

MODELS OF REGIONAL PROGRAMMING TECHNIQUES FOR PLANNING AGRICULTURAL PRODUCTION

by

Dr. FAHMI K. BISHAY*

*Assistant Prof., Faculty of Agriculture,
Cairo University.*

INTRODUCTION

Since Agricultural sector is made up of many regional or spatial components and since its production is composed of many commodities then refined planning to consider the interdependence of these many components is only possible through programming models. Programming models, therefore, have great advantage over other techniques because it makes it possible to investigate changing the mix of products produced, the regional proportions of commodities, the proportions of resources used, and other structural relationships. Moreover, programming techniques are the most appropriate tools to investigate the change in the ratio of capital and labor to land and to analyze the diminishing productivity of capital such as fertilizer and irrigation. Thus, mathematical programming models provide a promising potential for planning the economic development of agriculture. Even in the simple linear forms, these models can allow great improvement of planning activities than other methods.

Data problems in applying programming models represent usual problems in this respect. However, the data applied in many countries in their agricultural planning can be used with slight extensions and modifications. In countries where formal planning is taking place, developing and specifying the agricultural models could be of great aid in organizing data collection in the future.

Varying degrees of refinement in programming models can be developed according to specific needs. Models can be so simple such that linear forms and simple routines are used. Other models can be highly refined. Refined models might incorporate demand functions and generate, with a normative framework on the supply side-equilibrium prices, quantities for the economy, and optimal production patterns by regions and

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farms within regions. But, this high degree of refinement is scarcely needed in developing nations. In these countries, however, an objective function with constant weights, and demands represented by a fixed bill of goods from the agricultural sector, is usually sufficient.

Refinement of programming models, as tools in the process of economic planning, can be also achieved though parameterisation of the restraints, of the weights of the objective function, and of the input-output coefficients. Parameterisation, therefore, can help in building up flexible plans, and also help in testing different plan assumptions.

Under decomposition computer routines, available nowadays, linear models can incorporate several thousand equations, and the constraint in application of programming is becoming much more one of data than computing capacity.

This study investigates the potentiality of developing models of regional programming techniques for planning agricultural production. Moreover it mainly investigates the inter-regional production patterns, optimum land use to meet specified demand quantities for the various products, and how to design programming models for planning agricultural production. To visualize these concepts several simple models developed in India, U.S.A. and U.A.R. are presented. However, it should be emphasized that the methodological aspects in building up models of regional programming for planning agricultural production are the salient features of this study.

MODELS BASED ON SAMPLES OF FARMS REPRESENTING REGIONS

Theoretically, each single farm in a nation could be analysed in a single programming model. Programming models for a farm can specify optimum commodity and resource mixes under different demand conditions or assumptions, it can also estimate normative commodity supply and resource demand functions. But, data and computational limitations prevent application of models incorporating this degree of details. Thus, a sample of farms for a region can be drawn. Then programming models can be used to estimate normative supply functions or resource de-

mand relationships for individual farms, and these findings can be weighted into regional cooperatives.

Sampling techniques are used, in this respect, so that the sample of farms selected, in this approach, should be highly representative of the agricultural sector. Several sampling methods can be used according to the circumstances of every situation. However, a famous sampling technique in this respect can be presented as follows:

(a) The agricultural sector can be divided into a number of regions which are supposed to be as homogeneous as possible.

(b) Each region is divided into a number of stratas, such that each strata should be as homogeneous as possible with respect to resource restraints, as land, capital, and type of farming or tenure system.

(c) A single representative farm is randomly selected from each strata.

Programming models can then be developed and investigated for this sample of farms, and then can be aggregated to visualize the regional levels.

Normative supply functions, however, can be estimated for every farm and then aggregated into the regional levels. These functions are useful for policy makers in planning agricultural production especially in the developing nations. Moreover, normative supply functions are of great help in two main spheres : (A) investigating the potential role of the agricultural prices as a tool of economic planning, since they show, the farmers agricultural production response to changes in prices. (B) giving the agricultural planners an idea about the supply of the agricultural production.

