"AN APPROACH TO A STRUCTURE MODEL OF AGRICULTURE SECTOR" IN EGYPT

by

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Introduction

Agriculture in Egypt, as in most developing economics, is a major source of employment and foreign exchange earnings.

The initial aim in constructing this model was to formalize the major aspects of **Multi-Sector and Decomposition.**

It is not specially designed for analyzing agriculture research and extension programs, crop insurance policies, or credit policies. It is structured so that it is a simple matter to change factor prices, including costs of labor, capital, water, and agricultural chemicals, and to present subsidies to production by crop and geographical area.

Basic Structure of the Model.

The specific dimensions to build the model are :

(A) Separation of sources of supply and demand, for both products and inputs, is the basic under which this model is specified.

(B) The model contains many steps supply and demand functions for each crop, and these functions for different crops are interdependent.

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* This model is developed from the study of agriculture Sector by World Bank in Mexico 1977.

(C) Production for own-consumption is given an imputed price equal to the price for commercial production. For non-traded agricultural goods, the prices are completely endogenous. For internationally traded crops, they must be between the import and export prices.

(D) The cropping activities in the model constitute factor demand activities. Factors are supplied by a separate set of activities, and there are balance equations to ensure equilibrium on the factor markets. Some factor supply functions are perfectly elastic (chemicals and capital), others are perfectly inelastic (some categories of land).

(E) In the former category, factor prices are exogenous to the model, in the latter they are endogenous. In intermediate cases, they are endogenous within limits.

(F) Labor is divided into three classes :

1) Farm owners plus their family labor.

2) Hired agricultural labor.

3) Machinery operators.

Notation for algebric statement

Symbol	Description
I : Variables	

X^{dz}_{hij} Crop production d = district

                                                                          z = zone

                                                                          h = degree of
                                                                              mechanization

                                                                          i = type of
                                                                              irrigation

                                                                          j = crop.

                                                                          n = class of
                                                                              investment

I^{d}_{n} Fixed Investment r = region

T^{d}_{j} Total crop production at the district level

A^{r} Regional supply of draft animal services.

F^{r} Regional supply of chemical inputs

C Sectoral supply of short-term credit

K Sectoral supply of machinery services

S Sectoral supply of purchased seeds.

D^{g}_{ms} Domestic Demand. g = crop group

                                                                          m = commodity
                                                                              mix

(5)

Symbol	Description	
E	Exports	s = demand
M_j	Imports	
P_j	Technical progress variable.	
K'	Sectoral supply of machinery services.	
C^d	District-level counter for short-term credit	
CP	Private long-term capital used.	
CT	Total long-term capital used.	
SALS	Sectoral wage charging activity.	
SALr	Activities for changing regional wage differentials.	
LMAN	Sector annual employment counter.	
LMANt	Sector monthly employment counter.	
dDLt	Monthly day labor supply activities in each submodel.	
dFlq, dFlt	Farm labor supply activities by submodel, quarterly in irrigation submodels, monthly otherwise.	q = quarterly index t = monthly index
	Migration activities for day labor from region r to region r' by months.	
ω_p^d	Well water supply by district.	

II. Parameters

$\alpha_{m\,j}^g$	Quantity of crop j demanded in mix m of group ga *	
ω_s^g	Entry in maximand for demand group g and demand segment s.	

Symbol	Description	
ρ^g_s	Entry in income rows for demand group g and demand segment s.	
δ^g_m	Entry in the demand convex combination constraint for demand group g and mix m.	
K	Ratio of farmer reservation wage to day labor wage.	
$\gamma^{d\,z}_{ij\,t}$	Water input coefficients.	$t = $ month $i = i''$ well water
δ^d_j	Purchased seed input coefficients.	
Φ^d_j	Chemical input coefficients.	
$\mu^d_{h\,j}$	Machinery services input coefficients.	
$\beta^d_{h\,i\,}$	Labor input requirements.	
$\Theta^d_{h\,j}$	Draft animal services input requirements.	
η^d_n	Capital costs per unit of investment project.	$n = $ class of investment project.
$\tau^d_{h\,j}$	Credit input requirements.	
υ^d_r	Ratio of region r wage to other region.	

| + | *The vector α_j is the union over g and m of all coefficients $\alpha^g_{m\,j}$ |

III. Prices

p^e_j Exports

p^m_j Imports

p^l Labor

$p^{'}_k$ Cost of machinery services, excluding in-
terests cost and base wage compo-
nent of machinery operator's wage.

p^i Long-term interest rate.

p^c Short-term interest rate.

p^a_r Regional unit cost of draft animals ser-
vices.

p^{wp}_d Well water.

