WORKING PAPER

MARS 1 AND MARS 2 FOR THE FAP'S STUDY "HUNGER GROWTH AND EQUITY"

V. Iakimets

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IIASA
International Institute
for Applied Systems Analysis

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FOREWORD

Even with globally adequate food availability, large numbers of people remain chronically undernourished today. Evaluation of alternative national and international policies that can help reduce rapidly hunger in the world has been a major theme of the FAP since its inception.

Though national redistributive policies may be essential to reduce hunger at a satisfactory rate, the resources available with the developing countries are limited. International capital transfers are thus needed.

Among the sources for such funds can be reduction in arms expenditure.

With the help of FAP's Basic Linked System (BLS) of national agricultural policy models we have explored consequences for economic development and reduction in hunger of mutual arms reduction and redistribution of parts of the resources thus saved.

In this paper, Vladimir Iakimets describes the logic and specification of mutual arms reduction scenarios – that we call MARS.

Kirit S. Parikh
Program Leader
Food and Agriculture Program.

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I am very grateful to Professor Kirit Parikh for fruitful discussions and to Cynthia Enzlberger for editing and typing this paper.

ABSTRACT

In this paper two versions of the MARS for the FAP's study "Hunger, Growth and Equity" are elaborated for implementation in the BLS.

CONTENTS

MARS 1 and MARS 2 FOR THE FAP'S STUDY "HUNGER, GROWTH AND EQUITY"

Vladimir Iakimets

1. Introduction

In two previous papers of the author (Iakimets 1985a, Iakimets 1985b) the main ideas for the development of the MARS (Mutual Arms Reduction Scenarios) for the Food and Agriculture Program's study "Hunger, Growth and Equity" were described. In the first paper objectives of the MARS, its importance, assumptions for its construction, problems to be solved as well as the description of its structure were given. The second paper contains the formal description of the hypotheses relating to desired dynamics of annual reduction in a country's military expenditure.

This paper is devoted to detailed consideration of two versions of the scenario's implementation with the BLS (MARS 1 and MARS 2) including methodological and formalized description of variants for the solution of problems of the MARS implementation stated in the first paper (Iakimets, 1985a).

2. General objectives and specific aims for both scenarios

The general objective of the MARS1 and MARS2 is to show once more that all countries will be gainers in a social and economic sense when the resources used for military purposes are redirected to development of the civil economy. These scenarios are devoted to the analysis of the possible impact of such a redirection of resources on the growth rates of national economies and on alleviating the world hunger problem.

The specific aims of the scenarios are to find the most preferable alternatives for the utilization of released funds in DC's and LDC's in solving the economic problems in these countries – in a case where the total released funds of a country are used for only internal purposes (MARS1) and for that and aid by DC's to LDC's (MARS2).

3. Calculating the annually released funds of a country

If follow assumption for the MARS elaboration stated in Iakimets 1985a, then military expenditure $M_j(t)$ of j-th country in year t could be determined as the share $\lambda_j(t)$ of the country's $GDP_j(t)$.

$$M_j(t) = \lambda_j(t) \cdot GDP_j(t)\,, \quad j = \overline{1,m}, \quad t = 1, 2, \ldots, T \qquad (1)$$

In this case the value of $\lambda_j(t)$ could be estimated on the basis of corresponding time series of $M_j(t)$ and $GDP_j(t)$ taken from national or international statistical yearbooks. Then the estimated value of $\lambda_j(t)$ could be used in the BLS runs during the simulation period for calculating annually released fund of j-th country $\Delta M_j(t)$ created due to a reduction of military expenditure in the following way:

$$\Delta M_j(t) = \mu_j(t) \cdot M_j(t)\,, \qquad (2)$$

where $\mu_j(t)$ is a coefficient for reducing military expenditures of j-th country in year t. Values of this coefficient should be depended upon hypotheses prescribing the dynamics of a country's behaviour related to its arms reduction (see Iakimets 1985b). However, in the case of the application of the formula (2), the questions about the accuracy of values of the coefficients $\lambda_j(t)$ could arise.

