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MINIMIZING EGYPT'S FOREIGN EXCHANGE DEFICIT FOR 18 CROPS

by

Jerry Foytik, University of California, Davis
Nabil Habashy, Ministry of Agriculture, Egypt

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INTRODUCTION

In recent years Egypt has experienced huge foreign exchange deficits for the agricultural sector of its economy. Considerable interest exists in changing production patterns as a means of reducing the current gap between the value of imports and exports. Of particular concern in this study is the extent to which production changes are indicated for nine horticultural crops currently in foreign trade. Nine other crops are included to provide a larger basis for obtaining results. A linear programming model is used for determining the optimum production patterns.

Two simplifications are made to limit the scope of the study. Some important farm enterprises, notably the livestock-meat industry, are omitted. Each crop is considered on a national basis without recognizing regional differences. Several additional assumptions, to be mentioned later, are incorporated into the model. It is believed that results are not materially affected.

Shifting from current to optimal land use patterns requires no production of lentils and an expansion of 10 percent for the other eight horticultural crops. It also requires a 5 percent decrease in land planted to wheat, maize, and cotton and an increase of 10 percent in the amount used for rice and the other three nonhorticultural crops. As a consequence, imports are decreased and exports increased, resulting in a substantial reduction in the foreign exchange deficit for these crops. Admittedly, various obstacles, economic and noneconomic, will need to be overcome. The results, however, do indicate the direction in which changes should be attempted to improve the situation.

DATA USED

Nine horticultural products are imported to, or exported from Egypt in significant quantities. These are, in order of planted area: tomatoes, beans, oranges, potatoes, melons, lentils, onions, harricot, and garlic. Nine other crops are included since they compete for the same land. They are wheat, maize, rice, cotton (short and long), sugarcane (type I and type II), peanuts, and sesame.

Conditions prevailing during 1976-1979 are used to define the parameters required for the analysis. Thus 1976-1979 averages are used for yield, production, import, export and domestic consumption of each crop and for the land and water resources available for producing these crops. Other inputs are assumed to be available in adequate amounts from domestic and foreign sources. Average prices during 1976-1979 are used for values of imports, exports and three imported production inputs.

Quantities produced, imported, and exported are converted to equivalent land areas using national average yields. For example, suppose the average yield for cotton produced in Egypt is 0.40 tons per feddan. Then a quantity of 1,000 tons is represented by 1,000 ÷ 0.40, or 2,500 feddans. Import and export prices are converted similarly to indicate the foreign exchange values per feddan for quantities imported and/or exported.

Estimates for the exchange values for imports of production inputs are limited to three items: fertilizers, insecticides, and machinery. Data for insecticides are included only for cotton and onions. Data for fertilizers and machinery are for imports only, i.e., domestically produced quantities are excluded.

Domestic consumption for each crop is merely set at production minus net exports or plus net imports as the case may be. Water usage is set at average rates experienced during 1976-1979.

It is recognized that substantial shifts in production patterns may change some of the input data. For example, the quantities of imported fertilizer, insecticide and machinery could be altered. Also national yield data might change merely because land with lower yield will tend to be used if production is being expanded or tend to shift to other crops if production is being curtailed.

The input data used for the study are given in Tables A and B at the end of this report.

METHODOLOGY

The objective of this linear programming problem is to minimize the sum, in monetary terms, of the net imports of 18 crops and the net imports of three inputs used in their production. This optimization is subject to various constraints imposed on the selection of values for the decision variables.

The first part of the objective function, representing the value of net imports, is expressed by

$$\Sigma P_j X_j - \Sigma Q_j Y_j \quad \text{for } j = 1, 2 \ldots 18$$

where X_j and Y_j denote, in feddan equivalents, the quantity of crop j imported and exported, respectively. P_j and Q_j denote the value, in Egyptian pounds per feddan, the quantity of crop j imported and exported, respectively.

The second part, representing the value of the imported production inputs, is expressed by

$\Sigma C_j(S_j + W_j)$ for $j = 1, 2, \ldots 18$

where S_j and W_j denote, in feddan equivalents, the land area used for producing crop j during the summer and winter seasons, respectively. C_j denotes the cost per feddan, in Egyptian pounds, of the imports of three inputs (fertilizer, insecticide, and machinery) used in producing crop j.

Actually the above term gives the cost of three inputs used for the total produced, including amounts consumed domestically. Since domestic consumption for each crop is assumed constant, as noted later, an adjustment is not required.