The equations of the system

(i) Commodity balances, sectoral and district

(a)

$$y_j \quad x_j \ + \ M_j \ -- \ \alpha_j \quad D^g \ --$$

$$-- \ E_j \ + \ P_j \ \geq \ o$$

$$\begin{pmatrix} \text{Domestic} \\ \text{production} \end{pmatrix} + \begin{pmatrix} \text{Imports} \end{pmatrix} - \begin{pmatrix} \text{Domestic} \\ \text{sales} \end{pmatrix}$$

$$- \begin{pmatrix} \text{Exports} \end{pmatrix} + \begin{pmatrix} \text{Adjustment for yield-enhancing} \\ \text{technical progress.} \end{pmatrix}$$

(b)
$$y_i^d \quad x_i^d \quad - \quad T_j^d \quad = 0 \qquad \text{each j, d.}$$

$$\left(\begin{array}{c} \text{District - level} \\ \text{production in} \\ \text{various techniques} \end{array} \right) - \left(\begin{array}{c} \text{Definition of district} \\ \text{total crop production} \end{array} \right) = 0$$

(ii) Sectoral and regional labor balances.

(A) Sectoral wage accounting equation :

$$- \text{SALS} + \text{K} + \sum_r \quad J_r \qquad \text{SALr} = 0$$

$$\left(\begin{array}{c} \text{wage charging} \\ \text{activity} \end{array} \right) + \left(\begin{array}{c} \text{Accounting activity} \\ \text{for} \\ \text{employment of machinery} \\ \text{operators} \end{array} \right)$$

$$+ \left(\begin{array}{c} \text{Regional wage} \\ \text{differentials} \times \\ \text{regional wage} \\ \text{accounting} \\ \text{activities} \end{array} \right) = 0$$

(b) Regional wage accounting rows :

$$- \text{SALr} + \text{k RESr} + \sum_{der} \sum_t \text{dDLt} \leqslant 0 \qquad \text{each r.}$$

$$- \left(\begin{array}{c} \text{Regional wage} \\ \text{accounting} \\ \text{activities} \end{array} \right) + \left(\begin{array}{c} \text{Reservation wage Ratio} \\ \times \text{ regional farmer} \\ \text{employment activity} \end{array} \right)$$

$$+ \left(\begin{array}{c} \text{Sum over district and} \\ \text{months of regional day} \\ \text{labor employment} \end{array} \right) \leqslant 0$$

(c) **Regional farmer employment accounting rows :**

$$- RES_r + \underset{der\ q}{\Sigma \Sigma} dFL_q + \underset{der\ t}{\Sigma \Sigma} dFL_t = o \qquad \text{each } r.$$

$$-\left(\begin{array}{c}\text{Regional farmer}\\ \text{employment}\\ \text{activity.}\end{array}\right) + \left(\begin{array}{c}\text{Sum over districts}\\ \text{and quarters of}\\ \text{quarterly farmer}\\ \text{employment}\end{array}\right)$$

$$+\left(\begin{array}{c}\text{Sum over districts}\\ \text{and months of}\\ \text{monthly farmer employment}\end{array}\right) = o$$

(d) **Total employment accounting in man-years**

$$- 12\ LMAN + \underset{t}{\Sigma}\ LMAN_t = o$$

$$- 12\left(\begin{array}{c}\text{total employment}\\ \text{in}\\ \text{man-years}\end{array}\right) + \left(\begin{array}{c}\text{Sum over months of}\\ \text{total employment in}\\ \text{man-months}\end{array}\right) = o$$

(e) **Total monthly employment accounting rows in man-months.**

$$- 2.2\ LMAN_t + \underset{d}{\Sigma}\ dDL_t + \underset{d}{\Sigma}\ dFL_q + \underset{d}{\Sigma}\ dFL_t = o \quad \text{each } t \text{ and } q$$

such that t Eq.

$$- 2.2^*\left(\begin{array}{c}\text{total employment}\\ \text{in month t}\end{array}\right) + \left(\begin{array}{c}\text{Sum over districts of}\\ \text{day labor employment}\\ \text{in month t.}\end{array}\right)$$

$$+\left(\begin{array}{c}\text{Sum over districts of}\\ \text{quarterly farmer}\\ \text{employment in the}\\ \text{quarter containing}\\ \text{month t}\end{array}\right) + \left(\begin{array}{c}\text{Sum over districts}\\ \text{of monthly farmer}\\ \text{employment}\end{array}\right) = o$$

*there are 22 working days per month. (Hypothetically).

