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Impacts of the Economic Reform Program on the Performance of the Egyptian Agricultural Sector

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Abstract
From 1986 to 2007 Egypt's agricultural policy transitioned from a tightly controlled to a more liberalized regime. This study examines the impact of this change on the performance of the wheat (imported grain) and rice (exported grain) sectors.

In terms of profitability, we found that the cost of production increased substantially in both grains, driven primarily by the rise in land rent and labor wage. But the wheat and rice sectors' profitability did not suffer significantly, as advances in new seed technologies and adoption of better farm practices including farm mechanization increased yield and compensated for the higher cost.

Considering market efficiency, we found that over the study period the farmer's share of the consumer's expenditure dropped from 51% to 37% in the case of wheat, while it increased from 24% to 26% in the case of rice. The reverse happened for wholesale and retail margin share, where it increased for wheat and decreased for rice. It is likely that the discipline from foreign suppliers of imported wheat and foreign market opportunities for exported rice may explain the difference in the changes of the distribution of consumer expenditure.

Finally, we found that area response elasticity decreased over time from 0.58 to 0.12 for rice and 0.60 to 0.38 for wheat. The lack of response in rice area despite rising prices is attributed to the land limit strictly imposed by the Government of Egypt because of water supply constraint considerations. On the other hand, the lack of response in wheat area despite rising wheat prices may be attributed to the rising competitiveness of Egyptian clover, which is a main feed ingredient for the growing livestock sector.

Keywords
agricultural liberalization, area response elasticity, market efficiency, profitability

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Introduction

Egyptian agricultural policy followed a centralized, managed economy from the early 1960s until the mid-1980s whereby the government determined the cropping pattern, associated with obligatory delivery of the main crops to government agencies at fixed prices. Also, inputs were provided to farmers at subsidized prices. Foreign trade faced several central control and barriers. Such interventions and barriers depended on the type of commodity, prices, exchange rates, and quantities. Since the second five-year development plan of Egypt (1987-1992), however, the Egyptian economy, particularly the agricultural sector, started a structural change program towards privatization and market liberalization, which was almost completed by the mid-1990s.[1] In particular, the program phased out agricultural land allotment among crops, which freed the cropping pattern decisions for farmers. Every year the Ministry of Agriculture (MOA) announces only an indicatory cropping pattern. Both agricultural inputs and outputs were liberalized with limited to no government intervention. On the macro economic level, the interest rate and currency exchange rate were also liberalized, and the foreign trade policy, in which the private sector played the main role, was oriented to meet World Trade Organization (WTO) commitments.[2,3]

Increasingly, the government's role has been more focused on support policies for the agricultural sector, particularly extending technical support and agricultural extension services. For example, these policies included support for agricultural mechanization, introduction of high yield varieties, and rationalization in the supply of pesticides and insecticides and chemical fertilizers. The agricultural economic reform era also included the "national campaign for main crop development." Such a campaign focused on the current three main crops of Egypt: wheat,[4] rice[5] and sugar cane.[6] The campaign included introduction of a technological package of custom

services, new varieties, optimum doses of chemical fertilizers, and limitation of chemicals applications.

The main objective of this study is to assess the impacts of the economic reform program on the performance of Egypt's agricultural sector over the last three decades using selected techno-economic indicators.

Methodology and Analytical Procedure

The study approach provides a comparative analysis of selected indicators of agricultural sector performance over the last three decades from 1986/87 to 2006/07. This period covers the important phases of policy regime changes including the onset of the economic liberalization program in the agricultural sector (i.e., 1987), the period during the implementation (transitory period) up to 1995, and the period after completion of the program, (i.e., 1996) until the present time.[7] The Egyptian development targets were spelled out through a successive five-year development plan, which started in 1982.

The main methodology involves application of comparative analysis of time series data of the selected indicators. The annual average value as well as annual growth rate of each indicator over the whole target period was derived from the estimated time trend model, with estimates reported for each five-year development plan period. Such rates are considered statistically not different from zero when the time trend coefficient is insignificant. The selected indicators are the crop area, yield per feddan,[*] crop price, cost of production per feddan, farmer's profit per feddan, and the average response of the crop area to changes in prices.[8] The study uses the local

[*] One Feddan = 4200 m^2.

unit such as the currency (Egyptian pound = L.E.)[†] and local volume measure of crops (erdab for wheat),[‡] and the local area measure of feddan. For conversion factors, 1 L.E is equivalent to approximately US$5.5, 1 feddan equals 420m^2, and 1 erdab of wheat is equivalent to 150 kg.

It should be noted that the calculated profit per feddan in this study was not the typical profit, which estimates only the share of management and entrepreneurship in gross income. In this study, the return to the farm-owned capital invested is included.[9] The value indicators (prices, costs, and profits) were calculated not only at current prices, but also were recalculated at a constant price level using the wholesale price index (WPI) as the deflator. The base year used was 1986/1987, setting the price level at 100.

Also, the study made appraisal for the marketing performance of crops of interest via the analysis of the consumer price spread.[10] This analysis shows the share of costs of production, producer's profit margin, and marketing margins for both wholesale and retail stages for each pound spent by consumers.

