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Impact of Technological Changes and Economic Liberalization on Agricultural Labor Employment and Productivity

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Summary and Conclusion

Egypt has passed dramatic economic changes over the last two decades. Such program has different impacts on agricultural sector performance, including the mechanization, expansion and substitutability for human labor.

Therefore the objectives of this study are to assess the impacts of technological changes and economic liberalization on agricultural labor employment and Productivity. The analytical procedures included was the estimation of crop production function for rice before and after the economic reform application in agricultural sector. The study used two field survey data in two successive periods conducted in "Sharkia Governorate".

It was concluded that the optimum allocation of inputs for rice production implied to decrease the human labor use on farms, even though under the export border price of rice. It means that such major crop in Egypt as a case study of the agricultural sector can not provide a feasible

employment opportunity for human labor. To reach a maximum income from such agricultural activities a less labor intensity should be used. Positive analysis approach showed that the employment of human labor has decreased by almost one-fourth due to all technological changes and economic reform policies practiced over the last decade. The normative approach analysis (least cost combination of inputs), showed that the human labor employment should be decreased by about two-thirds, in order to maximize income.

All economic criteria, derived from the normative approach analysis, in this study showed that the growth in production and maximization of income must rely upon physical and biological technologies (new varieties, fertilizers and mechanization of farm operations).

Rural development programs and economic development plants should create employment opportunities for such excess agriculture labor, either in agricultural related industries of non-agricultural small industries in villages or other economic activities in rural towns, in order to keep agriculture growing at an economic competitive performance.

Introduction

Although the urban population and industrial sector have grown significantly in Arab countries (except the Gulf Oil Countries), the rural population and agricultural labor forces are still the major portion of their populations. Also the agricultural development and food security have top priorities of the development programs of these countries. The theme of the agricultural development in the region over the last ten years focused upon: introducing (1) modern high technological packages (either biological or

physical) and (2) liberalization of the input-output prices and marketing of agricultural products as well as resources. However, the magnitude and level of implementation of both components of such strategy are varied among the countries of the concerned region. Biological technology package composed mainly of higher yield varieties, associated with higher level of fertilization and more efficient farming practices. The physical technology composed mainly of the intensification of agricultural machinery.

Egypt is considered as a representative case study to analyse and evaluate the socio-economic impacts of such strategy on agricultural labor.

The successive three "5 years" development plants" in Egypt, since 1982 have devoted much concern towards introduction of such technology to the farming operations for major field crops. The development plants aimed at expansion of the different machines. Up to mid of eighties, the program objective was to reach a full mechanization of land preparation and expansion of water pumps. Up to early years of nineties, the plan aimed at introducing and expansion of the machinery for harrowing, harvesting for rice, wheat and fodder. Up to the 2000 the goals are a full mechanization for major field crops.

On the other hand, Egypt has passed various dramatic economic changes over the last two decades. In particular, since 1986/1987, the economic reform and structural adjustment program has strongly started with agricultural sector. Such program has different impacts on agricultural sector performance, including the mechanization, expansion and substitutability for human labor.

Therefore the objectives of this study are to assess the impacts of technological changes and economic liberalization on agricultural labor employment and productivity.

Data Base :

Towards achievement of the study objectives. The empirical part of this study depended upon two sample surveys conducted by the author in two different periods. The first was for the agricultural year in 1986 (before the boom of the economic liberalization in Egypt) and (before the great expansion of agricultural machinery and intensification). The other sample was conducted for the agricultural year (1996), i.e. ten years later; to compare the associated changes occurred in agricultural labor employment and productivity, before and after introduction of both technologies and economic liberalization. The two samples collected from the same districts of "Sharkia Governorate", which is located to the East of the Nile Delta and West of "Sues Canals" for a major exportable crop, "Rice". Sharkia Governorate cultivates 15% of rice area in Egypt. The first sample included 125 farms, in 1986 while the second sample included 100 farms, in 1996. Each sample represented the pattern of the farm size in the conventional village in Egypt, i.e. from 1 "Feddan", which is about one-acre to more than 10 feddans per farm.

Analytical procedures

For assessment of agricultural mechanization expansion for farming operations, a Chi-Square test was applied for the cross-tabulation of the farms used machinery versus those who did not use it, over the study period, and by operation.

