Technological Change and Surplus Labor in Egyptian Agriculture During a Reform Era

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Summary

This paper investigates the production structure of Egyptian agriculture from the early 1960s to the mid-1990s to identify technological change considering the effect of agricultural reform programs. The results suggest that agricultural production in Egypt (1964-1995) depends mainly on technical inputs such as machinery and fertilizer as a result of increasing in labor cost, and total factor productivity growth was generally stagnant but grew rapidly after the program implementation. These facts imply that farmers' efficiency significantly improved due to reform programs, and provide a justification to introduce the structural adjustment based on the idea of neo-classical economics. Thus, agricultural reform programs were successful in meeting their objectives; however, much less so in terms of income distribution. Distortions still remain particularly in the labor market while price distortions were corrected and the governmental control on agricultural management was significantly relaxed.

1. Introduction

One of the most remarkable changes in the developing countries since the late 1980s is the introduction of the stabilization and structural adjustment program led by the International Monetary Fund (IMF) and the World Bank, particularly in "major *dirigiste* countries" which adopted a more stringent type of controlled economic system for promoting their post-1945 development[1]. Egypt is one of the countries in the Middle East that initiated reforms in the early stage of modern economic development. The point of

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[1] Ishikawa (1993: 146-151) nominated Egypt, China and India as the three major *dirigiste* countries in which an economic management system was established as a socialist nature as well as a social welfare system, and the state's intervention prevailed in the nation's economic process both extensively and intensively.

departure of the liberalization of the economy was the open door policy called "*infitaf*" introduced in 1974 to overcome economic stagnation under the socialist type of the command economy. Rapid economic growth was achieved from the latter half of the 1970s to the mid-1980s; however, the government of Egypt has been suffering from chronic difficulties in the balance of payment and the budget deficit, and economic growth became stagnant towards the mid-1980s as a result of the fall in oil price[2]. As a consequence, the government of Egypt requested the assistance of the IMF and the World Bank in 1986, and introduced comprehensive economic reform to tide over the economic crisis.

The transformation of the overall economy affected the Egyptian agricultural sector and enhanced efficiency in production of farmers in several ways: encouraging investment and spread of new technologies, strengthening access to markets for agricultural inputs, providing export incentive, and creating jobs in industries for agricultural raw materials for abundant workers. Thus, the basic presumption of this paper is that agricultural policy reforms had a positive impact on the improvement of farmers' efficiency in production and management.

The comprehensive analysis made by Fletcher (1996) regarding the impact of agricultural policy reforms provides a positive evaluation of the reform implementation, and the survey of Egyptian farm labor market by Richards (1991, 1994) suggests superiority of the neoclassical assumption to explain the behavior of farmers. Regarding technological change in agricultural production, Youssef and Grabowski (1984) made a empirical analysis to identify the labor using type of technological innovation. Neither study, however, provides empirical investigation concerning the effect of reform implementation on technological change. Hence, the purpose of this paper is to analyze the production structure of agriculture in Egypt, and identify technological change in productivity by estimating total factor productivity, particularly focusing on the effect of policy reforms after 1987 in the context of structural adjustment.

Hereafter, let us divide the period of development of agriculture in Egypt into three: period I (1964-1973) characterized by the socialist regime under the Nasser administration; period II(1974-1986) when the policy was changed and liberalized through the open door policy; and period III(after 1987) when agricultural policy reforms were

[2] The high growth is largely explained by capital inflows through petroleum exports, remittances from migrant workers, Suez Canal revenues, and earnings from tourism during the oil boom. Yet, GDP growth rates declined in the early 1990s and, as an influence of the Gulf War, the economy was hit by a significant decrease in overseas remittances due to increase in returnees from Gulf countries while the unemployment rate was already high.

initiated. In the next section, several agricultural policy reforms and the growth and structural change in agricultural production are explained from the point of liberalization and deregulation. The methodological framework is developed in section 3. Sections 4 and 5 present the data and empirical results of the estimation of production function and growth accounting. The surplus labor condition is examined including changes in factor substitution, and the remaining problem of distortions in the labor market is discussed in section 6. Section 7 provides the conclusion.

2. Policy Reform and Growth of Agriculture

The government of Egypt has been implementing macro-economic stabilization and structural adjustment programs since 1987 to resolve the economy's underlying macro -economic imbalances and structural distortions. Initial efforts were concentrated on some liberalization of trade and domestic prices aimed at providing an incentive for the growth of production and export for the overall economic sector. In 1991 the government of Egypt adopted the comprehensive Economic Reform and Structural Adjustment Program (ERSAP), which was intended to lessen reliance on the state's control on the overall economy, to develop a stronger market economy and to open more opportunities for the private sector. The program was designed to deregulate interest rates, unify exchange rates and devaluate the currency, reduce consumer and industrial subsidies, lower the money supply and fiscal deficits, liberalize prices and foreign trade, and restructure public enterprises and initiate their privatization.

Agricultural reform programs were introduced in the line of stabilization and structural adjustment. Deregulation and liberalization in overall economic activities also benefited the agricultural sector with respect to the liberalization of direct markets and price control of thirteen major crops including cotton, rice, wheat and maize, elimination of input subsidies and government marketing monopolies, and devaluation of the exchange rate. This section explains agricultural policy reforms implemented in period III. Then, let us observe growth and structural change in agricultural production particularly comparing between before and after the reform implementation.