The programming models based on farms representing regions to find the normative supply functions can be summarized as follows :

Notations used in the model :

$F(R)$: The regional normative supply function

$F(r_i)$: Normative supply function of sample farm in the i th strata.

- n : Number of farms in the *i* th strata
- s : Number of strata in the region (1,..., i,..., s)
- m : Number of crops subject to the study (1,..., j,..., m)
- c : Number of constraints on the sample farm level.
(1,..., l,..., c)
- b_{il} : Level of the *l* th constraint on the sample farm level
in the *i* th strata.
- R_j : Regional *j* th product supply
- a_{ilj} : The amount of the *l* th input required to produce
the *j* th activity on the *i* th representative farm.
- P_j : Net price unit of *j* th product.
- x_{ij} : amount of the *j* th product produced by the individual
representative farm of the *i* th strata.
- E_l : The amount of the *l* th land type exchanged.

The Model :

1 — The regional normative supply function can be stated as :

$$F(R) = \sum_{i=1}^r n_i f_i(r) \dots\dots\dots (1)$$

However, for each farm in the sample a programming model is developed. In these models each producing unit (farm) will have restraints to represent land of various types buildings for different kinds of livestock, labor supply, capital available,... etc. Thus, the *i* th farm strata has (c) constraints various objective functions might be used however, the objective function used in this model is one of maximizing agricultural return as follow:

$$\text{Max : } Z(X) = \sum_{i=1}^S \sum_{j=1}^M p_j n_i x_{ij} \dots\dots\dots (2)$$

Subject to the following constraints :

$$\sum_{j=1}^m a_{ilj} x_{ij} \leq b_{il} \dots\dots\dots (3)$$

$$\sum_{j=1}^m a_{ilj} x_{lj} \leq b_{il} \dots\dots\dots (3')$$

$$\sum_{j=1}^M a_{icj} x_{ij} \leq b_{ic} \dots\dots\dots (3)''$$

$$E_i = \sum_{l=1}^S \sum_{j=m+1}^{m+2} a_{ijl} n_l x_{ij} \dots\dots\dots (4)$$

(g= 1,....., T)

Also there are (m) equations to allow direct summation of the aggregative output of the j th product in the s region.

$$R_j = \sum_{i=1}^S n_i x_{ij} \dots\dots\dots (5)$$

As far as equation (4) is concerned, it investigates the possibilities of exchanging land between farms. That is, with T types of land which can be exchanged among farms, there is an exchange equation (4) for the g th soil type where: a i j l is (—1) for j = n+1 to denote land purchase, and is (+1) for j = n + 2 to denote land sale by the i th representative farm.

And for the positiveness criterion :

$$X_{ij} \geq 0 , (i = 1, \dots, s) \text{ and } \dots\dots\dots (6)$$

(j = 1, \dots, m)

Solving this model to determine the values of x_{ij} which are optimum and feasible gives an optimal solution.

However, when a set of optimal solutions are solved corresponding to different values for (P j), then normative supply functions can be achieved.

This model can be used to program normative supply responses, factor (s) demand, farming structure, income and costs. The model can be mainly applied when the regions are small and / or soil types are homogeneous.

MODELS WITH REGIONS AS THE PRODUCING UNITS

Interregional models for agriculture

Interregional models for agriculture can, usually, serve effectively for investigating certain broad policies, economic planning, and developmental problems of agriculture. However, the extent to which these models are realistic and useful for particular

policy purposes, mainly depends on the allowed degree of disaggregation. The extent to which soils of different types and qualities, and the inputs used can be aggregated into particular geographic regions, presents a major problem in the specification of farming regions required to set up interregional models. However, land classification into regions can be achieved through factors like soil types, locations, patterns of production, productivities and other relevant criteria. Furthermore, it should be also emphasized that both groups of criteria a) physical criteria represented by the physical production functions, and b) economic criteria represented by price functions for factors and commodities, are the most important basis for the specification of farming regions.