The impacts of the economic liberalization on annual cultivated area were investigated via comparing the annual relative change of rate of wheat and rice acreage with their respective farm prices over each development plan. The five-year development plans considered are 1987-1992, 1992-1997, 1997-2002, and 2002-2007. Also, the annual average farm price of each crop within each development plan period was compared with the annual average of the adjusted international price of the same crop. The resultant ratio measures the nominal protection coefficient. It shows how the government protects the domestic production to compete with imports. If the price ratio was greater than one, there would be a protection for the domestic supply against imports.[10] Otherwise, a price ratio less than one means an indirect taxation policy

[†] The local currency is one Egyptian pound (1 L.E.) = 100 piaster. The current exchange rate is about L.E. 5.52/ 1 US$.
[‡] One erdab of wheat grains = 150 kg. However rice grains are weighed by tons.

was imposed on the agricultural sector.[11] If the domestic farm price was the economic price and the price ratio was less than one, there would be a comparative advantage of Egypt in producing such a crop.

The international price was adjusted to be comparable with the domestic farm price by deducting the marketing margin from the international price. An approximate estimate of the area supply response to changes in farm price was estimated over time. The estimated elasticity coefficients were from the four annual pairs of averages of crop area and farm price derived from the time series data of each five-year plan. The following equations were used:

(1) $$r_{kj} = \left(\frac{\beta_{kj}}{\bar{Y}_{kj}} \right) 100$$

(2) $$Y_{kj} = \alpha + \beta_{kj} T$$

(3) $$w_{cp} = \left(\frac{C_{it}}{P_{rit}} \right) 100$$

(4) $$w_{pm} = \left(\frac{P_{pit} - C_{it}}{P_{rit}} \right) 100$$

(5) $$w_{wm} = \left(\frac{P_{wit} - P_{pit}}{P_{rit}} \right) 100$$

(6) $$n = \left(\frac{P^d}{P^w} \right)$$

(7) $$P_{pit} = \left(1 - \left(\frac{P_{pit} - C_{it}}{P_{rit}} \right) \right)$$

(8) $$e_{ij}^a = \frac{\left(\frac{A_{it} - A_{it-1}}{A_{it} + A_{it-1}} \right)}{\left(\frac{P_{it} - P_{it-1}}{P_{it} + P_{it-1}} \right)}$$

where r is the annual growth rate of the selected indicators, β is the estimated regression coefficient of the trend variable, Y is annual average of a selected indicator, T is time variable, index k is selected indicator and j is five-year development plan period, C is average costs of production per unit (one erdab of wheat grains and one ton of rice grains), index i is crop type, P is price per unit (index r is for retail, w for wholesale, and p is for farm, and superscript d is domestic and w is world), e is supply response elasticity and A is annual average area.

The analysis was applied for wheat and rice as the two major crops in Egyptian agriculture. Wheat is the main crop in the winter season from October to April. It occupies about one-third of the cropped area in winter.[12] Moreover, it provides 67% of the calories of the Egyptian daily diet and its main product is Egyptian bread (Baladi Bread loaf), which accounts for 50% of the daily caloric intake of the Egyptian diet.[13] Rice is the main summer crop from May to September, and it provides more than 15% of the calories of the Egyptian diet. While wheat is the top item in the food import bill of Egypt, rice is Egypt's top exportable food crop. Wheat imports reached about 6.9 million tons with a self-sufficiency ratio of 53%, and rice exports reached about 1.4 million tons in 2006/07.[14] While expansion in rice production is constrained by a limited water supply, the government has provided incentives in recent years to expand wheat-cultivated area by offering a guaranteed price higher than the international price upon delivery to the mill plants.[3] The government recently established a policy that penalizes farmers who cultivate rice beyond the regions and acreage allocated by the MOA. Both crops enjoy a national-level development campaign mentioned earlier, which began during the economic liberalization program.

Wheat straw has market value since it is a main source of roughage feed in Egypt. The average yield per feddan after threshing was estimated at around 12 loads. Each load is about 250 kilograms. Therefore, the study estimated the wheat profit with and without straw revenue.

The imputed value of straw includes not only the sold quantities, but also the proportion consumed on farm. In contrast, rice straw does not have a market as a feed source. For disposal, it is simply burned at the field fringes, which presents an environmental problem, particularly after the significant increase in rice yield and expansion in cultivated area.

In order to compare the technology changes that occurred over time, the economic efficiency of inputs used was calculated from estimated crop production functions, particularly the Cobb-Douglas form, abstracted from the literature. We use equation (9), which expresses the marginal return per unit value of an input, i.e.,

$$EC_x = P_y\left(\frac{MP_x}{P_x}\right) \tag{9}$$

where P is price, index y is output and x is input, and MP is the marginal product of input x in the production of output y. If $EC > 1$ there is an opportunity to intensify the input level per unit of land. Otherwise, its level should be lowered per unit of land.

Data Sources

The study used time series data published by official Egyptian institutions and agencies, particularly the MOA and the Central Agency for Public Mobilization and Statistics (CAPMAS) as well as international organizations, particularly the Food and Agriculture Organization of the United Nations (FAO).

Results and Discussion

The discussion of results is organized in three subsections. The first subsection presents the changes in time trend and level of profitability of both crops associated with corresponding changes in productivity, crop price, and cost of production. The cost structure was examined to

show the main input items that contributed to the increase in total cost of production. The second subsection assesses the marketing efficiency performance of both crops via the analysis of the distribution of what the final consumer pays on each crop through each stage of the marketing channel or value chain. The third subsection quantifies the crop area response to the changes in price policies and other incentives for wheat and rice production in each year of the five-year development plan.

