	.1835E+04	.8815E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.9003E+06	.6580E+05	.1717E+05	.2338E+05	.4367E+01
	0.	.1100E+02	.5000E+00	0.	.1000E+00	.3786E+06	.2622E+05	.7809E+06	.2267E+06	
	0.	.4333E+00	0.	0.	.1000E+00	.3516E+06	.7351E+04	.1124E+04	.2168E+05	
			0.	0.						
8	.6700E+00	.2500E+04	.5000E+00	0.	0.	.5560E+07	.1706E+02	0.	.5537E+06	.1877E+00
	.3300E+00	.1000E+01	.5000E+00	0.	0.	.3469E+06	.2701E+05	0.	.2004E+06	.1456E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1209E+08	.7539E+06	.1834E+04	.8815E+06	.5253E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.1307E+07	.1136E+06	.2573E+05	.2875E+05	.6597E+01
	0.	.1100E+02	.5000E+00	0.	.1000E+00	.4067E+06	.3058E+05	.1658E+07	.2139E+06	
	0.	.4333E+00	0.	0.	.1000E+00	.3797E+06	.1423E+05	.1691E+04	.7651E+05	
			0.	0.						
9	.1000E+01	.1250E+04	.5000E+00	0.	0.	.5209E+07	.1577E+02	0.	.5222E+06	.1877E+00
	0.	.1000E+01	.5000E+00	0.	0.	.2827E+06	.2706E+05	0.	.1808E+06	.1283E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1150E+08	.7022E+06	.1838E+04	.8815E+06	.2281E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.7251E+06	.6217E+05	.1700E+05	.2280E+05	.3751E+01
	0.	.1100E+02	.5000E+00	0.	.1000E+00	.3758E+06	.2473E+05	.7637E+06	.2044E+06	
	0.	.4333E+00	0.	0.	.1000E+00	.3487E+06	.7243E+04	.1139E+04	.2168E+05	
			0.	0.						
10	.6700E+00	.1250E+04	.5000E+00	0.	0.	.5383E+07	.1608E+02	0.	.5485E+06	.1877E+00
	.3300E+00	.1000E+01	.5000E+00	0.	0.	.3198E+06	.2706E+05	0.	.1978E+06	.1155E+01
	0.	.3000E+01	.5000E+00	0.	.2000E+00	.1178E+08	.7463E+06	.1838E+04	.8815E+06	.3471E+01
	0.	.9000E+01	.5000E+00	0.	.2000E+00	.1075E+07	.1084E+06	.2547E+05	.2802E+05	.4814E+01
	0.	.1100E+02	.5000E+00	0.	.1000E+00	.4024E+06	.2965E+05	.1627E+07	.1914E+06	
	0.	.4333E+00	0.	0.	.1000E+00	.3754E+06	.1402E+05	.1713E+04	.7087E+05	
			0.	0.						

TABLE IV

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Comparing Run 2 with Run 1 it is clear from the changes in per capita income (CFIPC) value added (VAN), etc., that, under the assumptions embodied in the model, the groundnut modernization program has been successful. Examination of the detailed computer output reveals that modern methods have been profitable for individual farmers and have widely diffused during the thirty-year simulation. Run 3 indicates that the cotton modernization program has also been successful though its impact upon the economy has been less than the groundnut program. This is because cotton is not as entensively grown as are groundnuts.

Run 4 indicates that modernization of food (in competition with groundnuts and cotton) has not been successful. The detailed simulation output indicates that this is due to the fact that the comparatively high fertilizer requirement for modern food production makes it unprofitable for farmers to adopt its use at prevailing fertilizer and cash crop prices. In other simulation runs, with more favorable prices, the model indicates that farmers <u>would</u> adopt modern food production practices because of the net increase in cash crop production that could result. (Due to the tendency of northern farmers to be food self-sufficient, greater food yields would release land and labor for increased cash crop production.)

Run 5 indicates that farm income (in the model) will actually decline if food production (not in competition with groundnuts and cotton) is modernized. This is due to the lower food prices that result from the increased supply. Note, however, that people who buy their food in the market are better fed. Per capita nutrition (PCNNA) has more than doubled between Run 1 and

Run 5.1/

It is important to note a fundamental difference between results of modernization of the two types of food discussed above. Increased yields of food grown in competition with cash earners such as groundnuts and cotton would not necessarily result in increased food supply and lower food prices. Our results to date indicate that cash food is not nearly as profitable for northern farmers as are groundnuts or cotton (where farmers have the option of growing the latter). They would therefore tend to allocate resources, freed due to increased food yields, to groundnuts or cotton and not increase food production.