Interregional models for agriculture, generally speaking, treat the region as the producing units and usually, optimize objective functions on the national level.

Interregional models for agriculture, can be of vital importance in the economies which follow some process of economic planning. The use of such models in these countries, give an overall look on the structural relationships and the magnitude of the instrumental parameters that exist in these economies. Hence, agricultural macro-economic planning and recommendations can be established. Moreover, serious problems like the optimum transportation problems, the satisfaction of the nations domestic and foreign demands, and setting up the optimal agricultural price policies, can be tackled through these models. That is, economic signals (e.g. shadow prices) can be drawn from the global level to be imposed when programming on regional and sub-regional levels are formulated.

To be able to investigate the dimensions of the interregional models for agriculture, some empirical studies are presented. These empirical studies are : a) a model for India; b) a model for the United States of America, and c) a model for the United Arab Republic. These models, however, are not presented in full details due to space limitations. The methodology, the design, and the analyses drawn from these models are the most interesting points of investigation.

SOME EMPIRICAL STUDIES

1 — *A Model For India :*

A summary of a relatively simple model for interregional planning of agriculture in India is presented in this study. This simple model, however, is of some interest, since it suggests an increase of about 12.5% (17) in food supply from the application of a formal model which considers interrelationships among regions as well as relative production possibilities within regions.

In this model, however, boundary conditions are incorporated into the model to hold changes which could be absorbed by various producing regions, and to provide a welfare economics criterion wherein total gain could be realized but with no individual region of cultivators sacrificing in income. These two criteria — in setting up boundary conditions — guarantee conservative plans, as well as the achievement of a certain degree of social justice. However, the author believes that the second criterion can be released, if necessary, and government subsidies can solve this problem.

This model for India intends to answer the following question : how much can agricultural efficiency be improved by use of more systematic planning models considering the specific comparative advantages of particular regions and without implying alternative technologies or new investments ? Moreover, the model specifies upper bounds on the extent of interregional reallocation of production to avoid extreme adjustments.

The Model :

The model for India can be summarized in the following sets of equations :

- (A) The objective function is one of maximizing the agricultural income in crop production as :

$$\text{Maximize : } Z = \sum_{i=1}^u \sum_{j=1}^p C_{ij} X_{ij} \dots\dots\dots (7)$$

(B) The set of constraints can be divided into four groups as follows :

(i) Boundary conditions restrictions as :

$$X_{ij} \geq A_{ij} \text{ (Minimum) } \dots\dots\dots (8)$$

$$X_{ij} \leq A_{ij} \text{ (Maximum) } \dots\dots\dots (9)$$

(ii) Ordinary physical restrictions as :

$$\sum_{j=1}^P X_{ij} = A_i \dots\dots\dots (10)$$

For every *i* *th* region, where slack variables are considered in equation (10)

(iii) A set of restrictions are specified

Such that a minimum level of a set of strategic agricultural products and a minum level of the income in every farming region can be achieved as follows :

$$\sum_{j=1}^P C_{ij} X_{ij} \geq I_i \dots\dots\dots (11)$$

$$\sum_{i=1}^U \sum_{j=1}^8 Y_{ij(f)} X_{ij(f)} \geq F \dots\dots\dots (12)$$

$$\sum_{i=1}^U Y_{ij(s)} X_{ij(s)} \geq S \dots\dots\dots (13)$$

$$\sum_{i=1}^U Y_{ij(c)} X_{ij(c)} \geq C \dots\dots\dots (14)$$

$$\sum_{i=1}^U Y_{ij(g)} X_{ij(g)} \geq G \dots\dots\dots (15)$$

$$\sum_{i=1}^U \sum_{j=12}^{16} Y_{ij(o)} X_{ij(o)} \geq O \dots\dots\dots (16)$$

(iv) A positivity set of restrictions as

$$X_{ij} \geq 0 \dots\dots\dots (17)$$

Where the symbols used in this model are

U = 17 regions,

P = 16 crops,

X_{ij} = is the level of the j *th* activity in the i *th* region (an activity unit is taken as one acre of a crop).