Impacts of Economic Liberalization on Profitability and Productivity

The annual average profit per feddan was 924 L.E. with a statistically significant annual growth rate of 6.4% (Table 1). The production cost per one feddan of wheat increased significantly at a rate of 8.1%, which is higher than the increase in the price of wheat grains of 5.9%. Annual average cost of production is L.E. 1172 per feddan. The difference in the rate of growth of price and cost was compensated by a significant increase in wheat grain yield at 1.8% of an annual average of 16.8 erdab per feddan. This observation is confirmed by estimation of the time trend of the same variables but at a constant price level (Table 2). Table 2 shows that at a constant price there was no significant change in profit over the period 1987-2007 even though the cost of production increased at a rate of 2.5% of an annual average real value of L.E. 398 per feddan. The reason is that yield growth compensated the higher increase in costs of production above the farm wheat price growth. The main item that pushed the increase in costs of wheat production is land rent, as it accounted for more than one-third of the total costs, while labor cost accounted for one-fifth of total costs of production. The third cost category is machinery cost, which accounts for 17% of total costs, (Table 3). The big cost push in the land rent rate began in 1997 when the government stopped the validity of the land reform law of 1953, which set a fixed land rent rate at seven times the land property tax value. The government has freed the

agricultural land market since 1997. Also, opportunities of rural labor for off-farm employment expanded and increased the wage rate. The parity wage rate in agriculture increased as the labor supply shrunk versus an expanded demand for agricultural labor.[1,15] The national Egyptian program to expand the agricultural machinery system started in 1986 to allocate 150 agricultural mechanization centers all over rural areas in Egypt, where by the mid-1990s, mechanized land preparation reached close to 100% of farms and mechanized harvesting reached more than 50%. The agricultural mechanization program started with the supply of machinery services at moderate rental rates, where each mechanization station served 5,000 feddans. Secondly, the program focused on the introduction of an information campaign for new mechanization systems, in particular, grain combines, grain planters and drillers, and laser systems for leveling the soil.

While costs of machinery and labor raised the costs of production, these costs also contributed in raising the yield per feddan.[16] The annual average profit per feddan without including the wheat straw revenue reached L.E.438 at current prices, which is only 47% of profit with straw revenue included. At a constant price level of wheat, the average annual profit per feddan without considering produced straw value reached about L.E. 177, which is 54% when straw revenue is included. This shows that wheat straw value affects significantly the profit of wheat production. Straw value affects significantly the profit of wheat production, as straw is the main roughage feed for ruminants in Egypt, where natural rangeland is absent.[17]

At current price levels (Table 4), rice profitability performance has not been far from the wheat enterprise performance. However, the growth rate in farm price, cost of production, profit and productivity were all higher than the growth rates of wheat. During the period 1987-2007, at a constant price level, the cost of production per one feddan of rice increased at 2.6% (Table 5). The annual average cost of rice production per feddan was L.E. 470. The real growth in profit

per one feddan of rice was at 2.5%, again driven mainly by an increase in the yield of rice of about 2.6% a year. The average yield of rice was 3.5 tons per feddan. Similar to the case of wheat, the main cost items that contributed to the increase in production costs of rice were the land rent rate with a share of 32% of total cost, labor costs at 21% of the total costs, and machinery services at 15% of the total costs. The increase in the yield of the crops in Egypt was mainly due to improved biological technology, in particular, the introduction of new high-yielding varieties. The contribution of yield improvement through biological technology was complemented by the accompanying improvement in physical technology, particularly the expansion of farm mechanization systems, which later played a big role in minimizing losses and savings in farm inputs.[18]

A recent study from a sample survey in 2004/05 showed that the introduction of a new high-yield variety of grains would raise the yield per feddan. However such high yields imply higher input intensity per feddan, then higher costs—at least for the variable items—even though the net enterprise income would not be changed because of higher yield.[19] Applying a new variety of rice on farms of the Sharkia Governorate (East Region of the Nile Delta) raised the grain yield per feddan from 3.4 tons to 3.8 tons. This yield increase was associated with an increase in organic fertilizer by 32%, nitrogen fertilizer by 33%, phosphorus fertilizer by 6%, and human labor by 5%. Accordingly, the variable costs increased by 7%.

A study sponsored by USAID under the NARP "National Agricultural Research Project of Egypt" during the mid-1990s compared the impacts of introducing new high-yield wheat varieties and non-conventional mechanization systems on production performances.[20] The sample size was 400 farmers, classified into four subsamples. The profile of wheat production performance based on one feddan showed important policy implications, as concluded from the

field survey data presented in Table 6. There was a positive interaction effect of non-conventional mechanization systems and wheat variety on the yield per feddan.

Despite low yields of hay, using a nonconventional mechanization package increased profitability per feddan due to lower production costs and increased yields of cereal significantly from both varieties, “Sakha 69” and “Giza 163.” Using this package with the variety Sakha 69 raised cereal yield higher than did using Giza 163, i.e., from about 10 erdab to about 15 erdab approaching the yield from variety Giza 163, which reached 166 erdab per feddan, which was 13 erdab with a conventional mechanization package.