Runs 6-10 are identical to 1-5 respectively with one exception. Runs 1-5 assume that marketing board price policies are such that these boards (for groundnuts and cotton) are breaking even and not generating surpluses by reducing producer prices. (PMB(1) = PMB(2) = zero). In Runs 6-10 the boards are assumed to be operating at a substantial loss (PMB(1) and PMB(2) = .25) in order to subsidize and stimulate groundnut and cotton production. The impacts upon farm income, foreign exchange earnings, etc., are dramatic (as are the marketing board deficits). The effects of a wider range of marketing board price policies will be discussed in more detail later.

In other simulation runs (not discussed here) the modernization budget has been allocated to draught animal level mechanization, (PREV(5) = 1). In these runs the innovation was not widely adopted by producers due to

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1/ This large increase indicates that the estimate for food demand price elasticity in the model is probably too high.

high costs relative to the small cash returns from traditional production. It would be interesting to examine what the outcome would be if the mechanization campaign follows or accompanies a crop modernization campaign. This is perhaps a useful area for future work.

We will now turn our attention to the simulation runs of Table II. Runs 1 and 2 of Table II are identical to runs 1 and 2 of Table I. In Run 3 of Table II the modernization budget was allocated to production campaigns for groundnuts <u>and</u> cotton (PREV(1) = .67, PREV(2) = .33). (In other respects this run is identical to Run 2 of Table II and Runs 2 and 3 of Table I.) Comparison with Run 2 of Table II or Runs 2 and 3 of Table I indicates that this allocation results in substantial improvements in all relevant criteria.

Runs 4 and 5 of Table II are identical to Runs 2 and 3 of Table II respectively except for a reduction in the level of allocation to modernization programs (RMAX = ₦ 5 million/year in Runs 4 and 5). Interestingly, the impact on relevant criteria such as income is quite small. Later simulation runs will explore the implications of additional reductions in the variable RMAX. Runs 6-10 of Table II are identical to Runs 1-5 of the same table with the exception of changes in marketing board price policies (PMB(1) = PMB(2) = -.25 in Runs 6-10 as opposed to zero in Runs 1-5). Again, significant increases in farm income, foreign exchange earnings, etc., result, but at the expense of large marketing board losses.

Table III further explores the impact of various marketing board price policies. The assumptions underlying Table III are identical to those of Table II with the following exceptions:

Runs	PMB(1) & PMB(2) (Table II)	PMB(1) & PMB(2) (Table III)
1-5	0	.25
6-10	-.25	.1

Some of the results of these alternative marketing board price policies are abstracted from the tables and summarized in Figures (2) and (3). Figure (2) shows marketing board revenue and value added accumulated over a 30-year simulation run (REVMBA and VANA) plotted against marketing board offtake for groundnuts and cotton, PMB(1) and PMB(2).

Figure 3 plots annual value added, VAN, and marketing board revenue, TREVMB, (both at the end of a 30-year simulation run) against marketing board offtakes, PMB(1) and PMB(2).

Table IV further explores the impact upon model results of additional decreases in the modernization budget as influenced by the model parameter, RMAX. The assumptions underlying Table IV are identical to those of Table III with the following exceptions:

Runs	RMAX (Table III)	RMAX (Table IV)
1-3, 6-8	10 million £/yr	2.5 million £/yr
4&5, 9&10	5 million £/yr	1.25 million £/yr

In essence, the RMAX values of Table IV are 25% those of Table III. Figure (4) abstracts data from all four tables and displays the impact of changes in the modernization budget upon per-capita income in the 30th year of the simulations (CFIPC) and value added accumulated over the duration

