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RISK ASSESSMENT OF MAJOR CROPS IN EGYPTIAN AGRICULTURE

JEL classification: Q18, Q14, Q15

Ibrahim Soliman*, Fabian Capitanio, Luigi Cerciello*****

Abstract. *The increase in agricultural commodity prices is driven by several factors. One of the principal amongst these is the headlong growth in food consumption, associated with population growth, and especially with higher purchasing power among increasingly broad ranges of the population in emerging countries. The largest increases in population will take place in developing countries, while in high-income economies it will remain almost stable and in some areas, especially in some regions of Europe, there may even be a decline. By contrast, in Africa the population is expected to double, growing from one to two million by 2050. Against this background, the present study focuses on the major variables which influence the risk to incomes in agricultural production in Egypt.*

Keywords: *Egyptian agriculture, risk management, food security*

1. Introductory background

Since the early ' fifties there has been a long period of stagnating and declining prices on agricultural markets, interrupted only by some sharp variations in coincidence with extraordinary events (such as the "oil shock" in the 1970s). The scenario changes in the mid 1990s when an inverse trend began, with sharp peaks in farm commodity prices in 2007/2008 and 2010/2011. The most recent forecasts indicate sizeable price rises for the coming years.

Several causes are contributing to the increase in agricultural commodity prices. One of the most important is the headlong growth in food consumption, associated with population growth, but especially with the higher purchasing power among increasingly broad ranges of the population in emerging countries. According to FAO, world population will exceed nine billion in 2050. This represents an increase of about one third against the current population of 6.9 billion, an increase that will be lower than in the past. In fact, the population increase of over 30% predicted by the FAO for the next 40 years is well below the relative growth in the past four decades, during which population more than doubled.

Moreover, the most important contribution to the global convergence of diets will be made by the expansion of the middle classes in emerging areas. Individual income in countries such as India, Brazil and China has risen at sustained rates in recent years, only to slow down, but not stop, during this long phase of world economic recession. The cases that stand out most are those

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of China and India which have recorded annual growth rates close to the double figures in the years immediately prior to the recession and which are forecast, according to the International Monetary Fund, to continue their trends at least for the next 20 years. This means, on one hand, that expenditure on food consumption will grow fast, but, on the other, that food habits will change radically (the so called "substitution effect" explained by Engel's Law).

As populations gradually become richer, in their diets the unprocessed starch products (like rice and flour) are replaced by products with a higher protein content (such as meat, milk and other dairy products) and by processed products with greater value added, promoting a process of dietary convergence worldwide along the models of richer populations. This trend is involving several billion people in emerging countries and the demand for livestock products is forecast to increase very fast in the coming years with the consequence of a multiplier effect on the demand for some agricultural raw materials, such as soya and wheat, which are at the basis of animal feed.

Against this background, the present study has focused on the major variables that determine risk in agricultural production in Egypt, variables here identified as land use and yield variability. Almost all the agricultural area in Egypt, except for about 3%, is fully irrigated. Fluctuation in rainfall is not, therefore, a main factor behind risk in agricultural production. Accordingly, farm price was considered as an explanatory variable assumed to affect the fluctuations in the variables considered, i.e. the area and the yield. Farm price is the market signal for producers to expand or to reduce production. To complete the investigation, the impact of international price levels on domestic prices was also assessed. Other factors that may cause risk (fluctuation) in either the crop area and/or yield level would be the plant protection programs against infection. Some vegetables such as tomatoes could be also be affected by the differences of temperature during the year, as it is cultivated three times a year (winter, summer and fall, "Nili season")