2.1 Agricultural Policy Reforms

Agricultural reform programs were developed in two phases. The first phase of reform was from 1987 to 1989, and the second phase was from 1990 to 1994. Before the policy changes, the government implemented direct price and marketing controls, public ownership of key agricultural industries, heavy net taxation of agriculture, and over-

valued exchange rates. Also, close supervision of the agricultural cropping pattern by the government became part of the agricultural policy beginning in the early 1960s[3]. Thus, until the mid-1980s, agricultural production incentives were reduced directly through implicit taxation on outputs due to price control, and indirectly through the high industrial trade protection and overvalued exchange rates[4]. Those administratively dictated direct price policies and indirect macroeconomic policies resulted in large-scale transfers of resources from agriculture to government, industry and urban consumer.

In 1986 the government of Egypt assisted by the United States Agency for International Development (USAID) initiated a program of reforms under the policy component of the USAID-funded Agricultural Production and Credit Project (APCP). The first phase covered price and marketing controls and delivery quotas for 10 major and minor crops, reduced subsidies on inputs, and began the process of opening markets to private investment. As a consequence, markets for the ten crops were freed, farm-gate prices of fertilizer increased by 75 percent, and citrus exports were opened to private sector, and the public agricultural bank made progress in diverting itself of input marketing. In the second phase, principal benchmarks were established to increase cotton procurement prices to 66 percent of the economic price (complete liberalization became the target in 1992 and was accomplished in 1994), remove procurement quotas on rice, eliminate subsidies on all inputs, reduce the role of the Principal Bank for Development and Agricultural Credit (PBDAC) in input marketing, restrict subsidized credit, improve PBDAC's institutional structure and operations, and reform the structure of seed production and marketing (Khedr, Ehrich and Fletcher, 1996: 51-53).

2.2 Growth and Structural Change in Agricultural Production

The agricultural sector in Egypt is the main industry, which accounts for around 15 percent of GDP and 30 percent of employment in the mid-1990s[5]. The growth of agricultural production from the mid-1960s is shown in Table 1. Before 1974, the

[3] Arguments for the control of crop areas were based on the concept that the agriculture sector was interrelated with other sectors of the economy and that errors in the agricultural sector, such as a shortage of cotton, would cause losses to the industrial sector. Also, the industrial sector was responsible for providing the inputs needed in agriculture and could not make production plans without knowledge of agriculture's need. The basic philosophy was that state planners could make better decisions than could individual farmers. It is a standard socialist dogma. See Nassar et al. (1996: 87-88).

[4] According to Khedr, Ehrich and Fletcher (1996: 57), producer's prices were kept at low levels relative to international market values with implicit tax on outputs offset to a degree by free irrigation water and subsidized credit and inputs.

[5] See the National Bank of Egypt, *Economic Bulletin*, Vol. XXXXXI No. 3, 1998, Cairo, pp. 93-94.

agricultural sector experienced rather moderate growth rates while the 1967 war with Israel had a negative effect on the sector. There are two main reasons for the growth of production in period I: (1) the completion of the construction of the Aswan High Dam and its complementary irrigation projects in 1970, and (2) the increase in agricultural investment in particular with land reclamation, irrigation and drainage during the years of the First Five-Year Plan (1960/61-65/66).

On the other hand, growth rates fell after 1974 despite the fact that the economy as a whole achieved rapid growth, indicating that real GDP grew at about 8 to 9 percent per year. This deceleration of growth rates during period II was, first, due mostly to the decrease in the agricultural labor induced by rapid migration heading to oil rich countries during the oil boom. Second, the deficiency of investment in irrigation and drainage during the Third Five-Year Plan (1978-82) in which the allocation of investment concentrated on the industrial sector in particular with that of petroleum and its products, and on the Suez Canal. Third and most important, governmental control on prices and cropping patterns as well as the overvalued exchange rates regime had a negative effect on the incentive structure for agricultural production activities. The agricultural sector had been squeezed due to the governmental intervention to promote industrial growth under protection and promotion of the industrial sector with import substitution strategy[6].

However, there was a significant increase in growth from 1987 to 1995 including the growth in the post-program period (1992-95), more than doubled compared with that of period II. Broadly interpreted, the recovery of growth is explained by policy reforms. First, the abolition of price control on the main crops and the deregulation of control over cropping patterns increased crop prices, stimulating farmers to increase crops yields (Khedr, Ehrich and Fletcher, 1996: 52, 71-73). Second, the transition to the export -oriented regime after 1986 and following devaluation and liberalization of foreign exchange gave an incentive to export. In addition to these policy changes, the increase in crop prices stimulated farmers to adopt new varieties including high-yielding varieties and to apply better management technologies. Fourth, there was a significant increase in reclaimed land totalling 72,600 ha in 1993/94 and 51,200 ha in 1994/95[7]. Moreover, the

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[6] Shaban, Assaad and Al-Qudsi (1998: 70-71) pointed out regarding the general policy adapted by the Arab countries including Egypt that overall demand for agricultural labor declined during the oil boom; this resulted from worsening terms of trade in agricultural commodities because of appreciating currencies which cheapened the domestic price of imported agricultural goods and from government policies that kept the prices of major cereal crops artificially low to subsidize urban consumers.