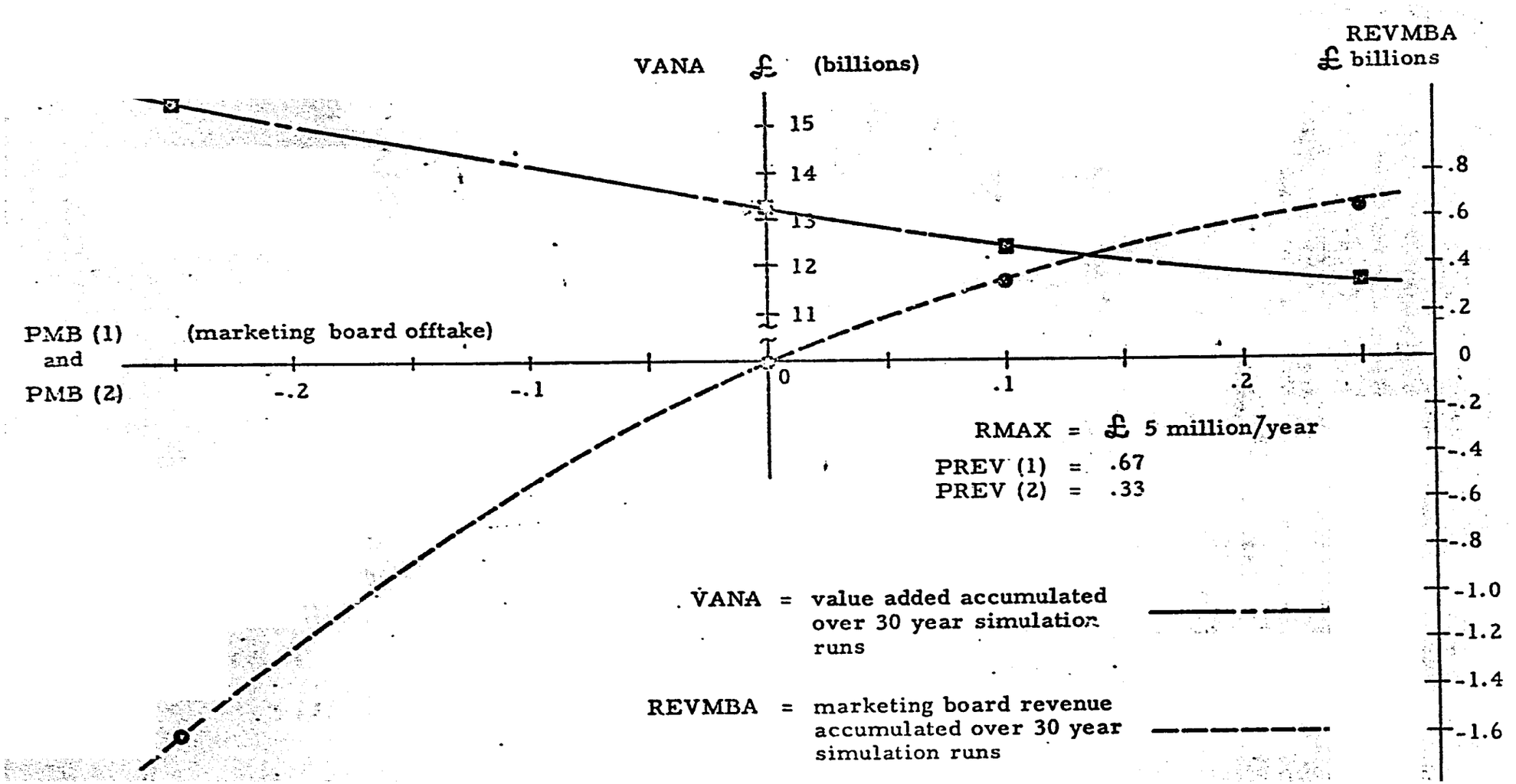
VANA £ (billions)
REVMBA £ billions
15
14
13
12
11
.8
.6
.4
.2
0
-.2
-.4
-.6
-.8
-1.0
-1.2
-1.4
-1.6
PMB (1) and PMB (2)
(marketing board offtake)
-.2
-.1
0
.1
.2
RMAX = £ 5 million/year
PREV (1) = .67
PREV (2) = .33
VANA = value added accumulated over 30 year simulation runs
REVMBA = marketing board revenue accumulated over 30 year simulation runs