In order to eliminate such questions instead of (2) the following way for calculating the values of $\Delta M_j(t)$ can be used:

$$\Delta M_j(t) = M_j(t) - M_j^{MARS}(t)\,, \qquad (3)$$

where $M_j(t)$ is determined as in (1) and $M_j^{MARS}(t)$ is defined by formula*:

* This idea was suggested by Prof. K. Parikh

$$M_j^{MARS}(t) = (\lambda_j(t) - \alpha_j(t)) \cdot GDP_j(t) \,, \tag{4}$$

where $\lambda_j(t)$ is the same coefficient as in (1) and $\alpha_j(t)$ is a reduction coefficient, $\alpha_j(t) \le \lambda_j(t)$ by definition. Substituting (1) and (4) into (3) yields:

$$\Delta M_j(t) = \alpha_j(t) \cdot GDP_j(t) \tag{5}$$

Comparing (5) with (2) one can see that:

$$\alpha_j(t) \equiv \mu_j(t) \cdot \lambda_j(t) \tag{6}$$

However in contrast to (2) where values of $\lambda_j(t)$ are used explicitly those are excluded in (5). In other words we needn't know the value of $\lambda_j(t)$ and according to (5) the value of released fund $\Delta M_j(t)$ can be calculated on the basis of the endogenously determined $GDP_j(t)$ and exogenously given $\alpha_j(t)$ describing the hypothetical dynamics of a country's military expenditures reduction as it was done for $\mu_j(t)$ in Iakimets 1985b.

4. Exogenous calculating values of $\alpha(t)$

In order to apply formula (5) for calculating the annual value of released fund $\Delta M(t)$ within the BLS the scenarios behaviour of the function $\alpha(t)$ should be described. This function is used to reflect different prescribed hypotheses of possible countries' behaviour concerning the annual reduction in their military expenditure. Hypotheses on optimistic, cautious optimistic, cautious gradual progressive and straightforward behaviour of countries were explained in Iakimets 1985b. According to this description the function $\alpha(t)$ in (5) has to possess the following properties:

1. it has to be a non-decreasing function of time

$$\alpha(t+1) \ge \alpha(t) \,, \quad t \in [0,T] \tag{7}$$

2. by definition values of $\alpha(t)$ have to meet the constraint:

$$\lambda(t) - \alpha(t) \ge 0 \,, \quad t \in [0,T] \tag{8}$$

In a general case values of function $\alpha(t)$ in $t = 0$ and in $t = T$ should be specific ones for each country in the BLS as well as different hypotheses should be used for various countries. However for the sake of simplicity first of all we will use during the BLS run the same hypothesis for each country. It means that:

$$\alpha_j(t) = \alpha(t) \quad \forall j = 1, 2, \ldots\ldots, m. \tag{9}$$

Behind this an idea about mutually assured efforts in reducing military expenditures in all countries is pursued. The initial value of $\alpha(t)$ in $t = 0$ as well as the value of $\alpha(t)$ in $t = T$ have to be accepted to meet requirements (8).

The matter is if the value of $\alpha(t)$ is too high then models of countries with real low levels of military expenditures will give inappropriate results. In another case if this value ($\alpha(t)$) is too low, then the impact of released fund utilization can be negligible.

In order to determine the appropriate values $\alpha(0)$ and $\alpha(T)$ for all countries in the BLS, the comparison of the SIPRI estimates of ratios of each country's military expenditures to its GDP was made (SIPRI, 1984). Because these data given in this source contains uncertain information and estimates with a high degree of uncertainty (see SIPRI, 1984, pp. 127-130) the approximate classification of all countries and groupings of countries in the BLS into 3 sets of countries was made*:

A. countries where military expenditures is less or close to 1 percent of GDP

B. countries where this value is more than 1 and less than 3

C. countries where this value is more or close to 3 percent.

Classification of the BLS countries into these 3 sets is given in Table 1.

* It should be noted that this classification will be used in the BLS run for only illustrative purposes to show the possibilities of this system.

Table 1.Values of the $\alpha(0)$ and $\alpha(T)$ for three sets of countries in the BLS

Countries (or countries code) in the BLS		$\alpha(1980)$	$\alpha(2000)$
A.	Austria, Japan, Brazil, Mexico, 911	0.001	0.005
B.	Australia, Argentina, Canada, Indonesia, New Zealand, India, 902, 906, 908, 916, 901	0.002	0.01
C.	CMEA, EEC, Egypt, Nigeria, Pakistan, Turkey, Kenya, Thailand, China, USA, 903, 904, 905, 907, 909, 910, 912, 913	0.003	0.015

Initial value α (1980) for all these countries was determined taking into account as an example the Soviet proposal on the reduction of the military budgets of states permanent members of the UN Security Council by 10 percent which has been submitted by the USSR in 1973 for consideration of the 27th UN General Assembly Session. Values of $\alpha(t)$ in t = 2000 for all BLS countries were simply taken equal 5 · $\alpha(1980)$. Prescribed behaviour of $\alpha(t)$ for different hypotheses is shown in Figure 1.