[7] See the CAPMAS, *Statistical Yearbook 1990-1995*, July 1996, Cairo, pp. 94.

return of migrants to agriculture from the Gulf countries also contributed to the growth of production. Hence, period III, particularly in the 2nd phase and the post-program period, is characterized as the period in which supply-side constraints were significantly relaxed and production efficiency is assumed to have improved.

Table 1. Annual Rates of Growth in Agricultural Production (unit: percent)

	Total Output	Production Index
Period I : 1964-1973	4.7	2.3
Period II : 1974-1986	2.5	2.5
Period III : 1987-1995	4.1	3.5
(1987-1999)	3.8	3.9
1st Phase : 1987-1989	3.5	0.3
Pre-program period : 1987-1991	2.6	2.8
2nd Phase : 1990-1995	4.4	4.0
Post-program period : 1992-1995	6.1	3.4
(1992-1999)	4.7	4.1
Whole period : 1964-1995	3.8	2.7
(1964-1999)	3.6	2.9

(Note) Total output is real term deflated by GDP deflator (1977=1.0).
(Source) Central Agency for Public Mobilization and Statistics, *Statistical Handbook*, various editions, Cairo.
Central Agency for Public Mobilization and Statistics, *Statistical Yearbook*, various editions, Cairo.
FAO Statistical Database[8].

This cycle of growth, stagnation and recovery of production was accompanied by changes in relative factor inputs, as shown in Table 2. The major trend since the mid-1960s has been a decline in the share of labor input with a drastic increase in machinery inputs[9]. First of all, the growth rate of labor input measured by both number and workdays was already at a low level, less than 2.0 percent. It indicates that migration to the non-agricultural sector has been induced since the mid-1960s, accompanied by the mechanization of the production process, while the increase in investment in irrigation

[8] See FAOSTAT Agriculture Database: FAOSTAT Database Collections/Agricultural Production Indices <http://www.fao.org>.

[9] A sizable transfer of agricultural labor to the non-agricultural sector contributes to the growth of those sectors. The decline in the share of labor input of agriculture increased the level of labor productivity at 2.7 percent per year from 1964 to 1999. See CAPMAS, *Statistical Handbook* and *Statistical Yearbook*, various editions, Cairo.

and drainage during the First Five-Year Plan induced the growth of labor demand. The budget share spent on agriculture rose mainly in response to the input subsidies[10]. As noted, pricing policies together with input subsidies to transfer resources to the non-agricultural sector and urban consumers were an essential part of pre-reform agricultural policies. However, the growth rates of the labor input showed a significant decline during period II, and the labor input measured by the number of workdays changed to negative. Thus, price distortions partly explain changes in the factor proportion as substitution of labor with machinery and fertilizer.

Table 2. Annual Rates of Growth of Factor Inputs in Agriculture (unit: percent)

	Annual Rates of Growth(%)					
	Labor		Machinery	Fertilizer	Land	
	Number of Workers	Number of Workdays	Number in Use	Metric tons Consumption	Area Cultivated (hectares)	Area Cropped (hectares)
Period I : 1964-1973	1.4	1.8	3.9	3.1	1.4	0.1
Period II : 1974-1986	0.2	-5.0	7.2	5.9	-0.9	-0.7
Period III : 1987-1995	1.1	2.9	6.5	2.7	3.2	3.5
(1987-2000)	1.1	-	3.7	2.7	2.0	2.8*
1st Phase : 1987-1989	1.2	13.8	2.5	3.6	0.5	3.2
Pre-program period : 1987-1991	1.2	5.7	2.9	1.8	0.9	4.2
2nd Phase : 1990-1995	1.1	-0.2	8.7	2.9	4.3	3.0
Post-program period : 1992-1995	1.1	-2.8	12.2	8.0	4.1	3.8
(1992-2000)	1.0	-	4.2	4.7	1.6	2.4*
Whole period : 1964-1995	0.8	-0.2	5.7	4.2	0.9	0.9
(1964-2000)	0.8	-	4.9	4.0	0.8	1.0*

(Source) Central Agency for Public Mobilization and Statistics, *Statistical Handbook*, various editions, Cairo.
Central Agency for Public Mobilization and Statistics, *Statistical Yearbook*, various editions, Cairo.
FAO Statistical Database[11].
Gardner and Parker (1985: 13-14).
(Note) *indicates growth rate until 1999.

On the other hand, growth of input of machinery and fertilizer showed a remarkable increase while that of land changed to negative. This dramatic change in factor propor-

[10] Khedr, Ehrich and Fletcher (1996:62) suggested from the historical patterns of government expenditure of Egypt that there was likely a trade-off between subsidy expenditures and funding for public agricultural investments and support services.