Figure 2

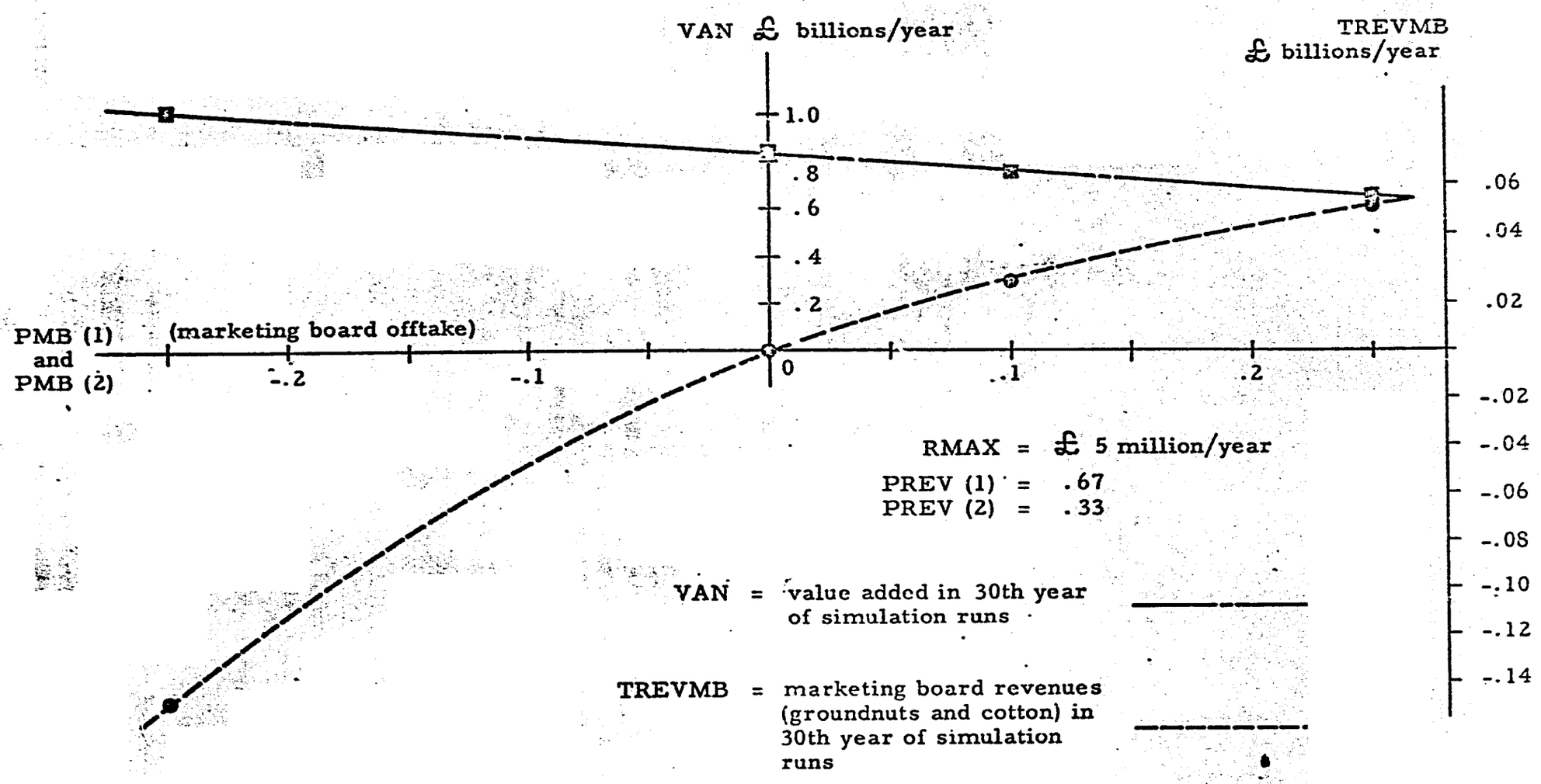
VAN £ billions/year
TREVMB £ billions/year
1.0
.8
.6
.4
.2
.06
.04
.02
-.02
-.04
-.06
-.08
-.10
-.12
-.14
PMB (1) and PMB (2)
(marketing board offtake)
-.2
-.1
0
.1
.2
RMAX = £ 5 million/year
PREV (1) = .67
PREV (2) = .33
VAN = value added in 30th year of simulation runs
TREVMB = marketing board revenues (groundnuts and cotton) in 30th year of simulation runs