The major crops were selected on the basis of their share in the cultivated area. The crops with the highest share in the acreage of each subsector were selected. The subsectors were field crops, fruits and vegetables. However, additional criteria were also applied in selection. Cotton and onions were selected, not only on the basis of their share in area, but also because they are major exportable crops, together with potatoes, tomatoes and citrus. Sugar cane was selected as the major permanent crop: it occupies land for 3 successive years and is the crop that consumes most irrigation water per unit of land. Consequently, sugar beet was selected as a promising crop to substitute sugar cane. It is a perennial winter season crop. Tables 1, 2, 3, and 4 show the agricultural land use and cropping pattern of Egyptian agriculture in 2010. It should be mentioned that the period of time concerned (1981-2010) included years of dramatic changes in the Egyptian economic system. The first period was 1981-1986, when Egypt was still to a large extent a planned economy. The second period (1987-1995) included the boom of the economic reform program, which aimed at moving the economic system strongly towards privatization and the free market mechanism, freeing the exchange rate and interest rate as well as prices of inputs and outputs, keeping only subsidies only for the common Egyptian bread, quotas of some food items that were distributed via ration cards, and fuel prices. The third period 1995-2010 was that after the application of the reform policies.

2. Data base and analytical procedures

The data used in this study were compiled from the agricultural statistics bulletin which is issued annually by The Economic Affairs Sector of the Egyptian Ministry of Agriculture and

Land Reclamation and from The Food and Agricultural Organization of the United Nations (FAO) Statistical Data Base. The risks in crop area, yield and farm price levels were estimated using the instability coefficients (Equation 1) over a reasonable historical time trend, (1981-2010). The derived average annual growth rate from the time trend model (Equation 2) was also considered in investigation of the time series data of the crops concerned, either to estimate $\hat{Y}$ for getting the instability coefficient, or to estimate the average annual growth rate (Equation 3). To investigate the effect of farm price on a certain crop area, the supply response model was estimated for each considered crop (Equation 4), where the effect was specified as a lag response of the farm price one year earlier. The effect of farm price on crop yield was estimated using Equation 5. The effect of the world price inflation of the considered crops on their domestic price levels was assessed using Equation 6.

Equation 1: Instability Coefficient: $\sum (|Y_{ij} - \hat{Y}_{ij}|) / \sum(\hat{Y}_{ij})$

Equation 2: Linear Time Trend Model: $\hat{Y}_{ij} = b_0 + b_1 T_j$

Equation 3: Average Annual growth Rate: $r_i = b_1/\hat{Y}$

Equation 4: Crop Area-Supply Response: $\hat{A}_i = a_0 + a_1 P_{i\,(t-1)}$

Equation 5: Effect of farm price on Crop Yield: $\acute{y}_i = a_0 + a_1 P_{i\,(t-1)}$

Equation 6: Response of Domestic Price to average world price in the year t: $P_{di\,(t)} = b_0 + b_1 P_{wi\,(t)}$

Where:

Y_{ij} = Actual value of the variable i (Area, Yield or Farm price) in the year j,
$\hat{Y}_{ij}$ = Expected value of the variable i (Area, Yield or Farm price) in the year j,
b_i = Parameter to be estimated
$\ddot{Y}$ = Estimated Annual Average of the variable i (Area, Yield or Farm price)
$\hat{A}_i$ = Expected value of the Area of the Crop i in the year j,
$P_{i(t-1)}$ = Farm price per ton of the crop i in the previous year (t-1)
a_i = Parameter to be estimated

The ANCOV (Analysis of Covariance) model was applied to test for the significance of the impact of the three successive periods of change in economic policy packages on the supply and/or yield response to farm price of each crop. Three regression lines were therefore estimated. The first was for the period before the application of the economic reform (1981- 1986); the second was for the period within such implementation (1987-1995) and the third reflects economic performance after the implementation of the reform program. The economic policy was introduced as a dummy variable (a qualitative variable) while the price was introduced as a quantitative variable, including the interactions between the two variables. The ANCOVA model is written as in Equation 7

Equation 7:
$$y_i = \beta_0 + \sum_{j=1}^{p} \beta_j X_{ij} + \sum_{j=1}^{\sigma} \beta_{k(ij)} j + \varepsilon_i$$

Where:

y_i is the value observed for the dependent variable for observation i,
X_{ij} is the value taken by quantitative variable j for observation i,
$k_{(ij)}$ is the index of the category of factor j for observation i and
ε_i is the error of the model.

The hypotheses used in ANCOV are identical to those used in ANOVA: the errors e_i follow the same normal distribution N (0,s) and are independent.