Hence the objective function is

(1) $\text{Min } \Sigma P_j X_j - \Sigma Q_j Y_j + C_j(S_j + W_j)$ for $j = 1, 2, \ldots 18$.

Five sets of constraints are imposed on the selection of the decision variables: X_j, Y_j, S_j and W_j.

This problem is not concerned with the question of whether domestic consumption should be altered for any one of the crops or for their total. In other words, it is assumed that domestic consumption is maintained at 1976-1979 levels. This requires for each crop j, $j = 1, 2, \ldots 18$:

(2) $S_j + W_j + X_j - Y_j = K_j$

where K_j denotes, in feddan equivalents, the domestic consumption of crop j. Furthermore, since each K_j is a constant their sum is a constant which is equal to production plus net imports. Thus,

(3) $K = \Sigma K_j = 8.95$ million feddans.

To limit water usage to its 1976-1979 level might unduly restrict changes in production patterns. Hence, the availability of water is set at 28,000 million cu.m., or about 10 percent above the average used in 1976-1979. The water constraint becomes

(4) $A_j(S_j + W_j) \leq 28{,}000$ million cu.m.,

where A_j denotes the rate, in cu.m. per feddan, used for crop j, $j = 1, 2, \ldots 18$.

A total of 4.70 million feddans is assumed available for producing the 18 crops, compared to 1976-1979 plantings on 4.53 million during the summer season and 3.50 million during the winter. Actually no land remains unused. The difference is planted mostly to fodder crops. Introducing the "extra" area insures that production patterns can shift. A larger, or smaller, area could have been selected without affecting the outcome of the optimization.

Table A indicates the season when each crop occupies the land. Five crops use the land throughout the year. For them $S_j = W_j$. Five are grown during the summer season only, and five during the winter only. This gives $W_j = 0$ for the former group and $S_j = 0$ for the latter. The other three crops and the "fodder" item can be grown either summer or winter and, consequently, no restriction is needed. Symbols S_{19} and W_{19} denote summer and winter land, respectively, used for producing "fodder". Summarizing, gives the following constraints on land use:

$$\Sigma S_j = \Sigma W_j = 4.7 \text{ million feddans} \quad \text{for } j = 1, 2, \ldots 19$$

(5)

$$\Sigma S_j = \Sigma W_j \quad \text{for } j = 1, 2, \ldots 5$$

$$\Sigma W_j = 0 \quad \text{for } j = 6, 7, \ldots 10$$

$$\Sigma S_j = 0 \quad \text{for } j = 11, 12, \ldots 15$$

It is unrealistic to assume a large increase in exports for Egyptian crops, at least for the immediate future. A limitation must be placed on the production of each crop by setting a maximum on the land used or, alternatively, on the amount exported. The latter method is used here. Eleven crops were exported during 1976-1979. Only fragmentary information is available for indicating how much these exports might be expanded. Hence volumes are selected somewhat arbitrarily at approximately 10 percent of 1976-1979 production. These increases appear possible if export sales are sought vigorously. There should be no serious difficulty in expanding production accordingly.

SOLUTION

For the 18 crops included in the study the foreign exchange values, in Egyptian pounds, averaged 762 million for imports and 275 million for exports during 1976-1979. Shifting to the optimal solution decreases imports by 69 million and increases exports by 65 million. In addition, a negligible decrease occurs in the value of imported production inputs. The net effect of adopting the optimal land use pattern reduces by 19 percent the foreign trade deficit for these 18 crops.

Changes required to reach optimal levels are summarized in three tables. The first indicates how imports and exports are altered for each crop. At optimum, imports are reduced to zero for beans and type II sugarcane. They are increased by about 8 percent for the other five crops now exported. Imports increase by the amount producible from 161,000 feddans; exports increase by the same amount. Over half of this increase is by the seven horticultural crops now exported. The volume of exports is increased sharply for these crops and for rice.

To implement these shifts in imports and exports necessitates changing land use patterns--see Table 2. Production is zero for lentils at optimum and about 10 percent higher for the other horticultural crops. Two thirds of the decrease in land used for growing wheat, maize and cotton is offset by expanded production of rice and sugarcane. For several crops the shift in production is substantial percentagewise, although not large in terms of the amount of land planted.

Table 3 compares the 1976-1979 foreign exchange position with the optimal situation. The trade deficit declines 19 percent, from 700 million Egyptian pounds to 564 million. The reduction includes a decrease of 69 million in imports, an increase of 65 million in exports, and a slight decrease in the cost of imported production inputs.