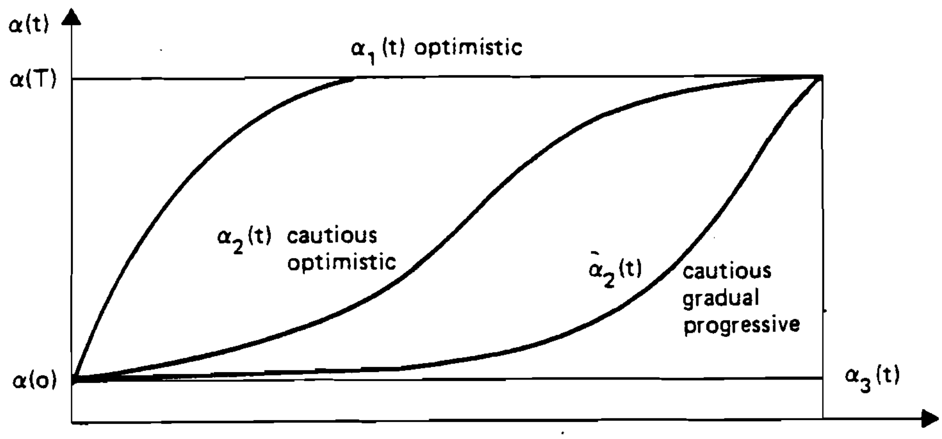

Figure 1. Behaviour of $\alpha(t)$

Corresponding formulas for calculating values of $\alpha(t)$ are:

$\alpha_1(t) = \alpha(0) \cdot (a_{11} - a_{12} \cdot e^{-a_{13} \cdot t})$ for optimistic hypothesis, (10)

$\alpha_2(t) = \alpha(0) + a_{21} \cdot t^2(a_{22} \cdot T - a_{23} \cdot t)$for cautious optimistic (11)

and cautious gradual progressive hypotheses,

$\alpha_3(t) = \alpha(T)$ (12)

Parameters $a_{..}$ (see Table 2) of functions $\alpha_1(t)$ and $\alpha_2(t)$ are determined taking into account given duration of considered period T and values of $\alpha(0)$and $\alpha(T)$ from Table 1. Calculated values of $\alpha(t)$ for three sets of countries for two hypotheses are given in Table 3.

Table 2. Values of parameters $a_{..}$

	$\alpha_1(t)$ optimistic			$\alpha_2(t)$ cautious optimistic		
	a_{11}	a_{12}	a_{13}	a_{21}	a_{22}	a_{23}
A	5	4	0.2	$0.5 \cdot 10^{-6}$	3	2
B	5	4	0.2	$1 \cdot 10^{-6}$	3	2
C	5	4	0.2	$1.5 \cdot 10^{-6}$	3	2

Table 3. Values of $\alpha(t)$ for groups of countries A, B and C

	optimistic hypothesis			cautious optimistic hypothesis		
Year	A	B	C	A	B	C
1980	0.001	0.002	0.003	0.001	0.002	0.003
1985	0.0035	0.007	0.011	0.0016	0.00325	0.00487
1990	0.0044	0.009	0.013	0.003	0.006	0.009
1995	0.0048	0.0096	0.0144	0.0044	0.00875	0.0131
2000	0.005	0.01	0.015	0.005	0.01	0.015

5. Adjustments needed for the BLS models

At the present time the BLS of the FAP consists of 34 models. Eighteen of these models are national agricultural policy models with standard structure (Australia, Austria, Canada, Japan, Argentina, Brazil, Egypt, Indonesia, Mexico, Nigeria, Pakistan, Turkey, Kenya, New Zealand, Thailand) and individual country-specific structure (China, India, USA), 2 models are country groups models (CMEA and EEC) and 14 are simplified country groupings models including 13 groupings of developing countries and 1 mixed grouping. An allocation of countries among the 14 groupings is described in FAP, 1985.