Figure 3

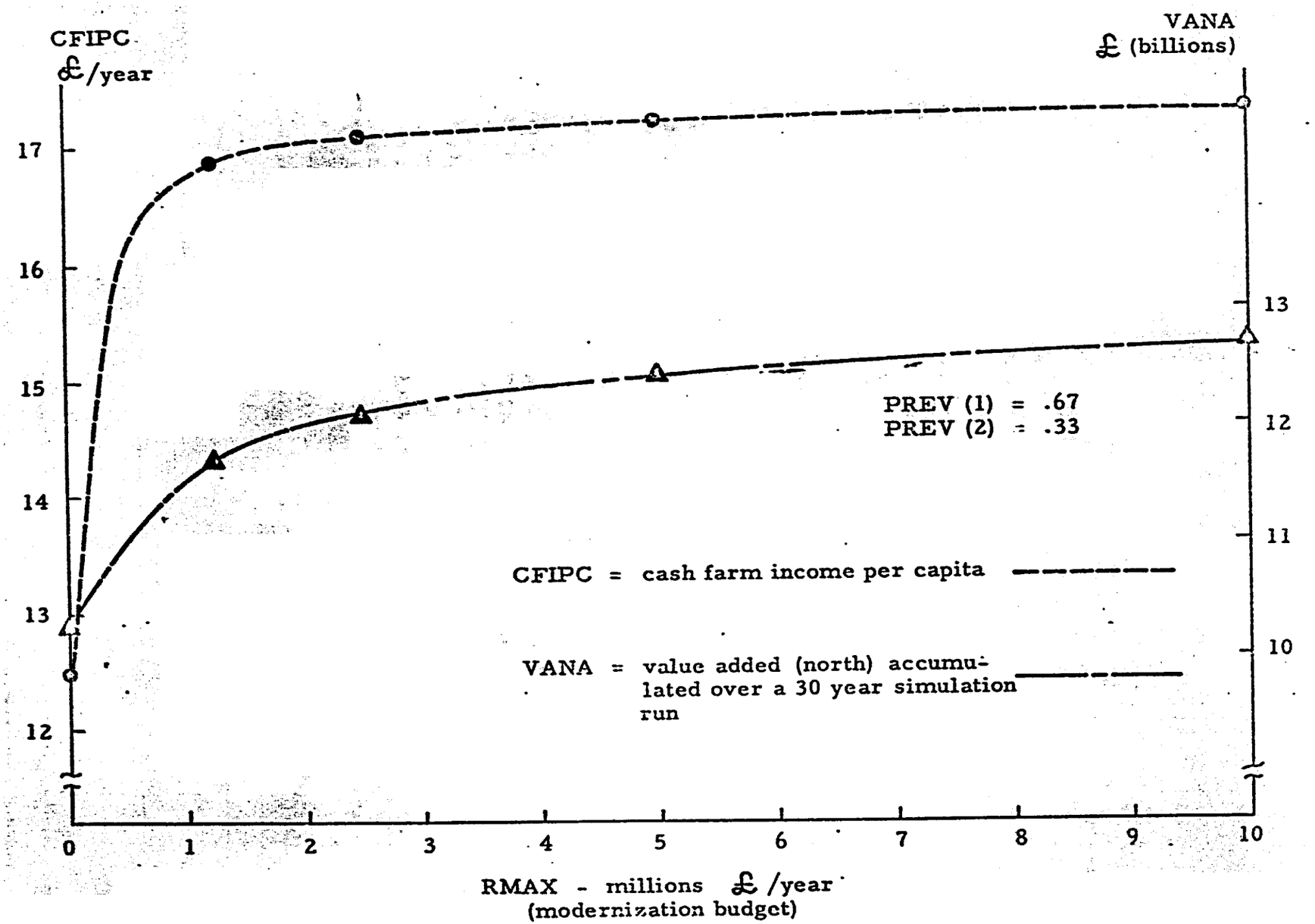
CFIPC
£/year
VANA
£ (billions)
17
16
15
14
13
12
13
12
11
10
PREV (1) = .67
PREV (2) = .33
CFIPC = cash farm income per capita
VANA = value added (north) accumulated over a 30 year simulation run
0
1
2
3
4
5
6
7
8
9
10
RMAX - millions £/year
(modernization budget)

Figure 4

of the 30-year simulations. The curves of Figure (4) assume that the modernization budget was allocated to the modernization of both groundnuts and cotton (PREV(1) = .67, PREV(2) = .33).

CONCLUSIONS AND AREAS FOR FUTURE WORK

This report has defined major policy instruments and criterion variables currently incorporated in the Northern Nigerian Agricultural Model and has displayed the results of typical simulation runs made to date. It is hoped that this will stimulate criticism and suggestions that would make refined versions of this model more useful to decision makers. The detailed simulation results displayed in Tables I-IV provide the reader with a means of, to some extent at least, evaluating the internal consistency of the model and its more basic structural assumptions.