Although the new mechanization package increased significantly the machinery labor costs, the total variable costs per feddan decreased by 39% with variety Sakha 69 and 5% with variety Giza 163. Such shrinkage in the total costs was a result of a sharp reduction in both human costs and animal labor work. Also the capital input costs decreased as a result of reduced quantity of physical inputs. The seed costs decreased by 12% with variety Giza 163, and 30% with variety Sakha 69, and costs of organic fertilizers were reduced by 69% with variety Giza 163 and 87% with variety Sakha 69. The chemical fertilizer costs were reduced by 24% and 30% with Giza 163 and Sakha 69, respectively.

The increase in grain yields due to application of modern mechanization systems resulted indirectly from better regulation of the individual plants in rows, giving balanced nutrients and causing good growth in total vegetation, leading to the disappearance of the phenomenon of stalks falling and remaining on the ground.

Although these results are catalysts for agricultural development, there is an associated negative externality, with the loss of 332,000 to 504,000 jobs from grain crop farms expected. Therefore, these policies require intensified efforts to transfer a portion of such expected

unemployed agricultural labor to work in industries that support agricultural mechanization such as maintenance and repair workshops and/or manufacturing. The rest should be transferred to small, intensive, non-farm labor projects in the villages or rural towns within a national integrated rural development program.[21]

Comparison of the changes in input productivity and rice grain yields was made through the analysis of two rice production response functions conducted in the same area of Sharkia Governorate in the Nile Delta Valley: the first in 1986, i.e., at the onset of the economic reform program, and the second in 1995, i.e., in the mid-term of the economic reform program.[16,18] Since the best-fitted form of the production response was the Cobb-Douglas function, the intercept represented the changes in technology level and the regression coefficient showed the average production elasticity. The technology level significantly increased in 1995 in comparison with 1986, as the intercept of the estimated function increased from 0.05 to 0.15. Such an increase can be attributed to the introduction of a new variety of rice and nonconventional mechanization, which led to higher yields and a more capital-intensive agricultural system, i.e., less human labor, more machinery labor, and more chemical fertilizers (Table 7).

The economic efficiency of both human labor and machinery were estimated using equation (9). The estimates were made under the current wage rate and rent per hour of both inputs and at the current price of rice grains associated with the two levels of technologies applied in 1986 and 1995. The analysis was repeated under a shadow price in 1995 of inputs and output. The shadow wage of human labor was that of the best alternative available job opportunity in the Egyptian market, which was construction work. The value of the subsidy provided to fuel for agricultural machinery was added to its current rent rate in 1995 to get the shadow rent rate in that year. For rice grains, the shadow price per ton was the border price of rice in that year.

Whereas, the economic efficiency of human labor was much higher than that of machinery labor in 1986, the machinery labor economic efficiency surpassed that of labor in 1995 (Table 8). Moreover, there was an opportunity to increase the level of both labor sources per feddan of rice in 1986. In 1995 the feasibility to expand labor on rice farms only held for machinery, while it was more economical to lower the level of human labor per feddan of rice. While the human labor wage in agriculture rose at 4% a year, the rent rate per hour of machinery labor increased at 9% per year and the price of rice per ton rose by 7% per year during the period 1986-1995. Even though the rice grains price per ton increased at 7% per year over the same period, it did not reach more than 57% of its shadow price as calculated in 1995. The economic efficiency of using human labor versus machinery labor under shadow prices of wage and rent rates of both inputs was recalculated from a response function estimated for the year 1995. Although, the shadow wage rate was three times the current wage rate, the economic efficiency of human labor decreased to L.E. 0.58 per one Egyptian pound spent on human labor, indicating that such input should be reduced per feddan of rice (Table 8). In comparison, the shadow rent rate of machinery labor was only 10% higher than the current rate in 1995. However, under the shadow rent rate, the economic efficiency of machinery labor increased to L.E. 2.6 per pound spent on renting machineries, while it was L.E. 2.3 at the current rent rate in 1995. Accordingly, it was feasible to apply more mechanization hours to rice production to substitute for human labor. As mentioned earlier, such an implication requires an integrated rural development program to generate feasible alternative jobs for human labor displaced by farm mechanization.

Domestic Marketing Efficiency of Grains under a Free Market System

Commodity market efficiency performance can be examined in many ways, one of which is by comparing the distribution of what the consumer pays along the marketing stages of both

crops, wheat and rice (Table 9 and Table 10). On average, from the price paid by the consumer at the retail level, the share of wheat producer profit over the period (1987-2007) was at 37%, surpassing the share of rice profit at only 24%. The average share of wholesale marketing margin for the period 1987-2007 was very high in the case of rice at 42%, while it was only 9% in the case of wheat. In contrast, the share of the retail stage marketing margin of wheat was relatively higher at about 26%, while it was a low 7% in the rice market. This comparative result appears empirically consistent. In the case of rice, milled rice represents almost the bulk of the final product of rice reaching the consumer; wheat flour has numerous forms of final products reaching the market, including bread, cookies, and sweets, in addition to several types of pasta. Even if the main product in the retail market is Egyptian bread in the case of wheat, there are several other types of bread. Therefore, the aggregate marketing margins of wheat between the wholesale and retail is expected to be relatively high. Also, these results can raise suspicion of a possible exercise of some market power by wholesalers in the rice market in Egypt.