The largest change is the decrease of 112 million Egyptian pounds in imports of type II sugarcane. All other imports increase by a total of 43 million. Export values decrease 20.3 million for type I sugarcane and long cotton. They increase 33.0 million for rice, 47.4 million for four horticultural crops (tomatoes, potatoes, melons and orange) and 4.9 million for the other four crops. In other words, for the crops alone (i.e., without the imported production inputs) imports are reduced by 9 percent while exports are increased by 24 percent.

The amount of water needed for the new land use patterns is 4 percent below the volume arbitrarily to be available--see Table 4. On the other hand, the amount needed is 5 percent above that used on the average during 1976-1979. Cotton, maize, rice and sugarcane account for about 80 percent of the total water used in 1976-1979 and also at optimum.

EVALUATION OF RESULTS

The optimal solution determined here indicates numerous shifts in production and foreign trade patterns required to reduce the deficit for one segment of the Egyptian economy. The reasonableness of these results rests upon the accuracy of the data used and the appropriateness of the assumptions made.

Every researcher must select the data deemed suitable for analyzing the problem to be solved. Frequently, the information is less satisfactory than desired because some aspects of the problem cannot be quantified, some data relate only indirectly to the variables in the model, some data are subject to considerable measurement error. That is the situation confronted in this study.

The import and export prices may be the least reliable of the input data. They relate to the season averages for all quantities imported and exported. For several crops they can be accepted as fairly accurate data. For other crops, such as horticultural products, they are less satisfactory. Fewer price data may be gathered for crops sold in smaller volume. Prices may fluctuate widely during the course of a season. Price differentials may vary considerably among varieties, quality grades, sizes, etc. Most exports and imports are sold to or from several countries. Such transactions may be completed in various currencies. Exchange rates vary over time and change among countries. Converting to Egyptian pounds can become difficult.

Data on the use of imported production inputs for individual crops are unavailable. The estimates used are derived from the value of fertilizers, insecticides and machinery imported by Egypt. These national totals were allotted among individual crops using assumed per-feddan rates supplemented by other information. The water data also are estimates derived from assumed rates of application. However, these are subject to less measurement error.

Quantities of production, imports, exports and domestic consumption are relatively accurate. Converting the tonnage amounts to feddan equivalents does present a problem in some case since national average yield are used for this purpose. For example, only one-third of the domestic consumption of wheat comes from local production. Converting imports to equivalent feddans at the average Egyptian yield may not be warranted. A large expansion in local production (to offset decreased imports) might alter the average yield substantially. A second example indicates a different situation. A grower of a crop for export may have a yield much higher than the average because he employs better cultural practices, plants more productive varieties, etc. On the other hand, his yield could be lower because he produces for the off-season market, grades his output more severely with the expectation of a higher price.

As indicated, data for several series (especially those appearing in Table B) are mere estimates, derived by piecing together fragmentary information from several sources. For this reason, rounded figures are used for all data. Hence the input data generally are significant to only two places. It is believed, however, that the results obtained do not need to be qualified severely for this reason. Furthermore, they can serve as reasonable first approximations of guidelines used for indicating the direction in which changes should be made for reducing the unfavorable balance of trade now facing Egypt.

The basic linearity assumption of linear programming is accepted. In other words, technological and economic relationships are assumed to be linear over the range of changes in the decision variables required to shift to the optimum solution. The shifts are not of a large magnitude and hence it seems likely that using linear functions is justified at least as first approximations.

Various other assumptions are made--some explicitly, others by implication. Each of these need not be discussed here. The following comments are limited to five.

Domestic consumption for each crop is retained at its current level because the study is directed at reducing the current unfavorable balance of trade. Nevertheless, the results include shadow prices which indicate how changes in domestic consumption affect the trade deficit. These unit costs vary widely. They could be used to justify attempts to alter consumption among crops. However, other factors need to be considered also: impact on health, consumer preferences, the food security program, etc.

The potential expansion of foreign exports is assumed to be about 10 percent for crops now exported. The optimal solution increases exports to the limits set. Furthermore, the sensitivity analysis indicates that much larger quantities could be exported provided relative prices for exports and imports were not changed materially. This result is of practical importance. It means that exports of these crops should be encouraged, even though it means increasing the imports of other crops.

Constant yields, at national averages for 1976-1979, are used for converting all tonnage data to equivalent feddans of land area. Such yields, however, do vary, sometimes considerably, for different segments of each crop. The assumption may have a larger effect than expected.

It was assumed that water availability is at 10 percent above current use. Setting the limit lower would change the optimal pattern of land use. An attempt was not made to determine the extent or magnitude of this change.