One of the features of ANCOV is to enable interactions between quantitative variables and factors (Dummy variables) to be taken into account. The main application is to test if the level of a factor (a qualitative variable) has an influence on the coefficient (often called slope in this context) of a quantitative variable. Comparison tests are used to test if the slopes corresponding to the various levels of a factor differ significantly or not. A model with one quantitative variable and a factor with interaction is written as in Equation 8.

Equation 8: $$Y_i = \beta_0 + \beta_i X_{i1} + \varepsilon\beta_{k(i1)1} + \beta_{k(i1)2} X_{i1} + \varepsilon_i$$

Three steps should be conducted successively:

(1) To test the homogeneity of variance of the two regression lines (before and after the implementation of the economic reform program in Egypt),
(2) To test whether the dummy variables (the successive periods of policy packages) changes interact with the price effect and
(3) To test if such dummy variables have an independent effect on either the area or the yield of the crop.

If the first step showed heterogeneity of the variances of the three regression lines, the other two tests are not not relevant. If homogeneity of the three variances results step (2) is conducted; if there is an interaction effect of the three qualitative and quantitative variables step three is not carried out. Otherwise, the **"Bartlett's Test"** for homogeneity of variances was applied. This test is very sensitive to departures from normality:

The Null hypothesis of the Bartlett's test is a commonly used test for equal variances (Equation 9).

Equation 9: $$H_0 = \sigma_1^2 = \sigma_2^2 - \ldots = \sigma_k^2$$

Against alternative hypothesis (Equation 10)

Equation 10: $H_0 = \sigma_i^2$ are not all equal

The model assumes the samples are of size n_i from the ith population, $i = 1, 2 \ldots K$, and the usual variance estimates from each sample: $s_1^2, s_2^2, \ldots, s_k^2$

Where each sample variance is estimated as (equation 11)

Equation 11: $$s_1^2 = \sum_{j=1}^{i} \left(x_{ij} - x_i \right)^2 / \left(n_j - 1 \right)$$

Introducing the following notation: $\upsilon_j = n_j - 1$ (the υ_j are the degrees of freedom) and

$$\upsilon = \sum_{i=1}^{k} \upsilon_i$$

$$s^2 = \frac{\sum_{i=1}^{k} \upsilon_i s_i^2}{\upsilon}$$

The Bartlett's test statistic M is defined by Equation 12.

Equation 12:
$$M = \upsilon \log s^2 - \sum_{i=1}^{k} \upsilon_i \log s_i^2$$

Bartlett showed that when none of the degrees of freedom is small, M is distributed approximately as χ^2_{k-1}. The chi-square approximation is generally acceptable if all the n_i are at least 5. However, this is a slightly biased test, according to Bartlett. It can be improved by dividing M by the factor (C), (Equation 13). Then instead of M, it is suggested to use M/C for the test statistic.

Equation 13:
$$C = 1 + \frac{1}{3(k-1)} \left[\left(\sum_{i=1}^{k} \frac{1}{\upsilon_i} \right) - \frac{1}{\upsilon} \right]$$

In our model(s) there was no homogeneity between the three variances of the three regression models (the three successive time periods). Therefore, the study concerned only the estimation of the area and yield response for the period 1995-2010 i.e. after the implementation of the economic reform, to be used for interpretation of the fluctuation in the area and yield of the concerned crops.

It should be mentioned that the best fitting model for the estimated supply response was identified depending on the magnitude of the adjusted R^2, in addition to the statistical significance of the estimated parameters and, above all, the economic logic of the effect. Therefore, some of the models estimated were polynomial curvilinear models, rather than simple linear regression, to reflect the cobweb model of price movements over time.

3. Results and discussion

Egypt is one of the few places where agriculture is almost fully irrigated and the available land is intensively cultivated for more than two seasons a year. In 2010 the total agricultural area in Egypt was around 3.7 million hectares, of which 78% arable land and 22% permanent crops. The arable land is of two subcategories: the main one is perennial field crops that occupied 56% of the total agricultural area; the second is vegetables that occupied 22% of the total agricultural area in 2010 (Table 1). Among the category of permanent crops are fruit trees, which took up 12% of total agricultural area in Egypt in 2010 (Table 1), and sugar cane that represented 4% of the total agricultural area.