(iii) Sectoral and Regional input Balance

(a) Short-term credit balance

$$\sum_{d} C^{d} \quad - \quad \leqslant c$$

$$\left(\begin{array}{c} \text{Sum of district credit} \\ \text{counting activities} \end{array} \right) - \left(\begin{array}{c} \text{Sectoral interest-charging} \\ \text{activity for credit} \end{array} \right) \leqslant 0$$

(b) Machinery services balance.

$$\sum_{d} \sum_{h} \sum_{j} \mu_{hj}^{d} \quad x_{hj}^{d} \quad - \quad K \leqslant 0$$

$$\left(\begin{array}{c} \text{Sum of demands for} \\ \text{machinery services in} \\ \text{cropping activities} \end{array} \right) - \left(\begin{array}{c} \text{Activity supplying} \\ \text{machinery services} \end{array} \right) \leq =$$

(c) Sectoral accounting row for use of well water

$$\sum_{d} \sum_{z} \sum_{j} Y_{ij}^{dz} \quad x_{ij}^{dz} \quad - \quad w_p = 0 \qquad i = i\text{''}$$

$$\left(\begin{array}{c} \text{Total demands for} \\ \text{well water} \end{array} \right) - \left(\begin{array}{c} \text{Well water} \\ \text{accounting activity} \end{array} \right) = 0$$

(e) Sectoral balance for purchased seeds

$$\sum_{d} \sum_{j} \delta_{j}^{d} \quad x_{j}^{d} \quad - S \quad \leqq 0$$

$$\left(\begin{array}{c} \text{Total Demands} \\ \text{for} \\ \text{purchased seeds.} \end{array} \right) - \left(\begin{array}{c} \text{Supply of purchased} \\ \text{seeds} \end{array} \right) \leqq 0$$

(f) Regional balances for chemical inputs :

$$\sum_{d e_r} \sum_j \phi_j^d x_j^d - F^r \leqq 0 \qquad \text{each r.}$$

$$\left(\begin{array}{c} \text{Total regional demands} \\ \text{for fertilizers} \\ \text{and pesticides} \end{array} \right) - \left(\begin{array}{c} \text{Regional supply} \\ \text{of fertilizers} \\ \text{and pesticides} \end{array} \right) \leqq 0$$

(g) Regional balances for draft animal services

$$\sum_{d e_r} \sum_h \sum_j \Theta_{hj}^d x_{hj}^d - A^r \leqq 0 \qquad \text{each r}$$

$$\left(\begin{array}{c} \text{Total regional demands} \\ \text{for services of} \\ \text{draft animals} \end{array} \right) - \left(\begin{array}{c} \text{Regional supply} \\ \text{of draft animal} \\ \text{services} \end{array} \right) \leqq 0$$

(h) Long-term private capital balances

$$\sum_d \eta_n^d I_n^d - C P \leqq 0 .$$

$$\left(\begin{array}{c} \text{Costs of investment} \\ \text{activities financed} \\ \text{with private capital} \end{array} \right) - \left(\begin{array}{c} \text{Supply of} \\ \text{private capital} \end{array} \right) \leqq 0$$

(j) Total long-term capital balance

$$\sum_d \eta_n^d I_n^d + K' + C P - C T \leqq 0$$

$$\left(\begin{array}{c} \text{Costs of investment} \\ \text{activities financed} \\ \text{with public capital} \end{array} \right) + \left(\begin{array}{c} \text{Capital component of} \\ \text{machinery services} \end{array} \right)$$

$$+ \left(\begin{array}{c} \text{Private capital} \\ \text{supplied} \end{array} \right) - \left(\begin{array}{c} \text{Total capital} \\ \text{supplied} \end{array} \right) \leqq 0.$$

(iv) District-level input balances

(a) District labor balances

$$\sum_h \sum_j \beta^d_{hjt} \; - \; dDLt \; - \; dFLt \; \leq \; 0 \qquad \text{each d, t.}$$

$$\left(\begin{array}{c} \text{Demands for Labor} \\ \text{dsitrict d, month t.} \end{array} \right) - \left(\begin{array}{c} \text{Day Labor hired, in} \\ \text{district d, month t} \end{array} \right)$$

$$- \left(\begin{array}{c} \text{Farmers employed} \\ \text{in district d, month t} \end{array} \right) \leqslant 0$$

(b) District credit balances :

$$\sum_h \sum_j \pi^d_{hj} \; x^d_{hj} \; C^d \; \leqq \; 0 \qquad \text{each d.}$$

$$\left(\begin{array}{c} \text{Demands for credit,} \\ \text{district d} \end{array} \right) - \left(\begin{array}{c} \text{Total district} \\ \text{credit required} \end{array} \right) \leqq 0$$