For assessment of labor employment and productivity, the analytical procedure used was the estimation of the best fitted model for input-output relations of "Rice-Response Function" for each period. The appropriate economic relations and parameters were derived from each fitted model to assess the changes in agricultural labor productivity and employment. These estimates included the production elasticity, the value of marginal product, the marginal return to each Egyptian Pound (I.E. = \$0.294) spent on both machinery and human labor (the economic efficiency of the input). The ISO-quant of machinery-labor was derived to estimate the most efficient, i.e. the last cost combination of human labor and machinery labor. The economic efficiency and optimum combination of both inputs were estimated under two district scenarios that simulate the economic changes in Egyptian Economy:

The first scenario, investigates the impacts of implementation of the economic reform strategy: It required comparing the derived economic indicators of both production functions in 1986 and 1996 under the current prices. The second Scenario assuming export promotion of rice and achievement of GATT conditions. Therefore, the border price of rice as exportable crop was used as the opportunity income from exporting rice. The opportunity cost of agricultural labor in the best alternative use of such kind of labor was assumed to be the wage rate of the worker in the construction and building activities. With respect to machinery labor, the input was introduced as weighted "horse-power". The shadow price of renting machinery was derived on base of phasing out the current subsidy of fuel price. From previous studies the expected increase in "Gasoline price would be 50%" above the market price. Fuel share in the total cost

structure of customs service is around 20%. Accordingly, the machinery rent under free price policy of fuel would be around 10% higher than its current level.

Results & Discussion

Expansion of Agricultural Mechanization:

Results of Table (1) show that land plowing, leveling and lining reached full mechanization in 1996. Even though the level of expansion of the drilling machine use for seeds cultivation was low (only, 23% of the farms in 1996), such percent was almost doubled over the period 1986-1996. Weeding is still a manual operation, and the mechanization of such operation has not passed 13% of the farms. To lift water by a pump for irrigation has stayed as a full mechanized operation on all farms. This is probably due to the policy of lowering the water level in all channels; by the ministry of irrigation such policy enforces farmers to bear the costs of lifting the water. It is considered as an indirect "way to rationalize the water use for agriculture, once water pricing for such sector can not be applied in the short run for social reasons.

On the other hand, the number of farms that applied mechanized harvesting was raised from about 23% in 1986 to about 37% in 1996. Because, the newly introduced, combined harvester serves threshing and winnowing, in addition to harvesting, the percentage of farms that used separate thresher and winnowing machine were decreased.

Over the last decade, expansion of mechanized transportation within the villages has reached 100%. Among the reasons that facilitated the wide expansion of such mechanized operation were the significant decrease in

custom tariffs of tractors, development of local manufacturing of tractors and the attached trailer and the big improvements of the infra-structure in the rural sector that have been occurred one the last decade.

Estimated Production Function:

Table (2), presents the estimates of the Rice-Crop production function in both seasons 1986 and 1996. The best fitted form, using "OLS" was selected on base of the highest estimated coefficient of determination " R^2 ", the economic logic of the estimates and the significance of the estimates. Therefore, the "Cobb-Douglas" form was the best fitted mathematical form of the crop production function. All estimates were statistically, significant at a probability less than 1%. The land (crop area) input response was significant in the 1996 function, but not in the function of 1986. The animal work input was not significant in 1996 function because it density has become very minor and insignificant.

About 78% of the variation in rice production was explained by the introduced inputs (human labor, machinery work, and animal work and nitrogen fertilizers) in the estimated function of 1986. Around 85% of farm production of rice was due to the introduced inputs in 1996 estimated function (human labor, machinery work, and crop area and nitrogen fertilizer).

Technological changes:

Comparison of the magnitude of the intercept of the two estimated production functions showed that there was a significant aggregate technological change in rice production between the two periods. From Table (2), the intercept of the estimated function for 1986 season was 0.05.

It increased to 0.15 in the estimated function for the season 1996. This implied a positive improvement in the technological level over the concerned period. These positive technological changes were mainly, due to improvements in biological over the period 1986-1996.