A comparison of farmers' profits over the last four successive five-year development plans (Table 9 and Table 10) showed a significant difference in impacts of the economic reform policies on both main grain crops. The share of the wheat farmer of the price paid in the retail market decreased from around 51% at the onset of market liberalization policy in 1987-1992 to about 37% during the period 2002-2007 plan. In contrast, the same share in the case of rice increased over the same period, from 24% in 1987-1992 to 26% in 2002-2007. The wholesale margin for wheat increased from 7% in 1987-1992 to more than 12% in 2002-2007. The same share in the rice market decreased slightly, from 40% in 1987-1992 to 37%, in 2002-2007. The control exercised by the government over the food market, in general, has slightly limited the share of retailers of both crops during the last plan in 2002-2007. This is particularly true for rice,

whose share decreased from 9% in 1987-1992 to only 6% in 2002-2007. Also the increasing trend of the retailers' share in the wheat market, from 24% in 1987-1992 to 30% in 1997-2002, was depressed to only 23% during 2002-2007.

Impacts of Price Policies on Grains Cropped Area

Since Egypt has been under a free market economy regime beginning in the mid-1990s to the present, the price has been the main variable influencing the area response of the major field crops such as wheat, rice, cotton, and sugar cane. Several approaches were followed to implement such policies. With respect to wheat, the major ones aimed at providing a guaranteed farm price to the farmer, which was maintained higher than the international price. Such a high price of domestic wheat paid to farmers over the last two decades provided an incentive to the wheat producers to expand wheat area. The rice market, on the other hand, was left to the mechanism of supply and demand to determine the domestic price. Since rice is an exported commodity, the demand for rice is comprised of both domestic and international demand. Therefore, unlike the case of wheat, it is the international price that affects the rice cultivated area. Although rice marketing has been practiced almost freely via the private sector, the public mill plants announce a guaranteed price for delivering paddy rice to those mill plants.

In some years or even months, the demand for rice exports pushes the domestic price up beyond the purchasing power of the majority of low-income households in Egypt. Hence, for social considerations, the government temporarily restricts the export of rice until the domestic market price softens and reaches an affordable level for low-income households. In addition, because rice is a water-intensive crop, the government tries to prevent farmers from exceeding the allocated area by imposing penalty charges on the excess area.[4,5] On the other hand, both rice and wheat have enjoyed a vertical development program in terms of the introduction of new

varieties and implementation of the national campaign for improving farming practices. We consider next what impacts, if any, these price policies had on the expansion of wheat and rice area. Table 11 shows the impact of the wheat price policy on acreage response over the period 1987-2007. The average annual growth rates of both area and farm price within each successive development plan period were estimated from the time trend equations presented in Table 12 The table provides the trend of wheat area over each of the four five-year development plans implemented during the economic liberalization era of the Egyptian economy. This periodic time trend was compared with the farm price changes that occurred over the same successive periods. Also, the ratio of the annual average farm price to the adjusted international price over each development plan was estimated to show how the policy intervened to generate either a nominal protection or indirect taxation for the domestic producers. The time trend of the whole period (1987-2007) showed a significant annual growth rate of wheat area of about 3.1%. This was associated with a farm price increase of 5.6% a year, which on average reached 149% of the international wheat price level over the same period. That is, domestic producers received some kind of nominal protection.

The wheat area has increased at a stepwise trend, from an annual average of 1.7 million feddans during the first development plan to 2.2 million feddans during the second five-year plan, to 2.4 million feddans during the third plan, and reached its peak of around 2.7 million feddans during the fourth five-year development plan (2002-2007). Over the development plan (1987-1992) the wheat area increased at an annual growth rate of about 10%, which was associated with a farm price increase of about 17% over the same period. The domestic price exceeded the international price, suggesting a nominal protection rate of around 1.16. During the successive plans, the farm price increased at 5% a year. However, it was not enough incentive to expand the

wheat area significantly, even though the farm price was about 112% of the international level over the second successive development plan. The wheat farm price increased to a level that surpassed the international price, reaching 168% and 214% of the international price over the periods 1997-2002 and 2002-2007, respectively. However, the growth rate in the farm price during the last two development plans was not enough to induce a significant increase in wheat area. It seems that other factors, which are not captured in the simple elasticity formula, rather than own farm price affected the fluctuation in wheat area from one year to another. Among those factors is the profitability of the main competing crop, the green fodder crop, which locally is called "berseem" (Egyptian clover). The expanding livestock sector in Egypt has strengthened the demand for berseem, making it a strong competitor against wheat for the limited land in Egypt.

The same analysis and investigation was made for rice area response over the same period (Table 13). The average annual growth rates within each successive development plan period of both rice area and farm price were estimated from the time trend equations presented in Table 14. The time trend of the whole period (1987-2007) showed a significant annual growth rate of rice area of about 2.6%, which was associated with a farm price increase of 6.1% a year. The rice price, on average, reached 0.52% of the international rice price level over the same period. A price ratio of less than one may suggest some kind of an indirect taxation imposed on the domestic rice producers or a sort of comparative advantage of Egypt in producing rice. Analysis based on the successive development plan periods showed that the rice area had increased drastically until the third five-year plan by the year 2002. It jumped from about one million feddans at the onset of the economic liberalization program to around 1.5 million feddans by the year 2002. However, rice area has not changed significantly over the fourth five-year-plan

(2002-2007). As mentioned earlier, limits on water availability is the main constraint for any expansion in rice area. The Government of Egypt imposes high penalties on farmers if they violate the determined allotted area of rice. Also, the international price of rice affected the area of rice, particularly that the domestic farm price had not surpassed the international price after the first development plan period.

