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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 procedure is 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 sucessive 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 amaximum 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.

In order to maintain agriculture growing at an economic competitive performance, all economic criteria, derived from the production function analysis in this study showed that the growth in production and maximization of income must rely upon a package of physical and biological technologies (new varieties, fertilizers and mechanization of farm operations).

Rural development programs and economic development plans should create employment opportunities for the excess agriculture labor –beyond the economic density. Such opportunities should be either in agricultural related industries, non-agricultural small industries in villages or other economic activities in rural towns.

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, (Baker, et al, 1987). 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, (Soliman, 1992). 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, (Frisch, 1965).

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, (Soliman, 1994). The development plans 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 expansion in mechanization, and substitutability for human labor, (Soliman, 1995).

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 the study objectives, the empirical part of this study depended upon two sample surveys conducted by the authors in two different periods. The first was for the agricultural year (1986/1987), i.e. before the boom of the economic liberalization in Egypt and before the great expansion of agricultural machinery intensification. The other sample was conducted for the agricultural year (1995/1996), 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". The target crop "Rice" is a major exportable crop in Egypt. 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 stratified pattern of the farm size in the conventional village in Egypt, i.e. from one "feddan", (about one-acre) to more than 10 feddans per farm.

Analytical procedures

For assessment of the level of expansion in agricultural mechanization 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 (Imam and Soliman, 1982).

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 in 1997, (1-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, (Dillon, 1977, Heady, 1978, Soliman, & El Shenawy, 1985 and Soliman, 1985):

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 is 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 (Soliman and Megahed, 1984). 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 input (crop area) response was significant in the 1996 model, but not in the model of 1986. The animal work input was not significant in 1996 estimated function because its 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 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, 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 technology (new varieties) over the period 1986-1996, (Soliman, et al, 1995).

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 tens in 1996. However due to high variation in yield within farms the 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 Cobb-Douglas 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.

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, (Soliman, et al, 1994b).

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 (Table, 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 Tables (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 implies "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 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. 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).

In order to keep agriculture growing at an economic competitive performance an integrated rural development programs should be inserted in the economic development plans to create employment opportunities for such excess agriculture labor,. Such opportunities should include either agricultural related industries, non-agricultural small industries in villages or other economic activities in rural towns. 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.

References

Baker, Randolph and Herdt, Robert W. (1978) "Equity implications of Technology Changes" Interpretive Analysis of Selected Papers from Changes in Rice Farming in selected Areas of Asia Los-Banos International Rice research Institute

Dillon, John (1977) "The Analysis of response in Crop and Livestock Production" Second edition, Pergamom Press Inc, Maxwell House, Fairview Park Elmsford, New York. USA.

Frisch, Ranger (1965) "Theory of Production" Translated from the Norwegian, by (R.I. Christopherson, D. Reidel Publishing Company. Dordrecht, Holland. PP. 30-38.

Heady, E. O. (1978) "Economics of Agricultural Production and Resource Use". Prentice Hall, New York. USA, PP. 790-800.

Imam, Shawky & Ibrahim Soliman (1982) "An Economic Study for Wheat production Activity in Egyptian Agriculture" The Proceedings of the 7th International Congress of Statistics, Computer Sciences, Social and Demographic Research, Computing Center. Ain Shams University, Abbassia, Cairo, Egypt

Soliman, Ibrahim & Megahed, Miassa (1994) "Economic Efficiency for Operating the Agricultural Tractor" Proceedings of the Fifth Conference of Agricultural Development Research, 20-22 December published in Annals of Agricultural Science, by Ain Shams University, Faculty of Agriculture. Cairo. Egypt.

Soliman, Ibrahim (1985) "An analysis of the Buffalo milk response under the Conventional Egyptian Farming System" Proceedings of the 10th Conference of Statistics, Computer Sciences, Social and Demographic Research, Vol. 3. P. 91-106 Computer Center, Ain Shams University, Cairo, Egypt

Soliman, Ibrahim (1992) "Agricultural Mechanization and Economic Efficiency of Agricultural Production in Egypt" An Invited Paper to The 92-lnternational Conference of Agricultural Engineering, Published in the conference proceedings, Vol. 1, Beijing Agricultural Engineering University. Beijing, P.R. China.

Soliman, Ibrahim and El-Shenawy, Mohammed (1985) "Livestock

Working Power in Egyptian Agriculture". 18-Annual Conference of Statistics, Computer Sciences, Operation Research and Mathematics Vol. 18 No. 1 Institute of Statistical Studies and Research. Cairo University, Giza, Egypt

Soliman, Ibrahim, Al-Zanati, M., Gaber, M. and Ibrahim, A. (1995) "Impacts of Techno-Economic Changes on Input-Output relations for Wheat crop in Egypt, Journal of Agricultural Economics, Vol. 4, no. 2, pp. 177-786, Published by Egyptian Journal of Agricultural Economics. Agricultural Club, Cairo, Dokki, Egypt

Soliman, Ibrahim, Gaber, M., A. Ibrahim (1994a) "Evaluation of Investment in Non-Conventional Agricultural Machinery under Private and State management" Journal of Agricultural Research, Faculty of Agriculture, Minia University, Minia, Egypt

Soliman, Ibrahim, Gaber, Mohammed and Ibrahim, A. (1994b) "Socio-Economic impacts of Non-Conventional mechanization for wheat Crop: A case study in Kafr Al Sheikh Governorate" Journal of Agricultural Research of Faculty of Agriculture, Minia University. Minia, Egypt.

Soliman, Ibrahim, Gaber, Mohammed and Ibrahim, A. (1994c) "Farm Production for Wheat under Non-Conventional Mechanization System" Proceedings of the Fifth Conference of Agricultural Development Research, 20-22 December Published in Annals of Agricultural Science, by Ain Shams University, Faculty of Agriculture. Cairo Egypt.

Soliman, Ibrahim, Gaber, Mohammed and Ibrahim, A. (1994d) 'Socio-Economic Impacts of Biological and Mechanical Technological package Applied for Sugarcane Development : A Case study in Minia Governorate" Proceedings of the Fifth Conference of Agricultural Development Research. 20-22 December Published in Annals of Agricultural Science, by Ain Shams University, Faculty of Agriculture. Cairo. Egypt

Spenser, Dustan & Byerlee, Derek (1976) "Technical Change, labor Use and Small Farmer Development: Evidence from Sierra Leone" American Journal of Agricultural Economics. Vol. 58 PP. 874-80.

Table (1): Percentage of farms that Conducted Farm operations with Machinery VS without Machinery

Year	1986		1996		Calc. Chi. Square
Farm Operation	**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	0.0.08	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

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
Man- Day	1986	45.06	35.4	N/A
	1996	33.67	24.91	12.1
Machinery hours	1986	12.6	19.6	N.A.
	1996	17.63	19.12	23.23