C_{ij} = the income per acre from the j *th* crop in the i *th* region

A_i = the available cropped area for all crops in the i *th* region

A_{ij} = (minimum) and A_{ij} (maximum) respectively are the minimum and maximum level of acreages for the j *th* crop in the i *th* region.

Y_{ij} = the yield per acre of the j *th* crop in the i *th* region.

I_i = the minimum income level for the i *th* region.

F,S,C,G, and O are the minimum quantities of food grains, sugar cane, cotton, jute, and oil seeds specified at the national level.

Before analyzing this model, it is of great interest to present the dual solution. This is due to the fact that most of the economic policy instruments used in policy decision making are derived from the dual solution.

The dual solution of the model for India is :

Minimize :

$$\begin{aligned} & \sum_{i=1}^U V_i A_i - \sum_{i=1}^U \sum_{j=1}^P V_{ij} A_{ij} (\text{min}) + \sum_{i=1}^U \sum_{j=1}^P V_{ij} A_{ij} (\text{max}) \\ & - \sum_{i=1}^U d_i I_i - P_s S - P_f F - P_c C - P_g G - P_o O \dots (18) \end{aligned}$$

Subject to :

$$\begin{aligned} & V_i - V_{ij} (\text{min}) + V_{ij} (\text{max}) - d_i C_{ij} \\ & - P_f Y_{ij(f)} - P_s Y_{ij(s)} - P_c Y_{ij(c)} \\ & - P_g Y_{ij(g)} - P_o Y_{ij(o)} \geq C_{ij} \dots \dots \dots (19) \end{aligned}$$

And :

$$V_i, V_{ij} (\text{min.}), V_{ij} (\text{max}), d_i, P_f, P_s, P_g, P_c, \text{ and } P_o \geq 0$$

Where, (20)

V_i = the general gross rent per acre of land in the i *th* region.

- V_{ij} (min.) = the specific rent for the j *th* crop in the i *th* region if the minimum acreage level of this crop is binding.
- V_{ij} (max.) = the specific rent for j *th* crop in the i *th* region when the upper limit restriction for this crop is binding.
- d_i = the proportion by which income per acre for a crop in the i *th* region should be raised to meet the minimum income requirement of the region.
- $P_f, P_s, P_e, P_g,$ and P_o : are the subsidy prices for food grains, sugar cane, cotton, jute, and oil seeds respectively.

Programming results of the model for India

A : Planning by prices in Agriculture :

The minimum income levels specified in this model may be attained through programs of subsidies. $P_f, P_s, P_e, P_g,$ and P_o are the subsidy prices for food grains, sugar cane, cotton, jute, and oil seeds respectively which must be added to the respective regional prices to induce regions to produce the commodities at their minimum income levels. The magnitudes of these parameters will be greater than zero, only if the relevant constraints are binding. In case these values exceed zero, existing price relations among commodities are not consistent with the composition of the optimal agricultural production pattern suggested in this model. However, in this Indian model, regional income restrictions, and national availability, constraints are not binding in the solution. Thus $d_i, P_f, P_s, P_e, P_g,$ and P_o are all zeros and indicate that the programming results make each region better off in income.

B : Policies of crop reallocation on the national level :

Solutions of this Indian model provide many interesting details of potential crop reallocation among and within regions. However, due to space limitation, only a summary of results at the national level is presented.

Tables «1» «2» and «3» summarize — at the national level based on the regional patterns — the acreage, percentage distribution, production of different commodity groups, and income from these crop groups for all regions. Moreover, components of these tables represent the situation during the base year and under changes of allocation allowed by parametric programming of the model.