Estimated Long-Run Arc Supply Response Elasticity

Because the annual average crop area of both wheat and rice were increasing from one development plan to the next, along with the associated increase in the farm price of both crops, this study estimated the supply response elasticity in each of the successive five-year development plans using equation (8). Estimates are presented in Table 15. In general, the estimated elasticity coefficients of both crops decreased over time. As the average area of rice reached around 2.3 million feddans in 2002-2007, the supply response elasticity decreased to 0.12 compared to the more than 0.59 at the onset period of the economic liberalization era (1987-1992). This result may strongly suggest that there is a likely ceiling of expansion in rice due to water scarcity and limits on land availability.

In the case of wheat, as the average wheat area reached 2.7 million feddans, the supply response elasticity decreased to 0.38 compared to the more than 0.6 at the onset period of the economic liberalization era. This result may suggests that rather than water scarcity as in the case of rice, the expansion in wheat area is affected more by the strong competition from the highly profitable fodder crop (berseem), whose high demand is directly linked to the expansion of the livestock sector, being the main animal feed crop in Egypt. New policies towards rationalization of water management and land reclamation in Egypt may change these trends.

On average, the supply response elasticity of the wheat crop is relatively higher than that of the rice crop, as the estimates showed that it reached 0.52 and 0.47, respectively, over the period 1987-2007. This difference can be attributed to the government intervention against expansion in rice area to save scarce water while it intervenes positively to expand wheat area through its price policy. However, because rice is an exportable crop of reasonable demand in the world market, farmers resist policies that impose high penalties on excess area. With limited growth in rice area, there are some years when the Government of Egypt has to stop rice exports to keep enough supply for domestic consumption at reasonable price.

Summary

Egyptian agricultural policy has followed a centralized, managed economy for a long period, until the second five-year development plan of Egypt (1987-1992), which, among other policies, ended agricultural land allotment among crops and freed the cropping pattern decision to farmers. Now the Government of Egypt is more focused on promoting agricultural mechanization; the introduction of high-yield varieties; and rationalization of pesticide, insecticide, and fertilizer use, associated with implementation of "national campaign" for development of its main crops—wheat, rice, and sugar cane. This study examined the impacts of the economic reform program on the performance of Egyptian agriculture using selected techno-economic indicators over the last three decades. The comparative analysis included the annual average value as well as annual growth rate of each indicator, the consumer price spread, and approximate average long-run supply response of the crop area. The analysis was applied for wheat as the main crop in the winter season and rice as the main crop in the summer season.

The results showed that yield growth of both crops has compensated the higher increase in costs of production above the farm price growth. The main items that pushed the increase in costs of production of wheat production were land rent and labor costs. The big push in land rent rates began in 1997 when the government freed the agricultural land market. Also, since market liberalization, off-farm labor income has reached a higher wage rate than the farm wage. Wheat straw value significantly affects the wheat profit on farm. The increase in the yield of the Egyptian crops was mainly due to introducing new high-yield varieties, in addition to the expansion in mechanization systems, which played a big role in minimizing losses and saving input quantities used.

The wholesale marketing margin in rice accounted for 42% of the Egyptian pound spread along the marketing stages of rice. The proportion of the retail stage-marketing margin of rice was only 9%, and it reached 25% for wheat because of the numerous final products of wheat flour in the retail market.

Investigation of the impacts of price policies on grain cropped area over the period 1987-2007 showed a decreasing estimated elasticity coefficient of both crops over time. As the average area of rice reached around 2.3 million feddans in 2002-2007, the supply response elasticity decreased to 0.12 from more than 0.59 at the onset period of the economic liberalization era in 1987-1992. This was probably due to the government intervention against expansion in rice area to save on scarce water. Since rice is an exportable crop of reasonable demand in the world market, farmers resist policies with high penalties on excess area. In some years the Egyptian government stopped rice exports to keep enough supply for domestic consumption at a reasonable price. As the wheat area reached 2.7 million feddans in 2002-2007, the supply response elasticity also decreased to 0.38, from 0.6 at the onset period of the

economic liberalization era. The primary limiting factor in the expansion in wheat area is the high competition posed by a profitable fodder crop (berseem), which has become attractive because of high demand from livestock feeding.

Table 1. Trend of Wheat Profitability and Productivity (1987-2007) at Current Prices

Comparative Item	Intercept	Regression Coefficient	R2	F-ratio	Annual Average	Annual Growth Rate
Domestic farm gate price of grains	41.81	5.71	0.88	131.13**	96.06	5.94%
Domestic whole sale price of grains	44.49	6.84	0.87	124.98**	109.47	6.25%
Domestic retail price of grains	63.54	8.82	0.92	219.81**	147.31	5.55%
Production costs	267.67	95.22	0.97	684.15**	1172.26	8.12%
Profit without straw revenue					437.71	
Profit with straw revenue	362.59	59.07	0.64	31.39**	923.77	6.39%
Yield/ feddan (erdab)	13.82	0.31	0.90	155.40**	16.76	1.80%

NA = not applicable, (88) = significant at less than 1%, (ns) = not significant
# 1 erdab = 150 kg, 1 feddan = 4200m2, grains, and straw yield/ feddan = 12 loads, 1-straw load = 250 kg, Imputed price of straw/ load = L.E. 40.5