Tab. 1 - Agricultural Land Use in Egypt		
Subsector	**(000) ha**	**%**
Agricultural area	3,689	100
Arable land of which:	2,884	78
Field Crops	2,072	56
Vegetables (including melons)	812	22
Total Permanent Crops, of which:	805	22
Forest		2
Dates	42	1
Fruit Trees	435	12
Sugar Cane	135	4
Alfalfa	124	3
Source: Compiled and calculated from: http://faostat.fao.org/site/570/default.aspx#ancor.		

Sugar cane yields 3-4 cuts over 3-4 years before replacement. It occupied more than 17% of the total land under permanent crops in Egypt, (Table 1) and, with rice, is the crop which uses the most irrigation water, (Table 1A).

Tab. 1A - Ranking of Major crops in Egypt by water use/ha (m3)			
Crops	**(000) Hectare**	**% of total Cropped area**	**Water Use/ha (m3)**
Sugar cane	141	3	18,585
Rice	703	14	12,350
Mango	77	2	12,250
Alfalfa	16	0.3	11,900
Groundnut	65	1	8,182
Citrus	166	3	7,461
Grapes	71	1	7,461
Cotton	242	5	6,716
Tomatoes	226	5	6,664
Potatoes	108	2	6,378
Perennial clover	766	16	5,995
Maize	774	16	5,553
Sugar beet	104	2	4,422
Wheat	1,141	23	3,713
Faba beans	89	2	2,849
Green beans	31	1	2,618
One-cut clover	203	4	2,242
Total	4,923	100	6,690
Source; Compiled and calculated from: Egyptian Ministry of Agricultural and Land Reclamation, (2009) Sustainable Agricultural Development Strategy Towards 2030.			

Wheat is the most important of the field crops studied. It is a winter crop. It represents about two thirds of the total field crops area (Table 2). Maize is a summer crop. It comes at second place in acreage. It occupied 47% of the total area of field crops in 2010, (Table 2). Rice is also a summer crop and occupied about one-fifth of the total area under field crops in 2010.

Tab. 2 - Share of Crops studied in the area under Field Crops in Egypt

Crop	(000)ha	%
Field Crops	2,072	100
Sugar beet	135	6
Wheat	1,288	62
Rice	460	22
Maize	969	47
Cotton	155	7

Source: Compiled and calculated from: http://faostat.fao.org/site/570/default.aspx#ancor.

Annual exports of rice are at fifth place among the leading six exportable agricultural products (Table 2A). Although cotton (a summer crop) and sugar beet (a winter crop) do not occupy a high proportion of the area under field crops in Egypt, i.e. only 7% and 6%, respectively, (Table 2), they were involved in this study because cotton still occupies the third rank of Egyptian exports of agricultural products by value and sugar beet is a promising crop that saves water and replaces sugar cane which has the highest rate of consumption per hectare of irrigation water, (Table 1A).

Tab. 2A - The Share of Crops studied in Total Agricultural Exports of Egypt in 2010

Commodity	(000)$	%
Total Agricultural Exports	2,451,586	100
Total Oranges	402,502	16.4
Total dry Onions	170,396	7.0
Cotton	140,123	5.7
Potatoes	129,562	5.3
Rice – total (Rice milled equivalent)	120,932	4.9
Total Tomatoes	6,740	0.3
Total Studied Commodities	970,255	39.6
Other Commodities	1,481,331	60.4

Source: Compiled and Calculated from: FAOSTAT: FAO Statistics Division 03 January 2013, http://faostat.fao.org/site/535/DesktopDefault.aspx?PageID=535#ancor.

Citrus, particularly orange, occupies more than one third of Egypt's acreage of fruit trees, (Table 3) and is the first of the exported agricultural commodities, (Table 2A). The vegetables investigated in this study were onions, tomatoes and potatoes. They come at the 2nd, 4th and 6th ranks by value of agricultural exports, (Table 2A) and together occupied more than one half of the total area of vegetables in Egypt in 2010, (Table 4).

Tab. 3 - The Share of areas of fruits studied in the Total Field Crops Area in Egypt		
Crop	**(000)ha**	**%**
Fruits	435	100
Citrus	158	36
Others	277	64
Source: Compiled and calculated from: http://faostat.fao.org/site/570/default.aspx#ancor.		