It seems likely that the use of land for sugarcane, rice, and oranges might be reduced since these crops are heavy users of water on a per-feddan basis.

The interdependence and conflicting objectives of different sectors of the economy may represent major obstacles to achieving the optimum pattern of foreign trade. International competition, marketing constraints, and lack of marketing information could become bottleneck to improving Egypt's balance of trade. The desirability of a country's attempt to increase exports is conditioned by several factors, such as the technical knowledge of its farmers, their use of good technology, and the use of crop rotation. There may be considerable competition among objectives being sought. For example, a cropping pattern which ranks high for export earnings may rank low in terms of food security.

Table 1. Indicated Shifts in Import and Export Quantities for 18 Crops, in 1,000 Feddans[a]

Crop	1976-1979 Level	Optimal Level	Indicated Change
Imported			
Wheat	2,460	2,542	82
Maize	355	403	48
Cotton, Short	150	200	50
Sugarcane, II	62	0	-62
Sesame	33	43	10
Lentils	83	141	58
Beans	25	0	-25
Total	3,168	3,329	161
Exported			
Rice	70	170	100
Tomatoes	3	33	30
Potatoes	18	41	23
Melons	2	12	10
Oranges	20	35	15
Harricot	1	4	3
Peanuts	13	16	3
Onions	7	10	3
Garlic	2	3	1
Cotton, long	490	475	-15
Sugarcane, I	12	0	-12
Total	638	799	161

[a]Import and export tonnages are converted to equivalent feddans, using national average yields for Egyptian production.

Source: Tonnage data for 1976-1979 were supplied by the Ministry of Agriculture, Egypt. These were converted to equivalent feddans. Data at optimal level were derived by this study.

Table 2. Indicated Shifts in Land Use Patterns for 18 Crops, in 1,000 Feddans

Crop	1976-1979 Use		Optimal Use		Indicated Change
	Summer Land	Winter Land	Summer Land	Winter Land	
Cotton, long	1,150	1,150	1,135	1,135	-15
Cotton, short	50	50	0	0	-50
Sugarcane, I	225	225	213	213	-12
Sugarcane, II	25	25	87	87	62
Oranges	160	160	175	175	15
Subtotal	1,610	1,610	1,610	1,610	0
Maize	1,400		1,352		-48
Rice	1,030		1,130		100
Melons	115		125		10
Peanuts	30		33		3
Sesame	30		20		-10
Subtotal	2,605		2,660		55
Wheat		1,380		1,298	-82
Beans		250		275	25
Lentils		58		0	-58
Onions		30		33	3
Garlic		13		14	1
Subtotal		1,731		1,620	-111
Tomatoes	200	100	200	130	30
Potatoes	100	52	100	75	23
Harricot	15	7	15	10	3
Subtotal	315	159	315	215	56
Fodder[a]	170	1,200	115	1,255	0
TOTAL	4,700	4,700	4,700	4,700	0

[a]This item is not an actual crop. The item merely represents the land area available for planting crops other than the 18 listed.

SOURCE: Data for 1976-1979 were supplied by the Ministry of Agriculture, Egypt. Data for optimal use were derived by this study.

Table 3. Current and Optimal Foreign Exchange Values for 18 Crops, in Million Egyptian Pounds

Crop	1976-1979 Value	Optimal Value	Indicated Change
Imported Crop			
Wheat	516.60	533.82	17.22
Maize	79.88	90.68	10.80
Cotton, Short	26.25	35.00	8.75
Sugarcane, II	112.20	0	-112.20
Sesame	5.94	7.74	1.80
Lentils	15.35	26.08	10.73
Beans	6.25	0	-6.25
Subtotal	762.47	693.32	-69.15
Exported Crop			
Rice	23.10	56.10	33.00
Tomatoes	1.50	16.50	15.00
Potatoes	8.82	20.09	11.27
Melons	2.25	13.50	11.25
Oranges	13.20	23.10	9.90
Harricot	.64	2.56	1.92
Peanuts	3.25	4.00	.75
Onions	3.74	5.35	1.61
Garlic	1.18	1.77	.59
Cotton, long	203.35	197.12	-6.23
Sugarcane, I	14.10	0	-14.10
Subtotal	275.13	340.09	64.96
Net Imports	487.34	353.23	-134.11
Imported Inputs	212.56	210.42	-2.14
Total	699.90	563.65	-136.25

Source: Data for 1976-1979 were supplied by the Ministry of Agriculture, Egypt. Data for optimal value were derived by this study.