Table 2. Trend of Wheat Profitability (1987-2007) at Constant Prices

Comparative Item	Intercept	Regression Coefficient	R2	F	Annual Average	Annual Growth Rate
Domestic farm gate price of grains (L.E./erdab#)	41.81	5.71	0.88	131**	34.31	0%
Domestic whole sale price of grains (L.E./erdab)	39.21	-0.47	0.003	0.06^{ns}	38.77	0%
Domestic retail price of grains (L.E./erdab)	52.55	-0.05	0.003	0.06^{ns}	52.11	0%
Production costs (L.E./feddan)	267.67	95.22	0.97	684**	397.75	2.49%
Profit without straw revenue					177.29	
Profit with straw revenue	362.59	59.07	0.64	31**	329.27	0%

Table 3. Average Production Cost Structure of Wheat and Rice (%) (1987-2007)

Cost items	Wheat	Rice
Total costs per feddan	1172.26	1390.63
Labor	20.8%	21.4%
Draft animals	0.4%	1.9%
Machinery	16.9%	15.0%
Seeds	5.6%	7.1%
Organic fertilizer	2.9%	1.0%
Chemical fertilizers	10.2%	6.8%
Pesticides	1.4%	3.3%
Land rent	36.0%	32.1%
Miscellaneous	5.9%	6.0%

Table 4. Trend of Rice Profitability and Productivity (1987-2007) at Current Prices

Comparative Item	Intercept	Regression Coefficient	R^2	F	Annual Average	Annual Growth Rate
Domestic farm gate price of grains (L.E./ton)	269.44	39.13	0.85	101.14**	641.15	6.1%
Domestic whole sale price of grains (L.E./ton)	556.66	63.97	0.91	172.98**	1164.36	5.49%
Domestic retail price of grains (L.E./ton)	611.04	67.41	0.89	145.33**	1251.39	5.39%
Production costs (L.E/feddan)	298.93	114.92	0.97	573.18**	1390.63	8.26%
Profit (L.E/feddan)	225.6	84.93	0.7	41.2	1032.45	8.23%
Yield/ feddan (tons)	2.65	0.09	0.97	558.64**	3.50	2.57%

Table 5. Trend of Rice Profitability (1987-2007) at Constant Prices

Comparative Item	Intercept	Regression Coefficient	R2	F	Annual Average	Annual Growth Rate
Domestic farm gate price of grains (L.E./ton)	233.17	-0.58	0.01	0.26^{ns}	227.66	0.0%
Domestic whole sale price of grains (L.E./ton)	430.33	-1.49	0.02	0.43^{ns}	416.17	0.0%
Domestic retail price of grains (L.E./ton)	461.54	-1.56	0.02	0.39^{ns}	446.71	0.0%
Production costs (L.E/Feddan)	355.37	12.08	0.47	16.14**	470.16	2.6%
Profit with straw revenue (L.E/feddan)	260.22	8.65	0.24	5.81*	342.36	2.53%

Table 6. Production Performance Profile of Wheat per Feddan under Different Wheat Varieties and Mechanization System Packages

Comparative Item per Feddan in L.E.	Wheat Variety 163		Wheat Variety 69	
	New Mechanization Package[a]	Common Mechanization Package	New Mechanization Package	Common Mechanization Package
Machinery Labor	299.5	145.6	277.6	196.1
Human Labor	75.3	152.4	64.8	300.4
Animal Work	5.1	24.3	5.2	45.5
Seeds	56.42	64.2	53.69	77.14
Organic Fertilizer	17.8	58.01	6.11	45.44
Chemical Fertilizers	85.09	112.44	85.09	121.21
Pesticides & Insecticides	8.5	17.51	8.04	32.04
Capital Inputs	167.3	252.2	152.9	275.8
Total Costs	547.71	574.46	500.53	817.83
Gross Income	1266.2	969.5	1173	817.73
Net Income	718.49	395.04	672.47	-0.1
Grains Yield in Erdab	16.56	12.82	15.13	10.28
Straw Yield in Load	4.95	6.86	10.83	6.08

[a] Includes mechanized harvesting, winnowing, wheat combine, planter, driller and laser instrument for land leveling.

Table 7. Average Output and Input per Feddan of the Sample Farms Used in Estimates of Table 8

Comparative Item	1986	1995
Grains yield in tons	2.38	2.89
Straw yield in tons	1.16	1.51
Human labor in man-day	45.05	33.67
Machinery in hours	12.9	17.63
Nitrogen fertilizer in kilograms	64.47	91.04

Table 8. Comparison of Economic Efficiency of Human and Machinery Labor in Rice Production in Egypt under Labor Intensive (1986) Versus Capital Intensive (1995) Technologies

Input	1986	1995	
	At Current Prices	At Current Prices	At Shadow Prices
Human Labor Economic Efficiency	2.07	0.96	0.58
Machinery Economic Efficiency	1.63	2.27	2.58
Labor Wage (L.E./Man-hour)	0.6	0.83	2.42
Machinery Rent (L.E./hour)	3.5	6.72	7.4
Ton of Grains (L.E.)	406	698	1221