For the purpose of the MARS implementation within the BLS, mainly the adjustment of the last 14 models was found necessary, because the approach taken for these countries is that their supply is exogenously calculated on the basis of the results of the FAO study (FAO, 1981) and holds at constant prices. In order to have opportunities for reflection of these countries' supply in dependence on additional capital resources, the corresponding correcting term $\Delta Y_{ji}(t)$ for i-th commodity output function of j-th country was introduced.

$$\Delta Y_{ji}(t) = \frac{\Delta M_j(t)}{K_j(t) \cdot GDP_j(t)} \cdot \Delta Y_{ji}(t) \tag{13}$$

where $\Delta M_j(t)$ and $GDP_j(t)$ are determined as early, $\Delta Y_{ji}(t)$ is an increment of i-th commodity output in a year t in comparison to the previous year determined on the basis of the results of the FAO study (FAO, 1981) and coefficient $K_j(t)$ for all country groupings is calculated as follows:

$$K_j(t) = \frac{\sum_{\nu} K_{\nu}^{j}(t) \cdot GDP_{\nu}^{j}(t)}{\sum_{\nu} GDP_{\nu}^{j}(t)} \tag{14}$$

where ν is index of ν–th country in j-th grouping. Initial values of $K_{\nu}^{j}(t)$ for t = 0 are taken from Yearbooks of National Accounts Statistics. Calculated values of $K_j(t)$ for 1980 for all country groupings in the BLS are given in Table 4.

Table 4. Calculated values of $K_j(t)$

Country groupings code	K_j
901	0.396
902	0.18
903	0.235
904	0.146
905	0.2
906	0.22
907	0.22
908	0.18
909	0.254
910	0.25
911	0.18
912	0.29
913	0.37

6. MARS 1

6.1. Background

The main objective of this scenario is to analyze the impact of different variants for utilizing a country's released funds for its own economic development. We can call MARS 1 the scenario for autonomous self-supporting development. Because for each country in the BLS a number of balances have to be met for each year during the simulation period in order to exclude the possible violation of balances, we need to consider the opportunity for redirecting part of the military expenditure for civil purposes. One important factor for the implementation of MARS is the balance of national income distribution.

Let us consider the following balance equation for a country's GDP (or net national product) by type of expenditures (all indexes are omitted)

$$GDP = gov + priv + cap + bal \ , \tag{15}$$

where

gov is governmental final consumption expenditure,

priv is private final consumption expenditure,

cap is gross fixed capital formation, and bal = exp - imp is trade balance with exp and imp correspondingly export and import values.

Let us consider that all military expenditures are included into governmental final consumption expenditures.

$$gov \underset{def}{=} gov^{civil} + gov^{defence} \equiv (1 - \lambda)\, gov + \lambda gov. \tag{16}$$

In order to extract the value of released fund let us rewrite (16) as follows:

$$gov = [1 - (\lambda - \theta)]gov + [\lambda - \theta]gov. \tag{17}$$

Because by definition:

$$gov = \nu \cdot GDP \tag{18}$$

then the substitution of (18) into (17) and rearrangement yields

$$gov = (1 - \lambda) \cdot \nu \cdot GDP + \theta \cdot \nu \cdot GDP + (\lambda - \theta) \cdot \nu GDP. \tag{19}$$

The third term in (19) is the value of governmental expenditures for military purposes after its reduction, the second term is the value of released fund and the first term is the "old" value of governmental expenditures for civil purposes. Both first and second terms in (19) give us the current value of governmental expenditures for civil purposes.

In accordance with our previous notations the value of released fund is:

$$\Delta M = \alpha \cdot GDP \equiv \theta \cdot \nu \cdot GDP \tag{20}$$

In order to utilize released fund due to its redirection for civil purposes we need to take into account balance equation (15). For the sake of simplicity we decided to suppose that private final consumption expenditures (priv) for the whole period under simulation will be constant share of GDP. Therefore we can use released fund for increasing gross fixed capital formation and for improvement of the trade balance.

6.2. Versions for utilization of released fund

We have at least three versions of the released fund utilization:

Version A: (total released fund is used for domestic investment)

In this version balance equation (15) taking into account (17) and (20) can be written as follows:

$$GDP = (1-\Theta) \cdot \nu\, GDP + priv + (cap + \Theta \cdot \nu \cdot GDP) + bal \qquad (21)$$

Actually (21) means that

$$GDP = [gov - \Delta M] + priv + [cap + \Delta M] + bal \qquad (22)$$

In other words such a redirection of a part of military expenditures for civil purposes provides for meeting national income balance.

