AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

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BATCH #14

1. SUBJECT CLASSIFICATION

A. PRIMARY
Agriculture
AA00-0000-G214

B. SECONDARY
General--Nigeria

2. TITLE AND SUBTITLE
The modernization executive component

3. AUTHOR(S)
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4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1970	10p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Mich.State

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*
(In Project working paper 70-1)

9. ABSTRACT

10. CONTROL NUMBER	11. PRICE OF DOCUMENT
PN-RAA-721	

12. DESCRIPTORS
Factor analysis
Nigeria
Simulation
Technological change

13. PROJECT NUMBER

14. CONTRACT NUMBER
CSD-1557 Res.

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

BAM

A SIMULATION MODEL OF THE NIGERIAN AGRICULTURAL ECONOMY

Contract No. AID/csd-1557

The Modernization Executive Component

Project Working Paper 70-1

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February 9, 1970
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The Modernization Executive Component

This model component performs three major functions:

1) It permits the user of the overall model to allocate modernizing resources to a number of alternative commodities or programs. In the case of the Northern Nigerian Model these alternatives currently are:

   i) Introduction of modern inputs into groundnut production

   i) Introduction of modern inputs into cotton production

   iii) Introduction of modern inputs into food production (in competition with groundnuts and cotton)

   v) Introduction of modern inputs into food production (not in competition with groundnuts or cotton)

   v,vi) Campaigns to introduce draught animals into the a) cash crop-food and b) food only regions of Northern Nigeria

   i) A campaign to eradicate tsetse flys in the middle belt of Nigeria

2) The component permits the policy maker to experiment with different levels of budget expenditures for modernization programs and different distributions of budget allocations over time

3) Once allocations are made to alternative modernization programs this component controls the <u>scale</u> of the various programs so allocated revenue is expended without excessive budget surpluses or deficits

While developed for use in the Northern Model, this component should also be useful in the Southern Model and elsewhere. In what follows the structure of this component will be discussed in some detail.

We will begin by describing the ways that total modernization revenue and its distribution over time can be determined. The basic input to the Modernization Executive component is the variable REVMN which represents the total revenue (₤/yr.) allocated to modernization programs at any point in time. Currently this variable is set by the user of the model as a policy variable (see Figure ME1).

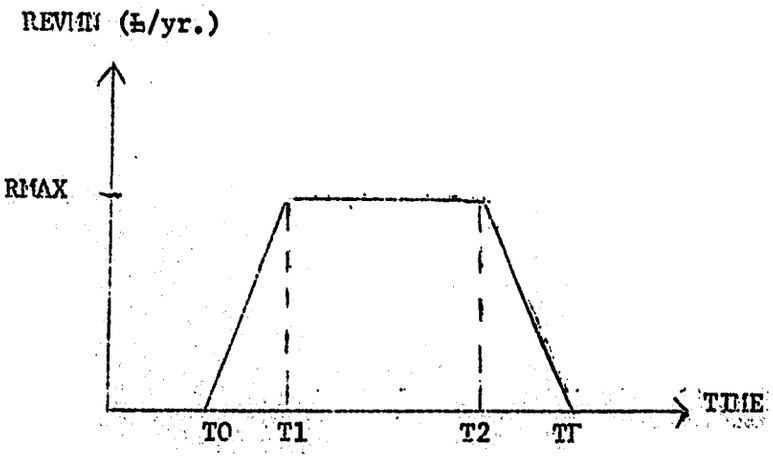

Figure ME1

As shown the user, by specifying the five parameters (RMAX, T0, T1, T2, TF), can control the size, start time, end time, buildup and phasing out of modernization programs. This is currently the way the modernization budget is being determined in the northern model. After merger with the southern model this variable, REVMN, can be determined at some higher policy level which, say, allocates modernizing resources to northern and southern regions.