[11] See FAOSTAT Agriculture Database: FAOSTAT Database Collections/Means of Production <http://www.fao.org>.

tions is interpreted by external effects. First, demand for Egyptian labor skyrocketed as a consequence of the 1973 and 1980 oil shocks. More than two million laborers migrated to the Gulf countries like Saudi Arabia, Kuwait, Qatar and Iraq. Second, the inflow of remittances earned by Egyptian migrants induced investment to small scale and labor -using industries as well as the construction boom (Richards, 1991: 77-80). The fact that labor was drawn out of agriculture to work abroad and in non-farm jobs including public sector employment implies that the rural labor market has been gradually tightened as agricultural real wage has been going up[12]. Third, inputs of machinery and fertilizer are still in upward movement even in the trend of the liberalization of economy. During the Sadat administration in this period the budget share allocated for subsidies remained stable or was even growing. Moreover, the overvaluation of exchange rate favored the price of imported inputs and the supply price was kept low compared to the international level. Those changes in relative factor prices induced mechanization of Egyptian agriculture. Governmental control on prices and cropping patterns remained in period II as well as the high burden on the budget due to the subsidization induced policy changes.

In contrast, governmental intervention in the agricultural sector was broadly liberalized in period III. Overall deregulation of its management together with the devaluation of foreign exchange provided incentive for farmers to adopt new technologies. It is noteworthy that the land input grew at more than 3.0 percent, and the growth of cultivated area went up to 4.3 percent in the 2nd phase of the reform era. The input of machinery and fertilizer also grew steadily despite the abolition of the input subsidies. Migration to oil rich countries flattened out due to dropping of the price of oil, but grew rather moderately. Increased rural wages together with agricultural price policies induced mechanization and capital intensity of agricultural production. In the next section, empirical investigation by the growth accounting approach is made to identify technological change.

3. Total Factor Productivity and Growth of Agriculture: Growth Accounting Framework

This section presents the methodological framework of the empirical investigation of this paper. The method used in this study is to estimate a production function, based on

[12] Richards (1994:240-244) suggested that in Egypt widespread discussion of 'agricultural labor shortage' became fashionable among farmers and national policy makers since the first oil shock of 1973.

R. Solow's approach. To capture the technological change, let us start with the following production function that represents the farmers' producttion technology:

$$Y=A_{(t)}\, f(K, L, F, R), \tag{1}$$

where Y is output, $A_{(t)}$ reflects Hicksian neutral and disembodied technological change; K, L, F, and R refer to inputs of machinery, labor, fertilizer and land in physical units, respectively. This function (1) is assumed to be continuous and twice differentiable. For econometric estimation, the following Cobb-Douglas type of production function is employed.

$$Y_{(t)}=A_{(t)}\, K_{(t)}^{\beta_k} L_{(t)}^{\beta_l} F_{(t)}^{\beta_f} R_{(t)}^{\beta_r} e^{\mu}, \tag{2}$$

where β_k, β_l, β_f, and β_r are parameters, and denote the factor share of machinery, labor, fertilizer and land in output, respectively. μ is the error term with its expected value being zero. Differentiate the equation (2) with respect to $L_{(t)}$, the marginal productivity of labor is written as:

$$\frac{\partial Y_{(t)}}{\partial L_{(t)}}=\beta_l \frac{Y_{(t)}}{L_{(t)}}\,. \tag{3}$$

As shown in equation (3), the marginal productivity of labor at t is derived as $\beta_l y_{(t)}$ where $y_{(t)}=Y_{(t)}/L_{(t)}$ is the labor productivity. Differentiate the function (1) totally with respect to time and divide by Y, yields:

$$\frac{dY}{Y}=\frac{dA}{A}+\frac{dK}{Y}\frac{\partial Y}{\partial K}+\frac{dL}{Y}\frac{\partial Y}{\partial L}+\frac{dF}{Y}\frac{\partial Y}{\partial F}+\frac{dR}{Y}\frac{\partial Y}{\partial R}\,. \tag{4}$$

Assuming that the factor market is perfect, the marginal productivity of each factor inputs equals the factor price in equilibrium. We finally obtain the total factor productivity growth rate denoted here as dA/A,

$$\frac{dA}{A}=\frac{dY}{Y}-\beta_k\frac{dK}{K}-\beta_l\frac{dL}{L}-\beta_f\frac{dF}{F}-\beta_r\frac{dR}{R}\,. \tag{5}$$

We do not impose the restriction of the constant returns to scale on the production function (1) a priori, but make a statistical test of this hypothesis. In the following section, data and empirical results based on the estimation of the function (2) are presented.

4. The Data

The data required for the estimation of the model is value of output, and quantity of four factor inputs: machinery, labor, fertilizer, and land. The main sources of data are

the *Statistical Yearbook* and *Statistical Handbook* published by the Central Agency for Public Mobilization and Statistics. The data of output (Y) was measured as gross value added in the agricultural sector in real terms which was deflated by the GDP deflator. The deflators were taken from the *International Financial Statistics* published by the IMF. As for the independent variables, the quantity of machinery input (K) was measured by the sum of the number of tractors and harvesters-threshers in use. The quantity of labor input (L) was defined as the total number of male-equivalent labor days in thousands. The number of male-equivalent labor days were estimated by dividing total labor cost by the price of male-labor. The quantity of fertilizer input (F) measured by the sum of nitrogen, phosphate and potash fertilizer consumption in thousand metric tons, and the quantity of land input (R) was defined as the total cropped area in thousand hectares. The data of machinery and fertilizer were collected from the FAO Statistical Database. The source of data of area cropped was Gardner and Parker (1985: 13-14) and the *Statistical Yearbook* by the CAPMAS.