Version B: (total released fund is used for trade balance improvement)

For this version balance equation (15) taking into account (19) and (20) can be rewritten as follows:

$$GDP = (1 - \Theta) \cdot \nu \cdot GDP + priv + cap + (bal + \Theta \cdot \nu\, GDP) \qquad (23)$$

or

$$GDP = [gov - \Delta M] + priv + cap + [bal + \Delta M] \qquad (24)$$

Version C: (total released fund is used both for increasing domestic investment and trade balance improvement)

For this version we have:

$$GDP = (1-\Theta) \cdot \nu GDP + priv + (cap + \beta \cdot \Theta \cdot \nu \cdot GDP) + [bal + (1-\beta) \cdot \Theta \cdot \nu \cdot GDP] \qquad (25)$$

or in other notation

$$GDP = [gov - \Delta M] + priv + [cap + \beta \cdot \Delta M] + [bal + (1 - \beta) \cdot \Delta M] \qquad (26)$$

The last equation means that total released fund ΔV. is divided in two parts with ratio $\frac{\beta}{1-\beta}$ and used both for domestic investment and trade balance improvement.

It should be noted that utilization of released fund in accordance with Version A means actually that in each model in equation for calculation of value of capital stocks one additional term ($\Delta M_t(t)$) is added:

$$K(t) = K(t-1) \cdot (1 - d(t-1)) + I(t) + \Delta M(t) \tag{27}$$

where

K (t) is capital stocks in year t,

d (t-1) is depreciation rate,

I (t) is investment.

In Version C apart from (27) the equation for trade balance calculation has to be substituted by:

$$bal'(t) = bal(t) + \Delta M(t) \tag{28}$$

6.3. Implementation of MARS 1

1. In order to implement MARS1 runs within the BLS at first corresponding adjustments of country models have to be made. These are related to those mentioned in section 5 and in section 6.2 (equations (27) and (28)).

2. Subroutines for exogenous calculating values of $\alpha(t)$ in accordance to (10), (11) and (12) have to be programmed.

3. Main steps for MARS1 implementation are:

    1. Equilibrium for one year is calculated, and all indicators are generated.

    2. Values of $\alpha(t)$ are calculated

    3. Values of $K_j(t)$ for country groupings are calculated

    4. Values of $\Delta M_j(t)$ are calculated

    5. Released fund $\Delta M_j(t)$ is allocated in accordance to one of the versions (A, B, or C) of this fund utilization in MARS1

6. Step 1 for next year is repeated

7. MARS 2

7.1. Background

General idea of the MARS 2 is to use some share of each country's (LDC and DC) released fund for domestic purposes as it was described in section 6 for MARS 1 and the rest of these resources are used for creating AID (Aid International Donation) which has to be distributed among "poor" LDC's.

Definition: "Poor" LDC's are those with annual GDP per capita less than US $ 1000.

Let us denote

$$\Delta M_j^{AID}(t) = \xi \cdot \Delta M_j(t) \tag{29}$$

share of each country's released fund used for domestic purposes, where ξ, $0 < \xi < 1$ is exogenously given coefficient. The total aid fund (AID) created by all countries for allocation among "poor" LDC's is defined as follows:

$$AID(t) = (1 - \xi) \cdot \sum_{j=1}^{m} \Delta M_j(t) \tag{30}$$

where m is the number of all countries.

Let us define

$$\delta M_j(t) = \gamma_j(t) \cdot AID(t) \qquad ,j = 1, 2, ...m_{p,}\ m_p < m \tag{31}$$

share of j-th "poor" LDC in total AID(t) with

$$\sum_{j=1}^{m_p} \gamma_j(t) = 1 \qquad ,0 \leq \gamma_j(t) < 1 \tag{32}$$

We postpone explanation how $\gamma_j(t)$ is determined till subsection 7.2. Now let us discuss how the balance of national income of each country will be met.