From Table (3), the intensification of chemical fertilizers was increased significantly between 1986 and 1996, associating introduced new higher yield varieties of rice. The mechanization of farm operations was intensified per feddan, i.e. from about 13 hours of mechanical work per feddan in 1986, to about 18 hours per feddan in 1996. However, the increase in machinery use per feddan was not significant at $P < 0.05\%$ (Table, 3). The grains yield increased from 2.38 tons per feddan in 1986 to 2.89 tons per feddan in 1996. Also rice straw increased from 1.16 tons per in 1986, to 1.5 tons in 1996. However due to high variation in yield within farms difference in yield was not statistically significant, (Table, 3).

The apparent increase in mechanization was associated with, statistically significant, less human and animal work per feddan. Human Labor work for farm operations of rice decreased from more than 45 man-days in 1986 to about 34 man-days in 1996.

The estimated regression coefficients of the production function represent econometrically, the average production elasticity of the inputs. Therefore, while, the productivity of human labor decreased from 0.4 in 1986 to 0.08 in 1996, (Table, 2), the associated agricultural machinery productivity was increased from 0.19 to 0.25. The chemical fertilizer productivity, slightly, increased from 0.25 in 1986, to 0.27 in 1996.

Therefore, from 1996 response function, an increase in machinery work and chemical fertilizers by 10% lead to an increase in rice production by 2.5% and 2.7%, respectively. A similar proportion of increase in human labor employment leads to an increase in rice production by less than 1%. It means that whereas additional fertilizers and mechanization are much recommended for physical increase in rice production, more human labor is not recommended.

Economic Efficiency of Human labor:

The economic efficiency of an input is expressed as its marginal return to each one Egyptian Pound spent on such input. It is the ratio of the average value of marginal product to the price of the input. If such coefficient of a given input is greater than one means that additional intensification of this input is economically feasible, but if such coefficient of an input is less than one it is feasible to decrease the level of that input to raise its economic efficiency.

Table (4), presents the current level of prices of output and inputs, as well as their shadow prices, which were used for investigating the economic efficiency of the concerned inputs in rice production. The shadow price of rice used here is its boarder price as an exportable crop. The shadow wage of human labor is its opportunity cost in construction activities. The shadow price of machinery work is its rent rate after phasing out the fuel price subsidy.

Estimates of the economic efficiency of human labor, in Table (5), showed that under the current price level of rice and wage rate, it decreased from about L.E. 2 per one pound spent on human labor cost in 1986, to less

than L.E. 1 in 1996. This coincide with the apparent decrease in human labor intensification per feddan over the period 1986-1996 (3). Under the shadow (border price) of rice and opportunity cost of human labor, the rice activity can not afford more employment activity for human labor, because its economic efficiency would be about 0.6. In other words human labor intensity on farms should be decreased.

On the other hand, the higher productivity of machinery, work and its relatively low price per unit (Horse Power), as presented in Table (2) and (4), reflects its high economic efficiency. Such high efficiency provides a good opportunity for mechanization to expand in agriculture, particular rice. Its economic efficiency, increased from 1.63 in 1986, to 2.27 in 1996 and under shadow prices it would reach 2.56. There are much more opportunities to expand machinery work on farm at the expenses of human labor.

As the economic efficiency of nitrogen fertilizer allowed intensifying its level (Table 5) it has increased over the concerned period. However, the environmental constraints would limit such promising expansion in chemical fertilizer. More fertilizers would cause negative externalities on soil, plant and then human poisoning effects.

The least cost combination of Human and Machinery labor:

Table (6) shows the estimation of the least cost combination of both human and machinery labor per feddan or rice. These estimates were derived from the Iso-Quant and Isoclines' functions for the crop production function estimated in table (2). The least cost combinations were compared with the existing combination and between the two successive periods

(1986 and 1996), as well as under shadow prices scenario.

It was concluded that the optimum allocation of inputs for rice production implied to decrease the human labor use on farms, even though under the export border price of rice. It means that such major crop in Egypt as a case study of agricultural activity can not provide a reasonable employment opportunity for human labor. To reach a maximum income from such agricultural activity a less labor intensity should be used. Positive analysis, (Table 2), showed that the employment of human labor has decreased by almost one-fourth due to all technological changes and economic reform policies practiced over the last decade. The normative approach analysis (least cost combination of inputs), from Table (6), showed that the human labor employment should be decreased by about one-half at current prices of 1996 and at shadow prices of inputs human labor employment should be decreased by about two-thirds, in order to maximize income.