5. Empirical Results

The log liner form of the production function (2) was estimated by the ordinary least squares method with time series data from 1964 to 1995. Table 3 presents the estimates of the production function. The statistical test in EQ1 for the constant returns to scale indicates that the null hypothesis was accepted at 5 percent level. Thus, in EQ2 parame-

Table 3. Estimated Parameter of the Agricultural Production Function

	Regression Number			
	EQ1 Coefficient		EQ2 Coefficient	
Constant	-4.973**	(-2.136)	-3.983***	(-7.038)
Labor(β_l)	0.108**	(1.844)	0.110**	(1.911)
Machinery(β_k)	0.232***	(2.106)	0.258***	(2.824)
Fertilizer(β_f)	0.459***	(3.503)	0.436***	(3.687)
Land(β_r)	0.308	(1.127)		
Observations	32		32	
S.E. of regression	0.072		0.071	
Adjusted R^2	0.954		0.943	
D.W.	1.312		1.285	
Implicit Coefficient of Land(β_r)			0.196	

(Note) Equations are estimated by the ordinary least squares.
Figures in brackets are t-values.
*** and**indicate significance at 1% and 5% level, respectively.

ters are estimated with the restriction of constant returns to scale. The adjusted R^2 indicates a fairly good fit of the model, and the D.W. value indicates inconclusiveness of the serial correlation.

The levels of statistical significance of the estimated coefficients seem to be satisfactory in both cases. Inputs of machinery, labor and fertilizer are statistically significant. In particular, production elasticities of machinery and fertilizer interpreted as technical inputs are high while that of labor is low. As expected, these inputs contribute positively to growth of output.

In Table 4, the marginal productivity of labor (hereafter MPL) was calculated as a shadow price based on estimated production elasticity of labor (β_l) with the constant returns to scale. Agricultural real wage was rather stable but grew rapidly from the mid -1970s. While it changed to a decreasing trend from the end of the 1980s, the differential

Table 4. Labor Productivity, Marginal Productivity of Labor and Real Wage Rate in Agriculture (unit: L.E. in real terms)

Year	Labor Productivity (per labor-day) (1)	Marginal Productivity of Labor (2)	Real Wage Rate (per labor-day) (3)	(3)/(2)
1965	1.73	0.19	0.51	2.66
1967	1.77	0.19	0.57	2.94
1969	1.68	0.19	0.52	2.84
1971	1.74	0.19	0.49	2.57
1973	2.02	0.22	0.51	2.31
1975	2.07	0.23	0.49	2.15
1977	2.95	0.33	0.75	2.29
1979	3.65	0.40	0.85	2.11
1981	5.03	0.55	1.12	2.02
1983	7.02	0.77	1.47	1.90
1985	6.12	0.67	1.74	2.59
1987	5.18	0.57	1.75	3.06
1989	4.92	0.54	1.37	2.52
1991	4.82	0.53	1.09	2.05
1993	3.83	0.42	0.92	2.17
1995	5.40	0.60	1.29	2.16

(Note) Unit is L.E. in real terms deflated by the GDP deflator (1977=1.0).

(Source) Central Agency for Public Mobilization and Statistics, *Statistical Handbook*, various editions, Cairo.
Central Agency for Public Mobilization and Statistics, *Statistical Yearbook*, various editions, Cairo.

with the MPL has been reduced. The estimated correlation coefficient between the MPL and agricultural real wage was 0.887. These results imply that the agricultural wage rate seems not to be determined institutionally at the subsistent level as it has been increasing since the mid-1970s, and to fluctuate in response to change in supply and demand as it positively correlates with the MPL. Yet, note that the MPL is below the real wage rate. Hence, it is suggested that labor remains abundant despite the labor market being gradually tightened.

Table 5 presents results of growth accounting based on the estimated production elasticities. The contribution to output of each factor input is calculated by the estimated coefficients with constant returns to scale. Several findings are noteworthy. First, the total factor productivity (hereafter TFP) grew at a slow pace throughout the observed period and its contribution to output growth is less than that of other machinery and fertilizer. In this analysis, however, we interpret that technological innovations are associated with a high level of such modern inputs in use. Thus, the high contribution of input of machinery and fertilizer indicates that technological innovations were induced in the process of the application of those technical inputs[13].

Second, it should be noted that the TFP growth rate changed to positive after the reform implementation. As shown, the TFP growth rate during the post-program period indicates 1.15 percent annually with its contribution to output growth rate of 19.0 percent. This fact suggests that agricultural reform policies significantly improved farmers' efficiency in production. On the contrary, rapid growth of TFP observed in period I is more than that of after the program implementation. Indeed, under the socialist regime of this period agricultural investment mainly targeted at the development of irrigation and drainage network rather than the diffusion of machinery and fertilizer, and significantly contributed to growth of output. In addition, farmers could increase the substantial production levels since irrigation water became available all the year round, thanks to the completion of the Aswan High Dam[14]. Therefore, it is interpreted that the high contribution of TFP in this period accounts mostly not for the technological innovation but for capital accumulation through the creation of large-scale agricultural infrastructures.