For all countries with GDP per capita higher than U.S. $ 1000 share of their released fund available for domestic purposes is calculated as in (29). And now in order to meet balance of national income for three versions of utilization of $\Delta M_j^{AID}(t)$ the value of $\Delta M_j(t)$ in corresponding balance equations (22), (24) and (26) has to be substituted by $\Delta M_j^{AID}(t)$. It is also true for equations (27) and (28). After such a substitution we have for all $j \in \{1, 2, \ldots, m\} \setminus \{1, 2, \ldots, m_p\}$

for version A:

$$GDP = (gov - \Delta M^{AID}) + priv + (cap + \Delta M^{AID}) + bal\ ; \qquad (33)$$

for version B:

$$GDP = (gov - \Delta M^{AID}) + priv + cap + (bal + \Delta M^{AID})\ ; \qquad (34)$$

and for version C

$$GDP = (gov - \Delta M^{AID}) + priv + (cap + \beta \cdot \Delta M^{AID}) + (bal + (1 - \beta)\Delta M^{AID}), \qquad (35)$$

as well as

$$K_t = K_{t-1} \cdot (1 - d_{t-1}) + I_t + \Delta M_t^{AID} \qquad (36)$$

and

$$bal'(t) = bal(t) + \Delta M^{AID}(t) \qquad (37)$$

What is concerning to all "poor" countries ($j = 1, 2, \ldots, m_p$), $m_p < m$ corresponding balance equations for three versions of allocating their own released fund $\Delta M_j^{AID}(t)$ and their share of $\delta M_j(t)$ in AID(t) will be written as follows (indexes are omitted):

for version A:

$$GDP + \delta M = (gov - \Delta M^{AID}) + priv + (cap + \Delta M^{AID} + \delta M) + bal\ ; \qquad (38)$$

for version B:

$$GDP + \delta M = (gov - \Delta M^{AID}) + priv + cap + (bal + \Delta M^{AID} + \delta M)\ ; \qquad (39)$$

for version C:

$$GDP + \delta M = (gov - \Delta M^{AID}) + priv + [cap + \beta(\Delta M^{AID} + \delta M)] + [bal + (1 - \beta)(\Delta M^{AID} + \delta M)] \qquad (40)$$

For these countries equations (36) and (37) have to be rewritten as follows:

$$K(t) = K(t-1) \cdot (1 - d(t-1)) + I(t) + (\Delta M^{AID}(t) + \delta M(t))$$

and

$$bal'(t) = bal(t) + (\Delta M^{AID}(t) + \delta M(t))$$

7.2. Distribution of the AID among "poor" LDC's

In this section the problem of calculating the share $\delta M_j(t)$ of "poor" countries in AID(t) is discussed (see equation (31)). Two definitions of $\gamma_j(t)$ $j = 1, 2, \ldots, m_p$ are suggested: first when $\gamma_j(t)$ is determined without taking into account the bounds on the capital absorption capacity of "poor" LDC's in the BLS and second when $\gamma_j(t)$ is determined with taking into account such bounds.

7.2.1. Case of unlimited capital absorption capacity of LDC

In this case $\gamma_j^u(t)$ is suggested to be determined as the weighted mean for all "poor" countries value inversely proportional to GDP per capita of j-th country:

$$\gamma_j^u(t) = \frac{1}{GDP_j^c(t)} \cdot \frac{1}{\sum_j \frac{1}{GDP_j^c(t)}} \quad , \forall_j = 1, 2, \ldots m_p \tag{41}$$

where

$$GDP_j^c(t) = \frac{GDP_j(t)}{pop_j(t)}$$

In other words AID(t) will be distributed among "poor" LDC's according to weighted mean value proportional to population of j-th country and inversely proportional to its GDP:

$$\gamma_j^u = \frac{pop_j(t)}{GDP_j(t)} \cdot \frac{1}{\sum_j \frac{pop_j(t)}{GDP_j^c(t)}} \quad , \forall_j = 1, 2, \ldots m_p \tag{42}$$

7.2.2. Case of limited capital absorption capacity of LDC

Using (41) for calculation of value $\delta M_j(t)$ we can get such value of $\delta M_j(t)$ for poorest countries (with GDP << U.S. $ 1000) which can essentially exceed their capital absorptive capacity. In order to take into account upper bounds for such capacities of LDC's the other formula for calculating value of $\gamma_j(t) \equiv \gamma_j^1(t)$ is suggested:

$$\gamma_j^1(t) = \frac{cap_j(t)}{GDP_j^c(t)} \cdot \frac{1}{\sum_j \frac{cap_j(t)}{GDP_j^c(t)}} \quad , \forall j = 1, 2, \ldots, m_p \tag{43}$$

where

$cap_j(t)$ is the value of gross fixed capital formation of j-th country and $GDP_j^c(t)$ is its GDP per capita. Equation (43) can be written as follows:

$$\gamma_j^1(t) = \frac{cap_j(t) \cdot pop_j(t)}{GDP_j(t)} \cdot \frac{1}{\sum_j \frac{cap_j(t) \cdot pop_j(t)}{GDP_j(t)}} \quad , \forall j = 1, 2, \ldots, m_p \tag{44}$$

In other words in this case AID(t) will be distributed among "poor" countries according to weighted mean value proportional to product of j-th country's population and value of gross fixed capital formation and inversely proportional to its GDP.