Table (1) *Distribution of acreages among different groups of crops for all regions in million acres. (Actual and programmed)*

Commodity group	Under Original		Under Programmed Solutions					
	Distribution		± 10% change		± 20% change		± 40% change	
	Area	Dist. (a)	Area	Dist.	Area	Dist.	Area	Dist.
Food Grains	229.8	79.8	227.4	79.0	225.5	78.3	221.1	76.8
Sugar Cane	5.2	1.8	5.7	2.0	5.7	2.0	6.2	2.2
Cotton	19.5	6.8	20.6	7.2	21.7	7.6	24.0	8.3
Jute	1.7	0.6	1.9	0.7	2.1	0.7	2.4	0.8
Oil Seeds	31.7	11.0	32.3	11.2	33.0	11.5	34.2	11.9

(a) Percentage Distribution.

Source : Reference (17).

Table (1) above shows the crop reallocation by areas and it indicates that only food grains decreases in area.

Increases in production and income suggested under the various solutions of the model are presented in tables (2) and (3) as follows :

Table (2) : *Production of different commodity groups for all regions (in million maunds*)*

Commodity group	Under Original Allocation	Under Programmed Solutions					
		\pm 10% Change	\pm 20% Change	\pm 40% Change	\pm 10% Change	\pm 20% Change	\pm 40% Change
		(a) Q.	(b) Inc.	Q.	Inc.	Q.	Inc.
Food Grains	1,876.7	1,903.5	1.4	1,934.1	3.1	1,991.4	6.1
Sugar Cane	210.1	231.1	10.0	231.1	10.0	252.1	20.0
Cotton	79.2	84.1	6.2	89.1	12.5	98.9	25.0
Jute	21.9	24.1	10.0	26.3	20.0	30.6	40.0
Oil Seeds	164.9	173.1	4.9	181.4	10.0	197.8	19.9

a) Quantity

b) Percentage increase over original production.

Source : Reference (17).

* Maunds = 82,286 pounds.

Table (3) : *Income from different commodity groups for all regions. (in million rupees*)*

Commodity group	Under Original Allocation	Under Programmed Solutions					
		\pm 10% Change	\pm 20% Change	\pm 40% Change	\pm 10% Change	\pm 20% Change	\pm 40% Change
		(a) Income	Inc.	Income	Inc.	Income	Inc.
Food Grains	28,877.4	29,517.0	2.2	30,207.1	4.6	31,535.4	9.2
Sugar Cane	3,402.7	3,742.9	10.0	3,742.9	10.0	4,083.1	20.0
Cotton	2,652.7	2,821.7	6.4	2,991.7	12.8	3,330.8	25.6
Jute	531.7	584.9	10.0	638.1	20.0	744.4	40.0
Oil Seeds	3,202.1	3,351.5	4.7	3,503.8	9.4	3,805.1	18.8
TOTAL	38,666.6	40,018.0	3.5	41,083.6	6.3	43,498.8	12.5

a) Percentage increase over original income of existing pattern.

Source : Reference (17).

* Rupee = \$ 0.21

It is obvious, that the magnitude of improvement observed in this model varies with the level of percentage change allowed by crop and region. When change is restricted to only 10 percent of the original base period, then the total increase in value of crop production specified for the nation is 3.5 percent. However, when change of 40 percent is allowed, the increase in the agricultural income rises to 12.5 percent. Thus, it can be observed that gains in the Indian agricultural national income is expected to come from the collection of resources already in agriculture and does not imply large capital outlays. For instance, it is observed that the programming solution for food grains specifies a decrease in total acreage (table 1), but, because their production is more efficiently allocated, both production and income from grains rise (table 2 and 3).

2 — A Model For U.S.A. :

As another example of interregional programming models applied to agriculture we present a relatively simple model for the U.S.A. The main interest in this presentation is to investigate the methodology, the design of the model and the specification of the variables and parameters.