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[13] Mechanical innovations are usually associated with larger inputs of power and machinery. Biological improvements, such as the innovations embodied in high yielding varieties, are typically associated with higher levels of fertilizer use. See Hayami and Ruttan (1970:896-897).

[14] Application of modern fertilizers becomes indispensable in the introduction of new varieties to raise productivity after the change of irrigation system from traditional type called *Basmin* to the modern system. Increase in fertilizer application as shown in Tables 2 and 5 after the completion of the Aswan High Dam is consistent with this fact.

Elaborating on factors accounting for the rapid growth, in particular with the second phase including the post-program period, the contribution of machinery input jumped up in comparison with the pre-program period, which explains more than 40 percent of total output growth. The contribution of fertilizer leveled off when compared between before and after the program implementation. The abolition of input subsidies for the application of fertilizer might have had a negative impact, but its contribution still explains about 25 to 30 percent of output growth. As noted, the application of modern machinery and fertilizer embodied technological innovations[15]. Thus, the high contribution of these technical inputs partly explains technological progress, and this fact is particularly true after program implementation.

Table 5. Accounting for Growth in Agricultural Output, based on Estimated Production Elasticities in terms of Annual Rate of Growth (unit: percent)

		Contribution of Factor Inputs to Output Growth Rate				Total Factor Productivity Growth Rate
	Output (dY/Y)	Labor ($\beta_L dL/L$)	Machinery ($\beta_K dK/K$)	Fertilizer ($\beta_F dF/F$)	Land ($\beta_R dR/R$)	
Period I : 1964-1973	4.71	0.03	1.00	1.66	-0.02	2.04
	(100)	(0.6)	(21.3)	(35.3)	(-0.5)	(43.4)
Period II : 1974-1986	2.46	-0.44	1.80	2.56	-0.10	-1.37
	(100)	(-17.7)	(73.3)	(103.9)	(-4.0)	(-55.5)
Period III : 1987-1995	4.11	0.37	1.50	1.30	0.74	0.20
	(100)	(9.0)	(36.6)	(31.6)	(18.1)	(4.8)
1st Phase : 1987-1989	3.52	1.28	0.48	1.56	0.83	-0.63
	(100)	(36.4)	(13.7)	(44.2)	(23.6)	(-18.0)
Pre-program period : 1987-1991	2.56	0.66	0.64	0.92	0.91	-0.57
	(100)	(25.9)	(25.1)	(35.9)	(35.4)	(-22.2)
2nd Phase: 1990-1995	4.41	-0.08	2.01	1.17	0.70	0.61
	(100)	(-1.9)	(45.6)	(26.5)	(15.9)	(13.9)
Post-program period : 1992-1995	6.06	0.01	2.58	1.77	0.54	1.15
	(100)	(0.11)	(42.5)	(29.3)	(9.0)	(19.0)
Whole period : 1964-1995	3.77	-0.06	1.47	1.92	0.16	0.28
	(100)	(-0.5)	(41.4)	(51.4)	(5.0)	(2.8)

(Note) Brackets indicate relative contribution to output growth rate (unit : percent).

[15] High yielding varieties (HYVs) have been tried to be introduced many times in Egyptian agriculture since the 1920s. However, they have not been so successful due to some problems in the quality and quantity of harvests, the low tolerances, and the low stem of HYVs that were not suitable for animal fodders. After the deregulation and abolition of agricultural price control by the government in 1986 and 1991, diffusion of HYVs was observed. See Khedr, Ehrich and Fletcher (1996:62).

On the contrary, the contribution of labor input was negative throughout the observed period, and it did not increase even after the program implementation. These results indicate that labor input measured by male-equivalent labor days had been gradually decreasing, and was substituted mainly by input of machinery[16]. This fact coincides with the relative scarcity of labor induced by out-migration to the urban non -agricultural sector as well as abroad. The contribution of labor was negative, particularly in period II when a myriad of migrants headed to the Gulf countries, but it changed to positive after the mid-1980s when many migrants returned as a result of the falling of the oil price.

The measure findings in the empirical results are summarized as follows. First, input of labor, machinery and fertilizer significantly contributed to the growth of agricultural production from 1964 to 1995. Second, the agricultural real wage rate positively relates to the trend of the MPL. This result implies that wage is not determined institutionally, but rather fluctuates in response to the change of demand and supply of labor. The result that the MPL is lower than the wage rate, however, suggests that labor is still abundant despite the relative labor scarcity caused by out-migration. Third, though the TFP growth rate as well as its contribution to output growth was low throughout the observed period, a significant improvement of TFP is observed after the reform implementation. This suggests that the reform programs promoted efficiency in agricultural production. Fourth, input of machinery and fertilizer accounts for more than 70 percent of the output growth, and the contribution of machinery significantly increased due to program implementation. Assuming technological innovations are embodied in these technical inputs, This suggests that technological progress is partly explained by the increase in those inputs and reform programs had a positive impact on diffusion particularly of machinery. Fifth, growth of labor input has been declining and its contribution to growth of output was negative throughout the observed period. This result together with the increase in the contribution of machinery suggests that labor has been substituted by machinery in the production process. This factor substitution is interpreted as a rise in labor cost induced by the increasing labor demand in the non-agricultural sector both in urban areas and abroad.