Note:

It should be noted that upper bounds for capital absorption capacity of LDC's would be changed during the simulation period. Dr. J. Hrabovszky suggested in the FAP internal memo to fix values of these bounds for 1980 and 2000. We can use this information also and calculate:

$$cap_j(t) = cap_j(0) \cdot (1 + \beta_j(t)) , \tag{45}$$

where

$$\beta_j(t) = \beta_j(0) + \frac{\beta_j(T) - \beta_j(0)}{T} \cdot t , \tag{46}$$

where $\beta_j(O)$ and $\beta_j(T)$ are correspondingly upper bounds for 1980 and 2000 and T = 20.

7.3. Illustrative calculation of values γ_j^u and $\gamma_j^l(t)$ for 1980

For all countries in the BLS with value of annual $GDP_j^c(t)$ < U.S. \$ 1000 for 1980 calculations of $\gamma_j^u(t)$ and $\gamma_j^l(t)$ as well as $\delta M_j^u(t)$ and $\delta M_j^l(t)$ were made for illustrative purposes. The list of these countries includes: Egypt, Indonesia, Nigeria, Pakistan, Kenya, Thailand, China, India and 10 country groupings. Values of GDP, pop, cap, GDP^c for 1980 for all 18 countries were taken from Yearbooks of National Accounts Statistics. Upper bounds on the capital absorption capacity of these countries were accepted for 1980 as these were determined by Dr. J. Hrabovszky. Values of $\gamma_j^u(t)$ and $\gamma_j^l(t)$ were calculated using equations (41) and (43) correspondingly, values of $\Delta M_j^{AID}(t)$ and $\delta M_j^u(t)$ and $\delta M_j^l(t)$ were calculated in accordance with (29) and (31). Results of illustrative calculations are summarized in Table 5. For these calculations the value of $\xi = 0.9$ and $\alpha(t) = \alpha_0 = 0.02$. The value of AID (1980) was taken as $0.1 \cdot GDP^{world}(1980) = 25660 \cdot 10^6$ U.S.\$ 1975. Columns 14 and 19 represent results of by what extent upper bounds for capital absorption capacity of a country would be exceeded (values with sign (+)) or not (values with sign (-)). When comparing values in these columns we can say that the second approach for calculation of $\gamma_j^l(t)$ is the most appropriate one, because exceeding upper bounds is observed in 6 cases with very low value of it.

7.4. Implementation of MARS 2

1. As in the case of MARS 1, implementation runs of MARS 2 within the BLS require adjustments of country models, mentioned in section 5 and 7.1 (equations (36), (37) and (29) for DC's).

2. Subroutines for exogenous calculating values of $\alpha(t)$ in accordance with (10), (11) and (12) have to be programmed.

3. Subroutines for endogenous annual calculating values of $\gamma_j^u(t)$ and $\gamma_j^l(t)$ $\delta M_j^u(t)$ and $\delta M_j^l(t)$ for "poor" countries should be prepared in accordance to (41), (43), (30) and (31).

4. Steps for MARS 2 implementation are:

    1. Equilibrium for 1 year is calculated and all indicators are generated
    2. Values of $\alpha(t)$ are generated and value of ξ is fixed
    3. Values of $K_j(t)$ for country groupings are calculated
    4. Values of $\Delta M_j^{AID}(t)$ are calculated
    5. AID(t) is created
    6. Values of $\gamma_j^u(t)$ (or $\gamma_j^L(t)$) are calculated
    7. Values of $\delta M_j^u(t)$ (or $\delta M^L(t)$) are calculated
    8. Released funds $\Delta M_j^{AID}(t)$ (for DC's) and $[\Delta M_j^{AID}(t) + \delta M_j(t))$] (for "poor" LDC's) are allocated in accordance with one of the versions (A, B, or C)
    9. Step 1 is repeated and all indicators are generated. $GDP_j^c(t)$ for "poor" LDC are compared with U.S. $ 1000 and $\gamma_j^u(t)$ (or $\gamma_j^L(t)$) are adjusted.
    10. Step 2

8. Conclusion

First efforts to develop more or less reasonable versions of the MARS for the FAP's study "Hunger, growth and equity" were described in this paper. During this stage a number of assumptions simplifying and even over-simplifying the real problem were accepted. However, from our point of view the variants of the MARS elaborated in the paper are quite appropriate ones for the simulation purposes for the BLS. There is no doubt that the analysis of simulation resuls will give opportunity for further improvement of both variants.