The main purposes of this model are to determine :

- a) which field crops should be produced in a 144 agricultural regions specified in the American agriculture,
- b) the total acreage required to produce the nation's food and fiber requirements.
- c) the amount of land which should be shifted from crop production if the nation were to cease accumulation of surplus stocks, and,
- d) the location of this land.

Thus, it can be stated that the model has the common objective of determining the optimal pattern of agricultural production and product shipments that satisfies all of the regional demands at the least possible cost.

Crops studied in this model are wheat, corn, oats, barley, grain sorghum, soybeans, and cotton. The model includes a set of 144 production or programming regions. It also includes 31

spatially separated consuming or demand regions for the three final demand categories namely; wheat, feed grains, and oil meals. Consuming regions follow state boundaries and are either composed of one state or several states. Regions, however, were selected as homogeneous as possible according to the following set of criteria :

- a) those having relatively the same level of technology,
- b) similar patterns of production,
- c) similar yields, and
- d) similar soil (to some extent).

A possibility of five production activities exists for each producing region, as : wheat, feed grain rotation, feed grain-soybean rotation, soybeans, and cotton. The model contains 31 wheat to feed-grain transfer activities, one for each consuming region. These activities allow for the use of wheat as livestock feed if it is the cheapest source of the livestock nutrients. Transportation activities for each of the three demand categories allow for the movement of grains between consuming regions.

A demand restraint is specified in all 30 consuming regions for wheat, feed grains, and oil meals. In addition, the nation's total demand for cotton lint is specified. Moreover, land restrictions in all 144 regions are defined.

The Model :

The objective function of this interregional model can be stated as :

$$\begin{aligned} \text{Minimize : } F(e) = & \sum_{i=1}^{144} \sum_{k=1}^5 C_{ki} X_{ki} + \sum_{m=1}^{31} d_m Y_m + \\ & + \sum_{l=1}^3 \sum_{m=1}^{31} b_{lm} Z_{lm} \dots\dots\dots (21) \end{aligned}$$

where :

C_{ki} = cost of production per acre of the k *th* activity in the i *th* programming region.

- X_{ki} = Level of production of the K *th* activity in the i *th* programming region.
- d_m = cost per unit of transferring wheat into feed grains in the m *th* consuming region.
- Y_m = Quantity of wheat transferred into feed grains in the m *th* consuming region.
- b_m = cost of transporting a unit of the l *th* product from (or to) the m *th* consuming to (or from) the m *th* consuming region.
- Z_{lm} = Quantity of the l *th* product transported from (to) the m *th* consuming region to (from) the m *th* consuming region.

Equation (21) is minimized subject to :

$$l_{1m'} = \sum_{i=1}^r a_{1i} X_{1i} - h_m Y_m \pm \sum_{m'=1}^5 t_{1m} Z_{1m'} \dots\dots (22)$$

$$D_{2m} \leq \sum_{i=1}^r a_{2i} X_{2i} + \sum_{i=1}^r a_{3i} X'_{3i} + h_m Y_m \pm \sum_{m'=1}^5 t_{2m'} Z_{2m'} \dots\dots (23)$$

$$D_{3m} \leq \sum_{i=1}^r a_{3i} X'_{3i} + \sum_{i=1}^r a_{4i} X'_{4i} + \sum_{i=1}^r a_{5i} X'_{5i} \pm \sum_{m'=1}^5 t_{3m'} Z_{3m'} \dots\dots (24)$$

$$D_c \leq \sum_{i=1}^{144} a_{5i} X'_{5i} \dots\dots (25)$$

where :

- D_{1m} = demand for the l *th* product in the m *th* consuming region in which :
 - $l = 1$ refers to wheat demand,
 - $l = 2$ refers to feed grain demand, and $l = 3$ refers to oil meal demand.