[16] An increase in agricultural wages during the oil boom induced mechanization, and an increased capital intensity of agricultural production reduced the sector's capacity to absorb the excess labor during the recession of the late 1980s and early 1990s. As for the application of fertilizer, Richards (1991:86) noted that operations remain largely manual tasks. Thus, the diffusion of fertilizer input seems to have a complementary effect on labor input.

6. Surplus Labor in Agriculture

The labor market in Egypt posed a classical debate between surplus labor and their neo-classical critics. As W. A. Lewis (1954) cited, Egypt is a relevant country to apply his theory of economic development, arguing that disguised unemployment exists and unlimited labor supply is available at a constant real wage. However, Hansen (1966, 1969) rejected this labor surplus hypothesis by providing empirical tests that the trend of agricultural real wage was highly correlated with labor productivity from 1914 to 1961, and asserted that the marginal productivity theory is more relevant to rural Egypt. Hansen's series of articles provide convincing evidence of the superiority of a neo-classical analysis of the Egyptian farm labor market.

The empirical results in this paper are compatible with the neo-classical idea of maximization, i.e. even farmers in traditional agriculture respond to economic incentives and behave rationally to maximize their profit. As shown, first, the agricultural real wage highly correlated with the estimated MPL. Second, the agricultural real wage seems not to be given institutionally, but to fluctuate in response to changes in labor endowment[17]. Third, the increase in labor cost as a consequence of labor migration induced mechanization. Fourth, farmers shifted their cropping to more profitable crops as an effect of the abolition of governmental control on prices and cropping patterns. These evidences convincingly confirmed the idea of neo-classical economics and provide a justification for introducing structural adjustments, assuming that liberalization and deregulation have a positive impact to promote farmers' efficiency in production and management. Indeed, empirical evidences support this hypothesis that technological innovation was significantly induced due to the program implementation (Table 4). Hence, it is possible to evaluate the effect of agricultural reform programs to be positive.

The effect of agricultural reform programs on income distribution is, however, doubtful despite the significant improvement in efficiency. The abolition of price control together with the deregulation of overall economic activities had a positive impact on correcting distortions in the product market, but the effect of reforms on distortions in factor markets might be doubtful. As long as a large wage differential and unemployment remain, distortions in the factor market have to be detected. In the Egyptian labor market, two distortions are noteworthy. First, myriads of agricultural labor are still in the

[17] According to Richards (1982: 227-230), wages in the agriculture sector had already been increasing since the mid-1950s. Together with Hansen's empirical studies, Egypt is no more the classical example of a labor surplus economy, and an unlimited supply of labor is no longer available from the 1960s; rather market mechanism is assumed to work even in the rural/agriculture sector. Yet, note that labor is limited but still exceeds demand.

condition of underemployment. Indeed, rural poverty fell sharply both absolutely and relatively during the oil boom (Richards, 1994: 258-259), and the growth in output must have agricultural income increased (Table 4). A recent survey, however, reported the number of unemployed in rural areas increased from 308,000 (1988) to 926,000 (1998)[18]. Moreover, the low MPL indicates the existence of a large number of underemployed (Table 4). These figures indicate that distortions are to some extent negligible.

Second, although unskilled agricultural wage increased rapidly due to the oil shock-induced migration as well as the growth of rural non-agricultural employment by remittance inflow, there still exists a substantial wage differential with the urban non -agricultural sector. This income inequality was reduced in comparison with the 1960s, but wages in non-agriculture are almost double of wages in agriculture. Moreover, the gap was widening during the reform period[19]. High urban expected wages provide incentives to rural unskilled labor to migrate, yet, growing migrants from agriculture in most cases result in either unemployment or underemployment in the urban labor market.

The most plausible explanation for these labor market distortions is that wage is downward rigid despite the excess supply of labor, and the labor market is somewhat segmented. Regarding the rural labor market, underemployment and unemployment exist simultaneously. This fact implies a possibility of segmentation within the rural labor market according to the type of contract, and labor is not perfectly substitutable[20]. Structural adjustment seems to be less effective on such a micro-level distorted structure. On the contrary, a frequently offered explanation of the downward rigidity of wage in the urban labor market is minimum wage legislation and power of union. In the case of urban Egypt, Starr (1990: 3-4) suggested that a minimum wage law was instituted in the urban formal sector, but about 75 percent of laborers in the informal sector earn more than the minimum wage[21]. This suggests that the minimum wage is not high enough to

[18] See R. Assaad, *Comparing Egypt Labor Force Sample Survey 1988 and Egypt Labor Market Survey 1998*, Vol. I, The Economic Research Forum for the Arab Countries, Iran and Turkey, 2000, pp. 29-30.

[19] Note that the implementation of the structural adjustment also contributed to the growth of production and income in the non-agricultural sector. A decrease in the wage differential during the oil boom is mostly explained by relative labor scarcity due to the increase in demand for labor in the Gulf countries. Thus, it is hard to explain the reduction of income inequality by the implementation of structural adjustment itself.