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Table 5. Two cases of distributing AID

No.	Country code	Country	GDP 10^6 US $	POP mill.	GDP^c US $	CAP 10^6 US $	$(\frac{CAP}{GDP})$ actual	$(\frac{CAP}{GDP})$ upper bounds	ΔM^{AID}
	1	2	3	4	5	6	7	8	9
1	59	Egypt	17821 (1979)	40.98	435	4812	0.27	0.38	321
2	101	Indonesia	69802	148.47	472	15356	0.22	0.28	1256
3	159	Nigeria	50170 (1977)	74.6	717	14549	0.29	0.32	903
4	165	Pakistan	27961	79.84	339	4474	0.16	0.2	503
5	114	Kenya	6992	15.32	426	1468	0.21	0.25	126
6	216	Thailand	33450	46.46	709	8697	0.26	0.3	602
7	901	Oil exporters	25310	27.76	912	10023	0.396	0.4	456
8	902	med. income/ food exports	20391	42.148	484	3670	0.18	0.3	367
9	903	med. income/ food imports	18571	35.8	518	4364	0.235	0.3	334
10	904	low income/ food exports	16742	87.64	191	2444	0.146	0.25	301
11	905	low income/ food imports	13603	101.962	133	2721	0.2	0.25	245
12	908	med. income	34785	60.74	573	6261	0.18	0.3	626
13	909	High-med.income/ food exports	34507	64.636	533	8765	0.254	0.3	621
14	910	High-med.income/ food imports	48605	119.352	407	12151	0.25	0.3	875
15	911	Low income	21058	153.121	137	3790	0.18	0.25	379
16	913	Med.-low income	5732	32.159	178	1720	0.3	0.3	103
17	41	China	264848	982.55	272	52970	0.20	0.3	4767
18	100	India	159831	663.6	241	30368	0.19	0.25	2877

Table 5. Two cases of distributing AID

Case of unlimited absorption capacity					Case of limited capital absorption capacities				
γ^u	δM^u	$\Delta M^{AID}+\delta M^u$	$\frac{\Delta M^{AID}+\delta M^u}{GDP}$	(13+7)-8	γ^l	δM^l	$\Delta M^{AID}+\delta M^l$	$\frac{17}{3}$	(7+18)-8
10	11	12	13	14	15	16	17	18	19
0.040	1066	1387	0.08	-0.03	0.019	507	828	0.046	-0.064
0.037	987	2243	0.03	-0.03	0.057	1520	2776	0.04	-0.02
0.024	640	1543	0.03	0	0.036	960	1863	0.037	0.007
0.052	1387	1890	0.07	0.03	0.023	613	1116	0.04	0
0.041	1093	1119	0.16	0.17	0.006	160	286	0.04	0
0.025	667	1269	0.038	-0.002	0.022	587	1189	0.035	-0.005
0.019	507	963	0.038	0.034	0.019	507	963	0.038	0.034
0.036	960	1327	0.065	-0.055	0.013	347	714	0.035	-0.085
0.034	907	1241	0.07	0.005	0.015	400	1307	0.07	0.005
0.092	2453	2754	0.16	0.056	0.022	587	888	0.05	-0.054
0.132	3520	3765	0.27	0.22	0.036	960	1205	0.088	0.038
0.03	800	1426	0.041	-0.079	0.019	507	1133	0.033	-0.087
0.033	880	1501	0.043	-0.003	0.029	773	1394	0.04	-0.006
0.043	1147	2022	0.041	-0.009	0.052	1387	2262	0.046	-0.004
0.128	3413	3792	0.18	0.11	0.049	1307	1686	0.08	0.01
0.098	2613	2716	0.47	0.47	0.017	453	556	0.097	0.097
0.064	1707	6474	0.02	-0.08	0.34	9067	13834	0.05	-0.05
0.073	1947	4824	0.03	-0.03	0.22	5867	8744	0.055	-0.005