As noted earlier, these simulation results should be regarded as illustrative only. In order to develop an operational simulation model additional work is required in two major areas:

1) Review and perhaps refinement of the basic structural relationships of the model -- the variables included and the specific equations that interrelate these variables.
2) Further data aquisition to provide improved estimates of key model parameters.

Of these two areas the first is much more important than the second. It is possible to draw valid conclusions from a properly specified model with uncertain estimates of model parameters but it is not possible to draw valid conclusions from an incorrectly specified model--even with the

best possible estimates of model parameters.

Accordingly, the highest priority in future work must be given to review and modification, where necessary, of basic structural relationships of the model. Not an easy task, this refinement phase would require extensive field and computer work and close consultations with specialists acquainted with various aspects of the agricultural economy--planners, administrators, economists, extension, marketing and production specialists, simulators, etc. Due to the scope involved and inherent cross disciplinary and cross cultural communication problems, the latter would be a time consuming process. The process might involve seminars including the breadth of disciplines cited above and one-to-one sessions with individual specialists. In order for this review and refinement phase to be successful, the people involved would have to be carefully selected and charged by their superiors with specific responsibilities to the undertaking.

While costly in terms of time expended on the part of persons involved, this process can be useful in its own right. It would seem that seminars, organized along these lines could contribute directly to the formulation and coordination of development strategies whether a simulation model is involved or not. But the use of the resulting model may significantly assist in the development of successful strategies.

Given a model that is properly structured in the sense discussed above, the problem of data acquisition to provide estimates for the many model parameters becomes paramount. While the data problem is a formidable one, it is encouraging to note here that it is <u>not</u> necessary to have precise estimates for all model parameters. In many cases a model can be useful to decision makers even when uncertainty exists about the values

of individual parameters. In this mode of operation a simulation model doesn't say categorically that, for example, development strategy A is superior to B with respect to its impact on specific development objectives (criterion variables). Rather, the model might say, that on the average A is superior to B. Further, the model would present the decision maker with the range of outcomes possible under various policy alternatives.

In order to exploit this particular capability of the simulation approach, data must be acquired which will make possible the estimation of a probability density function for each uncertain model parameter. Experience with PERT (Performance Evaluation and Review Technique) has indicated that in many cases it is possible to estimate a probability density function1/ for an uncertain model parameter if estimates are available for the minimum, maximum and most likely values for the parameter in question.

In the final analysis development planning is inherently fraught with uncertainty regarding the outcomes of various development policies and programs. There is evidence that the simulation approach can help reduce this uncertainty and lead to development strategies which are more likely to achieve desired objectives.

1/ A Beta distribution

APPENDIX A

Guide to The Interpretation of Tables I-IV

The four tables included in this report summarize the results of forty simulation runs made with the Northern Nigerian Agricultural Model. Each simulation run had a duration of 30 years and is identified by a run number in the leftmost (first) column of each table.

Columns 2-5 of the tables indicate the values that were assigned to each of the model decision or policy variables for each simulation run. Columns 6-11 indicate the values of model criterion variables (variables used to evaluate alternative development policies or programs) in the last or 30th year of a simulation run.

Each column is headed by a list of the variables which are tabulated in that column. For a given simulation run there is a one-to-one correspondence between the variables in list at the top of a column and the numbers tabulated in that column for the given simulation run. Some examples taken from Table I follow:

Example 1: The value assigned to policy variable PREV(1) (in Column 2 of Table I) in Simulation Run 2 is .1000E + 01.

Example 2: The value of criterion variable FOREXN (in Column 8 of Table I) in the 30th year of Simulation Run 3 is .4741E + 05.

A word of explanation is also necessary in order to interpret the numbers printed in the body of the table. The computer has printed numbers in what is known as exponential notation. Thus, .1000E + 01 is the same as $.1000 \times 10^1$ or 1.000 and .4741E + 05 is the same as $.4741 \times 10^5$ or 47410.

Finally, it is also necessary to observe carefully the units of measure that applies to each variable. As described on page 9, the units of FOREXN (annual foreign exchange earnings) are thousands of pounds per year. Therefore, Table I says that foreign exchange earnings in the 30th year of Simulation Run 3 are 47410 x 1000 or 47.41 millions of pounds per year. Thus, in order to properly interpret these tables the reader must use the definitions on pages 4-11 to determine the units of measure for the variables tabulated.

Admittedly, these tables are needlessly complicated. With additional programming effort this situation can be improved in future versions of our models.