Before leaving discussion of this model variable, it should be pointed out that REVMN in general represents the resources which are allocated to stimulate modernization overtly. It therefore represents such public programs as extension promotion and technical assistance. It can also represent any private expenditures which are directed toward the same ends. The effect of this allocation is to stimulate spontaneous demands for additional modernizing inputs through diffusion processes (modeled in the modernization component). The interactions between this component and the modernization component are quite important and will become clearer as the discussion proceeds.

Given REVMN the model then allocates this revenue to the various alternatives under consideration. This is done through a set of policy parameters $PREV_i$ (i = 1,2...N).

(ME1) $\quad EREV_i(t) = PREV_i(t) \cdot REVMN(t)$

$i = 1,2,...N$

Here $EREV_i(t)$ is the money allocated to the ith modernization program at any point in time, $FREV_i$ is the proportion of the total budget allocated to the ith program and N is the number of alternative modernization programs under consideration. The $FREV$'s of course must sum to one.

Given the revenue allocated to each program, the modernization executive component proceeds to spend this revenue in such a manner as to keep the program cash balance within some acceptable limits. Accordingly, the component must compute the cash balance for each modernization program. Equation (ME2) performs this function:

(ME2) $$BAL_i(t + DT) = BAL_i(t) + DT*(EREV_i(t) - TEXP_i(t))$$

Where:

BAL_i = The cash balance of the ith modernization program (ƀ)

$EREV_i$ = Incoming revenue for the ith program (ƀ/yr.)

$TEXP_i$ = The total expenditures of the ith program (ƀ/yr.)

The total program expenditure $TEXP_i$ is composed of a number of items as follows:

(ME3) $$TEXP_i(t) = EXO_i(t) + EX1_i(t) + EX2_i(t) + FSUB_i(t)$$

Where:

EXO_i = Program overhead (ƀ/yr.)

$EX1_i$ = Expenditures on program promotion (directed at enrolling farmers in production campaigns, etc.) - ƀ/yr.

$EX2_i$ = Expenditures on technical assistance (ƀ/yr.)

$FSUB_i$ = Expenditures on subsidies (ƀ/yr.)

The terms on the right of this equation are computed as follows:

(ME4) $EXO_i(t) = K5 \cdot EREV_i(t)$

Where

K5 = proportion of program revenue consumed by overhead

(ME5) $EX1_i(t) = WRE1 \cdot EXTI_i(t)$

Where:

$EXTI_i$ = number of man equivalents engaged in program promotion--man units (computed by Equation ME14)

WRE1 = corresponding wage rate-₺/man yr.

(ME6) $EX2_i(t) = WRE2 \cdot (DEEX2_i(t) + EXTI_i(t) \cdot S1_i)$

$DEEX2_i$ = number of man equivalents engaged in program technical assistance-man units (computed by the Modernization Component)

$EXTI_i$ man units required to distribute inputs (seeds, fertilizer, etc.)--computed by modernization component

$S1_i$ 0 if modernization program must distribute inputs
1 otherwise

WRE2 The appropriate wage rate. (₺/man-year)

(ME7) $FSUB_i(t) = E141_i \cdot (1 - K3_i)\ (TRNSLE_i(t) \cdot PFRTM_i)$

Where:

$E141_i$ = The program per acre fertilizer requirement (#/acre)

$TRNSLE_i$ = Total land currently in the modernization program--acres x 10^3 (computed in the modernization component)

$PFRTM_i$ = market price of fertilizer (¢/lb.).

$K3_i$ = a policy parameter - $(1 - K_{3i})$ is the proportion of fertilizer price that is paid out of the program budget as a subsidy.

In connection with this subsidy, the model computes a farm (subsidized) fertilizer[1/] price which is an input variable to the modernization process and hence a factor in determining the criterion function which influences adoption of the modernization program.

(ME8) $PFRT_i(t) = K3_i\ PFRTM_i(t)$

Here $PFRT_i$ is the farmer's fertilizer price and $PFRTM_i$ is the normal market price.