- a_{ki} = yield per acre of the k *th* producing activity in the i *th* programming region
 where : $k = 1$ wheat; $k = 2$ feed grains; $k = 3$, feed grains-soybeans; $k = 4$, soy-beans; and $k = 5$, cotton.
- X'_{ki} = level of production acres of the k *th* activity in the i *th* programming region,
 = number of programming regions in the m *th* consuming region.
- h_m = amount of wheat transferred into feed grains per unit of the wheat to feed grain transfer activity in the m *th* consuming region.
- Y^m = Level of the wheat to feed grain transfer activity in the m *th* consuming region.
- t_{lm} = amount of the l *th* product transported from the m *th* consuming region to the m *th* consuming region or the amount of the l *th* product transported to the m *th* consuming region from the m *th* consuming region per unit of the (l_m) transportation activity.
- Z_{lm} = Level of the l_m *th* transportation activity, i.e; the activity which :
 transports the l *th* product from (to) the m *th* consuming region to (from) the m *th* consuming region.
- D_c = National demand for cotton lint. Moreover, equation (21) must be minimized subject to these restrictions :

$$L_{Ti} \geq \sum_{k=1}^5 X'_{ki} \dots\dots\dots (26)$$

$$L_{Ci} \geq X'_{5i} \dots\dots\dots (27)$$

$$L_{Si} \geq X_{4i} \dots\dots\dots (28)$$

where :

L_{Ti} = Total amount of land available for the $k = 5$ producing activities in the k *th* programming region

- L^{ci} = amount of land available for cotton production in the i th programming region.
- L^{si} = amount of land available for the soybean activity in the i th programming region.

And for the positivity restrictions :

$$X'_{ki} \geq 0, Y_m \geq 0, Z_{lm} \geq 0 \dots\dots\dots (29)$$

Solution of this model provide a tremendous amount of numerical results by regions and on the national level. These results, including the shadow prices, have important implications for agricultural policy decision making. However, because of limited space, we will not include numerical results of the optimal pattern of grain production in U.S.A. suggested in this model and will only provide set of policy and planning remasts on the findings of this model.

Generally speaking, the solution of this model determines an optimal grain production pattern that meets the nations future demands with least possible cost. Moreover, it specifies interregional flows of commodities between consuming regions. These findings can be used to indicate the optimal location of storage and processing facilities for the various commodities. Other set of useful findings derived from the dual of this model are the shadow prices. Shadow prices can be used to indicate the subsidies which might be required to compensate farmers for shifting land among various uses.

3 — *A Model For U.A.R.*

Several trials have been set up in building up interregional model for agriculture in Egypt. Models initiated recently (9), including sets of demand functions and long term projections, are perhaps of most interest, but since their solutions are not available yet, the following pages are restricted to a rather simple model specified as an attempt at fitting a linear programming model for optimizing the profit of summer crops in U.A.R. The data used in this model are the input-output rela-

tionships for three summer crops in the U.A.R. These crops represent seven real activities as each crop has more than one variety. Restrictions in this model are land, capital, and the cotton law which fixes the area of cotton as one third of the total cultivable area. The objective function is one of maximizing net revenue of the studied crops. That is, net revenue must be maximized subject to the restrictions specified and that no activity level can be negative.

In this model, however, seven activities are set up as : three kinds of cotton, two kinds of rice, and two kinds of sorghum. Restrictions specified are five constraints as; (a) the land cultivated by these crops in Upper Egypt denoted as (L_u), (b) the land cultivated by these crops in Middle Egypt, denoted as (L_m), (c) the land cultivated by these crops in Lower Egypt denoted as (L_l), (d) capital used in the production of these crops denoted as (Q), and (e) the maximum area of cotton production fixed by the law as one third of the total agricultural land denoted as (C.L.). Levels of these five restrictions are as follows :

$$L_u = 615,369 \text{ (F)}, \quad L_m = 434,338 \text{ (F)}, \quad L_l = 1,887,241,$$

$$Q = 144,015,756 \text{ E. } \pounds, \text{ and C.L.} = 1,904,949.$$

The basic data used for programming in this model are summarized in table (4).