[20] In rural Egypt, the majority of farmers are family-based owner farmers and a large number of casual labor called *tarahil labor* exists. In Egypt casual laborers migrate seasonally to work both at the agriculture and construction sectors. *1960 Population Census, 1976 Labour Force Sample Survey and 1986 Population Census* by the CAPMAS indicate that the ratio of wage labor to total employment in the agriculture sector is 34.5% (1960), 49.9% (1976) and 45.3% (1986). Wages for family labor are two to three times higher than casual labor [Zaytoun (1982: 301-302), Radwan and Lee (1986: 144)] . The *tarahil* labor seems not to be perfectly substitutable with family labor.

allow the urban wage downward rigid. In addition, trade unions are not well organized except in some parts of the manufacturing sector. On the other hand, Zaytoun (1991 : 220 -246) and Assaad (1997: 85-93) pointed out the dominance of the public sector in the labor market where the public sector compensation policy together with the employment guarantee for graduates were instituted. Moreover, the urban labor market is credential where job applicants for government and public sectors are required to have qualifications of graduate, and income depends upon years of schooling and experience (Richards and Waterbury, 1996: 119-120). These findings imply that wages in the formal sector are not determined at market but given institutionally. Considering the growing unemployment of the educated labor, those employment policies would be a main factor in setting wages artificially higher[22]. Thus, the urban wage set institutionally higher than the market clearing level is interpreted as a main cause of wage dualism between urban and rural sectors. Unlike distortions in the rural labor market, these kinds of distorted structures were caused by the governmental employment policy. Hence, deregulation and privatization as targets of the structural adjustment should make a positive impact in removing such policy-induced distortions.

7. Conclusion

Throughout the *dirigiste* countries, the agricultural sector was somewhat squeezed by governmental price control on major crops and overvaluation of exchange rate to transfer resources to more dynamic sectors. Following the stabilization and structural adjustment program to tide over the macroeconomic imbalance, the government of Egypt initiated agricultural reform programs from 1987. This article investigated technological change in agricultural production in Egypt to evaluate the effect of the implementation of agricultural reform programs on farmers' efficiency in production and management.

The agricultural reform programs since 1987 had been a remarkable success in meeting their objectives: eliminate subsidization on inputs, liberalize price control on major crops, and deregulate close supervision of cropping patterns by the government. In addition, programs adopted by the ERSAP like deregulation of interest rates, unifying

[21] According to the law 53: 1984, the minimum wage in the public sector was 420 L.E. annually, and monthly about 35 L.E.. See Rizk (1991 : 184).

[22] According to the CAPMAS survey from the 1960s, the majority of unemployed were the illiterate and the read and write, but they have been shifting to the secondary and university graduates after the survey in 1986. In 1995 while unemployment of the illiterate, the read and write, and the less than secondary education account for 4.4 percent, graduates of secondary, training college and university account for 74.6 percent of the total unemployment. See the CAPMAS, *Labor Force Sample Survey*, 1995, Cairo.

exchange rates, devaluation of currency, reduction of consumer and industrial subsidies, and liberalization of prices and foreign trade benefited the agricultural sector as well. As shown in Table 1, the growth of output is fairly after program implementation, indicating 3.5 to 6.1 percent growth annually.

The rapid growth of output is mostly explained by technological innovation indicated in the significant growth of TFP and input of machinery and fertilizer, assuming technological progress is embodied in these technical inputs (Table 5). In addition, as labor cost has been gradually increasing that reflects the relative scarcity of labor, technological change characterized by rapid mechanization has facilitated the substitution of labor by relatively abundant factors such as machinery and fertilizer inputs in accordance with market price signals.

These empirical results confirmed the basic hypothesis in this study that the implementation of reform programs improved farmers' efficiency in production and management. Moreover, this implication provides a justification to introduce the structural adjustment program, assuming superiority of the neo-classical assumption that even farmers in traditional agriculture respond to economic incentives and behave rationally to maximize their profits.

Considering the significant reduction in rural poverty as well as the growth of income, the structural adjustment program was successful in terms of achieving the objectives, but much less so in terms of income distribution[23]. Observing more than eight years after the 1987 program, the development of private sector is short of expectations, and it is hard to see a significant impact on the reduction of wage differentials within the rural sector as well as between the urban and rural areas. The market reforms including price liberalization to correct distortions, elimination of input subsidies, devaluation of currency and gradual removal of trade barriers provide incentives to domestic farmers to increase their products, but seem to be less effective in removing distortions in factor market that the World Bank originally envisioned.

Investigating the structure of the labor market, it is found that the wage differential due to the difference in type of contract would be a factor in causing segmentation within the rural labor market. On the other hand, institutionally determined wage and employment by the public sector compensation policy and the employment guarantee of graduates are the main causes of distortion in the urban labor market. Structural adjustment as

[23] Vreeland (2001) tested the effect of the IMF programs on labor, and confirmed the view that IMF programs have negative distributional consequences. As for redistribution of income, it was away from labor and labor is worse off in terms of income when countries participate in the IMF program.

well as the agricultural reform programs were less effective on distortions in factor market while price distortions were removed and governmental control was significantly relaxed. However, deregulation and privatization would make a positive impact to remove distortions as long as the distorted structure was caused by governmental policy. As for the rural labor market, distortions are not policy-induced but rather based on the nature of the agricultural production. Thus, direct policy implementation targeted at the rural low-income groups would be effective in reducing income inequality.

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