All economic criteria, derived from the normative approach analysis, in this study showed that the growth in production and maximization of income depends upon physical and biological technologies (new varieties, fertilizers and mechanization of farm operations).

Integrated rural development programs and economic development plans should create employment opportunities for such excess agriculture labor, either in agricultural related industries or non-agricultural small industries in villages or other economic activities in rural towns, in order to keep agriculture growing at an economic competitive performance. These programs provide proper allocation of rural labor which, in turn, will raise farm family income. Higher agricultural family income provides

opportunities for more self-investment of the family in agricultural activities.

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Table (1): Percentage of farms that Conducted Farm operations with

Machinery VS without Machinery

Year	1986		1996		Calc. Chi. Square
	With	Without	With	Without	
Land Preparation	75.61%	24.39%	100%	0.0%	25.25*
Cultivation	10.16%	89.84%	22.73%	77.27%	4.87
Weeding	13.01%	86.99%	12.73%	87.27%	0.022 ^{n.s}
Irrigation	100%	0.01%	100%	0.0%	0.25 ^{n.s}
Harvesting	22.76%	77.24%	36/82%	63.18%	4.08*
Harvesting& Winnowing	77.24%	22.76%	40.45%	59.55%	26.45*
Transportation	14.84%	85.16%	100%	0.0%	144.85*

*= Statistically Significant at 5%, n.s. = Not Statistically Significant.

Table (2) Estimation of Rice Production Function

Variable	Year	Estimate	SE of Estimate	Cal. T Ratio
Constant	1986	0.05	0.011	4.40**
	1996	0.15	0.041	3.61**
Human Labor: Man- Hour	1986	0.40	0.008	4.46**
	1996	0.08	0.026	3.02**
Machinery labor: Horse Power	1986	0.19	0.05	3.72**
	1996	0.25	0.086	2.91**
Animal Work : Horse Power	1986	0.09	0.04	2.34**
	1996	n.s.	n.s.	n.s.
Nitrogen Fertilizer. Effective Substance (Nitrogen)	1986	0.25	0.09	2.67**
	1996	0.27	0.082	3.29**
Crop Area	1986	n.s.	n.s.	n.s.
	1996	0.11	0.035	3.11**

$R^2 = 0.78$ for estimated function in 1986 and $R^2 = 0.85$ for

The estimated function in 1993; (**) = Statistically Significant at $P < 0.01$.

n.s. = Not Statistically Significant.

Table (3) Comparison of inputs and output density per feddan of rice over the period 1986- 1993

Inputs and Outputs/ feddan	1986	1996	Calculated T
			Ratio
Seeds in Kg	83.81	85.56	0.28 ns.
Super Phosphate fertilizer	13.78	137.7	9.33*
Urea fertilizer in Kg	64.47	91.04	4.22*
Potassium Sulfate Fertilizer in Kg	103.17	179.4	4.08*
Human labor in Man- Day	45.06	33.67	2.99*
Machinery Labor in Hours	12.90	17.63	1.12ns.
Animal Work in Days	8.69	3.45	2.97*
Grains Yield in Tons	2.38	2.38	0.72 n.s
Straw Yield in Tons	1.16	1.53	1.50 n.s

(*) = Statistically Significant at $P < 0.01$: (n.s.) = Not Statistically Significant.

Table (4): Current and shadow Prices of inputs and outputs, in L.E.

Item	Egyptian Pounds		Shadow Prices
	1986	1996	
Labor Wage/ Man- hour	0.6	0.83	2.42
Machinery Work/ hour	3.5	6.72	7.40

Ton of Grains	406	698	1221
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Table (5): Economic Efficiency of inputs (marginal return/ L.E. Spent on an input)

Year		Human labor	Machinery labor	Crop Area	Fertilizer
1986	Current Price	2.07	1.63	N.A.	1.5
1996	Current Price	0.96	2.27	0.56	6.94
	Shadow Price	0.58	2.56	N.A.	-

N.A. = Not available.

Table (6): The least cost combination of labor- machinery work per feddan versus the existing combination.

Input identification	Year	Existing Situation	Least cost Combination at market wage and rent rate	Least cost Combination at Shadow wage and rent rate
	1996	33.67	24.91	12.1
Machinery hours	1986	12.6	19.6	N.A.
	1996	17.63	19.12	23.23