Let's turn our attention now to the compution of EXT1--the key variable used to control program size in accordance with the available

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1/ In the case of the Northern Model, subsidies have been in terms of adjustments in farm fertilizer price. If this is not appropriate in other situations, cash subsidies or subsidy of other inputs can be simulated by giving different interpretations to E141, PFRTM & PFRT.

budget. (Recall that EXT1 is the manpower allocated to program promotion and hence program size regulation.) In summary, the variable EXT1 is adjusted as a function of two factors.

i) the difference between the actual program cash balance (BAL_i) and a desired level of balance ($BALD_i$)

i) the rate of change of the program balance

The latter factor is included to provide an anticipatory factor[1/] which provides more stable and precise control of the budget. This is a coarse approximation of the forecasting and anticipation inherent in good administration and budgeting.

The following equations combine to generate EXT1:

(ME9) $BALD_i(t) = MINIMUM\ [K6 \cdot PREV_i(t) \cdot RMAX \cdot TCAM/T2,\ K7 \cdot PREV_i(t) \cdot RMAX]$

Where:

$PREV_i$, RMAX, T2 = as defined above

TCAM = time since the start of a modernization campaign, i.e. (TIME - TO)

K6, K7 = model parameters

This equation simply allows the desired balance (demand for cash reserves) to increase uniformly to some maximum value of $K7 \cdot PREV_i(t) \cdot RMAX$ at the end of the program funding (TF in Figure ME1) The purpose of this

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1/ In the parlance of feedback control theory this is "rate feedback"

revenue is to cover lingering program costs after external funding has ceased. These costs are incurred due to the needs of farmers left in the modernization "pipeline" when funding expires.

Given $BALD_i$ the desired level of expenditure for program promotion, $A1_i(t)$, is computed as:

(ME10) $$A1_i(t) = K_2(K_1 \cdot RBAL_i(t) + BAL_i(t) - BALD_i(t)) + K0 \cdot EREVP(K)$$

As discussed above, promotion expenditure is a function of the difference between the actual and desired program balances ($BAL_i(t) - BALD_i(t)$) and the rate of change of the program balance, $RBAL_i(t)$. The latter term is simply

(ME11) $$RBAL_i(t) = EREV_i(t) - TEXP_i(t)$$

or incoming revenue minus total current expenditures. The last term in Equation (ME10) is a "normal" level of promotion expenditure based upon a forecasted incoming revenue ($EREVP_i(t)$). This latter variable is

(ME12) $$EREVP_i(t) = PREV_i(t) \cdot REVMN(t + PRED)$$

Where REVMN (t + PRED) is the anticipated modernization budget PRED years hence.

The actual level of promotion expenditure is $A1_i(t)$, computed above, lagged to account for a number of real world delays inherent in decision implementation. Hence

(ME13) $$A2_i(t) = A2_i(t) + (DT/DELM1) \cdot (A1_i(t) - A2_i(t))$$

Where:

$A2_i$ = actual expenditure on program promotion. ₤/yr. (in absence of constraints)

DELAY1 = Implementation delay--yrs.

Finally, the level of campaign promotion, EXT1, is computed as:

(ME14) $EXT1_i(t) = MINIMUM[MAXIMUM(A2_i(t),0), ULEXT1_i \cdot WRE1]/WRE1$

Where:

$EXT1_i$ = man equivalents engaged in program promotion (in program expansion)

$A2_i$ = unconstrained expenditure on promotion--₤/yr.

$ULEXT1_i$ = upper limit on promotion effort (men)

WRE1 = appropriate wage rate--₤/man year

This equation computes promotion effort subject to two constraints:

a) one to ensure that this variable is non-negative

b) a second to ensure that total promotion effort does not exceed a manpower constraint, $ULEXT1_i$.

In conclusion the above described component allocates and manages resources for specific modernization alternatives being explored in a given simulation run. It is called once for each distinct modernization alternative which has been allocated resources for the run in question.