The findings of this model give interesting economic signals especially shadow prices. That is, shadow prices estimated in this model for land, indicating the marginal value productivity per feddan of land in Egypt for summer crops, are 12.91, 23.81 and 14.23 E \pounds in Upper Egypt, Middle Egypt, and Lower Egypt respectively. These figures, however, express the optimal rental values of these land for summer activities.

* Feddan (F) = 1.03 acres.

Table (4) : *Basic data for programming the U.A.R. Model.*

Items	Cotton	Cotton	Cotton	Rice	Rice	Sorghum	Sorghum
	I	II	III	I	II	I	II
Suitable kind of land	L _u	L _m	L _l	L _m	L _l	L _u	L _m
Average Yield per F.	(a) 5.58	(a) 5.62	(a) 5.05	(b) 1.85	(b) 2.38	(c) 10.56	(c) 8.95
Average price per unit (d)	15.00	16.80	16.80	17.00	17.70	3.55	3.50
Total revenue per F.	83.70	96.42	84.84	31.45	42.13	39.44	31.33
Total Cost per F.	45.00	49.82	40.24	27.52	27.90	24.58	24.90
Net returns per F.	38.70	49.82	40.24	3.92	14.23	12.91	6.43

a) Units are kentar per (F),

b) Units are dariba per (F),

c) Units are ardab per (F),

d) Units are E.£.

Source : calculated from statistics in reference (4).

SUMMARY AND CONCLUSIONS

Studies of the nature presented in this paper have become very important because of the major developments in quantitative concepts and computing facilities. These modern quantitative concepts (e.g., Linear programming techniques) permit the incorporation of many relationships and variables into a set of equations and allow simultaneous determination of optimal patterns. Therefore, building up such quantitative models in the complex industry known as agricultural is becoming a necessity.

This study, however, have methodological value in the sense that it expresses the potentiality of the use and implication of interregional models for agriculture. It also promotes data accumulation and conceptual developments which might lead to further and more efficient analyses of the interrela-

tionships between regions and commodities in the agricultural industry. The potentiality of the achievements which can be realised by the interregional programming techniques for planning agricultural production investigated and developed, theoretically and empirically, in this paper can be summarized as follows :

- (i) The determination of the optimal agricultural pattern (s) of production which optimized given objective (s) function (s) on both regional and national levels.
- (ii) Satisfaction of specified set of demands for agricultural production to meet domestic demand for consumption and the industry demand for agricultural products.
- (iii) Derivation of the agricultural normative supply functions and their elasticities.
- (iv) Derivation of the agricultural sector's demand (s) for the factors of production.
- (v) Determination of the agricultural shadow prices for factors and products.
- (vi) Incorporation of transportation activities in building up these models, to determine the optimal product flow from producing to consuming regions.
- (vii) Specification of the optimum location of storages and processing facilities for various commodities on the base of the previous achievements.
- (viii) Prediction of the future optimal agricultural pattern of production and future normative agricultural supply function on the base of estimated trends for agricultural productivity, resource supply, and agricultural product and input prices. Moreover, future normative agricultural supply functions can thus be derived.
- (ix) Models of regional programming techniques can be also utilized for solving and analyzing general economic policy models like Tinbergen's models for economic policy. The author showed, in another place, (2), how can models on general economic policy be modified such that programming techniques can be used efficiently to solve them.

- (x) When advanced models of linear programming are utilized in these interregional programming models, a set of objective and valuable findings are observed. The Author recommends some advanced types of programming techniques in this respect as variable resource programming models, models with variable sets of technical coefficients, variable prices programming models, recursive programming models, and stochastic programming models.

To conclude, it can be stated that models of regional programming techniques for planning agricultural production proved to be of great importance in setting up agricultural plans in developing nations as in mature countries.

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