Table 9. Consumer Price Spread of Wheat

Retail Price Components	19871992		1992-1997		1997-2002		2002-2007		Aggregate Average	
	Annual Average	%	Annual Average	%	Annual Average	%	Annual Average	%	Annual Average	%
Yield in erdab	**14**		**16**		**18**		**19**		**17**	
Farm gate price	60	69%	86	64%	104	63%	142	65%	96	65%
Costs	33	38%	60	44%	81	49%	100	46%	70	47%
Farmer's profit with straw revenue	46	52%	46	34%	49	30%	80	37%	55	37%
Farmer's profit without straw revenue	27	31%	27	20%	23	14%	42	19%	26	18%
Wholesaler's margin	6	7%	13	9%	11	7%	25	12%	13	9%
Retailer's margin	21	24%	36	27%	49	30%	49	23%	38	26%
Retail price	87	100%	135	100%	164	100%	217	100%	147	100%

Table 10. Consumer Price Spread of Rice

Retail Price Components	1987-1992		1992-1997		1997-2002		2002-2007		Aggregate Average	
	Annual Average per ton in L.E.	%	Annual Average	%	Annual Average	%	Annual Average	%	Annual Average	%
Yield in tons	2.9		3.4		3.8		4.1		3.5	
Farm gate price	363	51%	606	47%	670	46%	967	57%	641	51%
Costs	199	28%	351	27%	443	31%	549	32%	397	32%
Farmer's profit with straw revenue	174	24%	279	22%	249	17%	449	26%	295	24%
Farmer's profit without straw revenue	164	23%	255	20%	227	16%	418	25%	244	19%
Wholesaler's margin	283	40%	583	45%	669	46%	637	37%	523	42%
Retailer's margin	64	9%	93	7%	106	7%	95	6%	87	7%
Retail price	709	100%	1282	100%	1445	100%	1698	100%	1251	100%

Source: Calculated from the data of Table 1 and Table 4.

Table 11. Impact of Price Policy on Wheat Area

Development Plans	Wheat Area in Feddan		Farm Price		International Price			
	Annual Average (thousands Feddan)	Annual Growth Rate	Annual Average (L.E/Erdab)	Annual Growth Rate	Annual Average (L.E/Erdab)	Price Adjustment	Adjusted Average	Nominal Protection
1987-1992	1764.56	10.40%	59.89	16.71%	79.38	0.65	51.76	1.16
1992-1997	2223.1	0%	86.33	5.20%	118.55	0.65	77.31	1.12
1997-2002	2416.92	0%	103.61	1.39%	94.46	0.65	61.6	1.68
2002-2007	2722.22	6.30%	141.74	12.46%	101.61	0.65	66.26	2.14
1987-2007	2250.52	3.10%	96.06	5.60%	98.88	0.65	64.48	1.49

Source: Calculated from the data of Table 1 and Table 12.

Table 12. Time Trend Estimates of Wheat Area and Farm Price

Development Plans	Wheat Area in Feddan				Farm Price			
	Intercept	Regression Coefficient	R2	F	Intercept	Regression Coefficient	R2	F
1987-1992	1307.57	182.8	0.87	26**	75.1	4.49	0.84	26**
1992-1997	1902.77	128.13	0.6	6.044$^{\text{ns}}$	100.02	1.44	0.96	21*
1997-2002	2431.89	-5.99	0.04	0.159$^{\text{ns}}$	106.42	17.66	0.92	96**
2002-2007	2381.08	170.57	0.9	30.03*	41.81	5.71	0.88	30*
1987-2007	1585.77	69.97	0.8	72.48**	5.02$^{\text{ns}}$	17.86	22.01	131**

Table 13. Impact of Price Policy on Rice Area

Development Plans	Rice Area in Feddan		Farm Price		World Price			Nominal Protection
	Annual Average (thousan	Annual Growth Rate	Annual Average (L.E/Ton	Annual Growth Rate	Annual Average (L.E/Ton	Price Adjustment Coefficie	Adjusted Average (L.E/Ton	
1987-1992	1016.09	5.80%	362.53	11.75%	658.36	0.93	609.44	0.59
1992-1997	1371.48	4.31%	606.18	9.32%	1283.27	0.91	1163.93	0.52
1997-2002	1465.09	0%	669.64	0%	1648.68	0.93	1540.36	0.43
2002-2007	1528.7	0%	966.74	0%	1945.52	0.88	1716.73	0.56
1987-2007	1322.39	2.62%	641.15	6.10%	1352.77	0.91	1229.67	0.52

Source: Calculated from the data of Table 4, Table 10, and Table 14.

Table 14. Time Trend Estimates of Rice Area and Farm Price

Development Plans	Rice Area in Feddan				Farm Price			
	Intercept	Regression	R2	F	Intercept	Regression Coefficient	R2	F
	868.67	58.97	0.69	9.02*	256.01	42.61	0.81	16.66*
1987-1992	1223.71	59.11	0.92	45.75**	465.01	56.47	0.95	82.73**
1992-1997	1440.58	9.8	0.02	0.064$^{\text{ns}}$	724.91	-22.11	0.38	2.46$^{\text{ns}}$
1997-2002	1520.24	4.23	0.02	0.06$^{\text{ns}}$	789.11	88.82	0.7	6.8$^{\text{ns}}$
2002-2007	993.46	34.62	0.57	52.73**	269.44	39.13	0.85	101.14**

Table 15. Estimates of Long-Run Elasticity of Supply Response of Area to Farm Price

Period of Response	Wheat	Rice
(1987-1992) To (1992-1997)	0.64	0.59
(1992-1997) To (1997-2002)	0.46	0.66
(1997-2002) To (2002-2007)	0.38	0.12
1987-1992) To (2002-2007)	0.52	0.47

Source: Calculated from the data of Table 11 and Table 13.

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