(c) District well water balances

$$\sum_z \sum_j \gamma^{dz}_{ij} \; x^{dz}_{ij} \; - \; w^d_p \; \leqq \; 0 \qquad \text{each d } \; i = i\text{''}$$

$$\left(\begin{array}{c} \text{Demands for well} \\ \text{water district d} \end{array} \right) - \left(\begin{array}{c} \text{district d activity for} \\ \text{charging costs of} \\ \text{well water} \end{array} \right) \leqq 0$$

(v) District resource constraints

(a) Monthly land constraints

$$x^{dz}_t \; \leqq \; \beta^{dz}_t \qquad \text{each d, z, } \iota.$$

$$\left(\begin{array}{c}\text{Land requirements for}\\\text{cropping}\end{array}\right) \leqq \left(\begin{array}{c}\text{Land availability}\\\text{by district}\\\text{zone, month}\end{array}\right)$$

(b) District constraints on farmer and family labor :

$$dFLq \;\leqq\; A_d \qquad \text{each q, d with irrigation}$$

(vi) Technical progress balances

$$\alpha_j^g \; D^g + E_j - M_j - P_j = 0$$

each j, g   such that j Eg.

$$\left(\begin{array}{c}\text{Total sales on}\\\text{domestic markets}\end{array}\right) + \left(\text{Exports}\right)$$

$$- \left(\text{Imports}\right) - \left(\begin{array}{c}\text{Technical}\\\text{progress factor}\end{array}\right) := 0$$

(vii) Income constraints :

(a) Farmers' profit

$$\sum_g \sum_s \sum_m P_s^g \; D_{ms}^g + \sum_j p_j^e \; E_j$$

$$\sum_j p_j^m \; M_j - p^e \; SALs$$

$$- p^k \; K - p^i \; K' - p^c \; C\,P - S$$

$$- \sum_r F^r - \sum_r p_r^a \; A - \sum_d p_d^{wp} \; w_p^d$$

$$- (\Delta' p^{wp})\,wp + \sum_d \sum_j (\Delta p)^d \; T_j^d \;\geqq\; y$$

$$\left(\begin{array}{c} \text{Gross Revenue from} \\ \text{domestic sales} \end{array} \right) - \left(\begin{array}{c} \text{Export} \\ \text{earnings} \end{array} \right) - \left(\begin{array}{c} \text{Import} \\ \text{Costs} \end{array} \right)$$

$$- \left(\begin{array}{c} \text{Total labors} \\ \text{Costs} \end{array} \right) - \left(\begin{array}{c} \text{Interest on} \\ \text{long-term capital} \end{array} \right)$$

$$- \left(\begin{array}{c} \text{Interest on} \\ \text{short-term} \\ \text{capital} \end{array} \right) - \left(\begin{array}{c} \text{Seed} \\ \text{costs} \end{array} \right) - \left(\begin{array}{c} \text{Chemical} \\ \text{input costs} \end{array} \right)$$

$$- \left(\begin{array}{c} \text{Draft animals} \\ \text{service costs} \end{array} \right) - \left(\begin{array}{c} \text{Well water} \\ \text{costs} \end{array} \right)$$

$$- \left(\begin{array}{c} \text{Increments to} \\ \text{well water cost} \end{array} \right) - \left(\begin{array}{c} \text{District price} \\ \text{differences on crops} \end{array} \right)$$

(b) Farmer's income

This equation is the same as (vii a) except that the term :

$$+ \quad \sum_r \quad a_r \quad RES_r$$

is added, where a_r is the regional farmer reservation wage, to serve the purpose of adding farmers' wage income to profits in order to arrive at total farmers' income.

(c) Sector income

This equation is the same as (vii. a) except that — p^l SALs is dropped and the price of machinery services, p^k , is reduced to take out labor costs.

$(\Delta p)^{wp}$ indicates the uniform sector-wide changes in water prices.

$(\Delta p)^d$ indicates the district price differentials by crop.

(viii) Objective function (Maximand)

$$\sum_{g} \sum_{s} \sum_{m} w_{s}^{g} \, D_{ms}^{g} + \sum_{j} p_{j}^{e} \, E_{j} -$$

$$- \sum_{j} p_{j}^{m} \, M_{j} \, -- \, p^{l} \, SALS - p^{k} \, K -$$

$$- p^{l} \, CT - p^{c} \, CP - S - \sum_{r} F^{r} -$$

$$- \sum_{r} p_{r}^{a} \, A^{r} - \sum_{d} p_{d}^{wp} \, w_{p}^{d} - (\Delta p^{wp}) \, w_{p}$$

$$+ \sum_{d} \sum_{j} (\Delta p)^{d} \, T_{j}^{d}$$

The first term of the objective function is the sum of consumers' and producers' surplus rather than gross revenue. Total long-term capital is costed, via CT, instead of just private long-term capital.

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