Table 4. Indicated Shifts in Water Use and Cost of Imported Production Inputs, for 18 Crops

Crop	Water Used million cubic meters			Cost of Imported Production Inputs million Egyptian pounds		
	1976-1979	Optimal	Change	1976-1979	Optimal	Change
Cotton, long	4,002	3,950	52	77.51	76.50	-1.01
Cotton, short	174	0	-174	3.37	0	-3.37
Sugarcane, I	3,915	3,706	-209	9.63	9.12	-.51
Sugarcane, II	435	1,514	1,079	1.07	3.72	2.65
Oranges	960	1,050	90	1.86	2.03	.17
Rice	7,828	8,588	760	23.79	26.10	2.31
Maize	3,920	3,786	-134	40.74	39.34	-1.40
Melons	322	350	28	2.30	2.50	.20
Peanuts	81	89	8	.26	.29	.03
Sesame	81	54	-27	.41	.27	-.14
Wheat	1,932	1,817	-115	36.43	34.27	-2.16
Beans	275	303	28	2.57	2.83	.26
Lentils	81	0	-81	.54	0	-.54
Onions	75	82	7	2.68	2.95	.27
Garlic	36	39	3	.20	.22	.02
Tomatoes	870	957	87	5.82	6.40	.58
Potatoes	441	508	67	2.95	3.39	.44
Harricot	51	57	6	.43	.49	.06
Total	25,479	26,850	1,371	212.56	210.42	-2.14

Source: Computed using per-feddan rates (Table B) applied to 1976-1979 land use (Table A) and optimum land use as determined by the study.

Table A. Land Use for 18 Crops, 1976-1979 Averages
1,000 feddan equivalents[1]

	Crop[2]	Summer Production	Winter Production	Imports	Exports	Domestic Use
1	Cotton, long	1,150	1,150		490	660
2	Cotton, short	50	50	150		200
3	Sugarcane, I	225	225		12	213
4	Sugarcane, II	25	25	62		87
5	Oranges	160	160		20	140
6	Rice	1,030			70	960
7	Maize	1,400		355		1,755
8	Melons	115			2	113
9	Peanuts	30			13	17
10	Sesame	30		33		63
11	Wheat		1,380	2,460		3,840
12	Beans		250	25		275
13	Lentils		58	83		141
14	Onions		30		7	23
15	Garlic		13		2	11
16	Tomatoes	200	100		3	297
17	Potatoes	100	52		18	134
18	Harricot	15	7		1	21
19	Fodder	170	1,200		0	1,370
	TOTAL	4,700	4,700	3,168	638	10,320

[1]Imports and exports converted from tonnages to feddan equivalents using national average yields. Domestic use equals production plus imports minus exports.

[2]"Fodder" represents land area available for production by crops other than the 18 listed.

Source: Based on data supplied by the Ministry of Agriculture, Egypt.

Table B. Other Input Data Used in the Analysis, 1976-1979 Averages

Crop	Water Use 1,000 cu.m. per feddan	Cost of Imported Production Inputs, L.E. per feddan			Foreign Trade Price, L.E. per feddan[2]	
		Fertilizer	Machinery	Total[1]	Import	Export
Cotton, long	3.68	12.6	13.8	67.4		415
Cotton, short	3.68	12.6	13.8	67.4	175	
Sugarcane, I	17.40	27.7	15.0	42.7		1,175
Sugarcane, II	17.40	27.7	15.0	42.7	1,810	
Oranges	6.00	11.6	—	11.6		660
Rice	7.6	7.7	15.4	23.1		330
Maize	2.8	15.5	13.6	29.1	225	
Melons	2.8	20.0	--	20.0		1,125
Peanuts	2.7	3.9	4.8	8.7		250
Sesame	2.7	6.7	6.9	13.6	180	
Wheat	1.4	12.6	13.8	26.4	210	
Beans	1.1	1.9	8.4	10.3	250	
Lentils	1.4	1.9	7.4	9.3	185	
Onions	2.5	15.5	3.9	89.4		535
Garlic	2.8	11.6	3.9	15.5		590
Tomatoes	2.9	19.4		19.4		500
Potatoes	2.9	19.4		19.4		490
Harricot	2.3	19.4		19.4		640

[1]Includes cost of insecticide for cotton (41.0) and onions (70.0).

[2]Per-ton prices converted to prices per-feddan equivalents using national average yields.

Source: Based on data supplied by the Ministry of Agriculture, Egypt.