Tab. 4 - The Share of Areas of vegetables studied in the Total Field Crops Area in Egypt		
Crop	**(000)ha**	**%**
Total Vegetables (including melons)	812	100
Onion	62	8
Tomatoes	216	27
Potatoes	141	17
Others	394	48
Source: Compiled and calculated from: http://faostat.fao.org/site/570/default.aspx#ancor.		

Annual growth rate of area, yield and farm prices of major crops studied

Table 5, presents the estimated time trend models of the domestic and world farm price of the crops studied over the period 1981-2010 and Table 6 presents the estimated time trend models of the area and yield over the same period. If the time response (regression) coefficient was statistically insignificant, the derived annual growth rate of the corresponding variable was considered of zero value, i.e. no significant growth had occurred. A very important fact that can be seen from Table 5 is that all crops investigated showed an annual average farm price lower than the average world level for the period 1981-2010. This might be considered as a sign of comparative advantage of Egyptian agriculture, even though the ratio varied between the different crops. In general, the lower the ratio the higher is the comparative advantage of the crop. It should be noted, however, that the existence of a comparative advantage does not necessarily mean competitiveness of the Egyptian crop exports on the world market. The latter criterion depends upon other techno-economic variables.

Tab. 5 - The Time Trend of Local and World Farm Prices of Major Crops in Egypt

Crops	Item	Estimated Constant (Ton/ha)	Estimated Annual Change (Ton/ha)	Annual Average Price ($/ton)	Annual growth Rate (%)	R2 (%)	F	Significance of Annual Trend
Cotton	Local	948.42	-4.395	880.30	-0.5	2.9	0.84	n.s.
	World	1444.61	-9.487	1349.73	-0.7	5.4	0.97	n.s.
Rice	Local	308.15	-4.212	242.86	-1.7	18.1	7.42	Significant at ² 5%
	World	315.78	4.584	361.61	1.3	17.2	3.53	Significant at ² 5%
Maize	Local	288.17	-3.944	227.03	-1.7	11.0	4.60	Significant at ² 5%
	World	205.98	2.519	231.17	1.1	12.3	2.38	Significant at ² 5%
Wheat	Local	278.94	-3.515	224.45	-1.6	20.3	8.37	Significant at ² 5%
	World	225.58	0.167	227.53	0.1	0.1	0.01	Significant at ² 5%
Sugar cane	Local	27.94	0.053	28.75	0.2	0.7	0.20	n.s.
	World	70.06	-0.094	69.13	-0.1	0.1	0.02	n.s.
Sugar beet	Local	28.20	0.131	30.23	0.4	-0.9	0.74	n.s.
	World	39.79	1.825	58.04	3.1	57.0	22.55	Significant at ² 5%
Tomatoes	Local	181.89	-3.602	126.06	-2.9	71.4	73.30	Significant at ² 5%
	World	482.45	11.984	602.29	2.0	32.7	8.24	Significant at ² 5%
Potatoes	Local	194.93	-2.271	159.72	-1.4	14.4	5.88	Significant at ² 5%
	World	240.60	6.167	302.28	2.0	34.5	8.95	Significant at ² 5%
Onion	Local	159.80	-3.834	100.37	-3.8	39.9	20.28	Significant at ² 5%
	World	330.80	4.672	377.52	1.2	15.0	3.01	Significant at ² 5%
Citrus	Local	50.19	3.72	174.46	2.13	0.433	21.35.	Significant at ² 5%
	World	329.32	7.174	401.56	1.8	26.4	6.11	Significant at ² 5%

Local Price Series (1981-2010), World Price series (1991-2009)
Source: Compiled and Estimated from:
(1) Ministry of Agriculture and Land Reclamation (2009) Agricultural Statistics Bulletin, Issued annually by The Economic Affairs Sector, Cairo, Egypt.
(2) http://faostat.fao.org/site/570/default.aspx#ancor.

Tab. 6 - The Time Trends in Area and Yield of Major Crops in Egypt

Crops	Item	Estimated Constant	Estimated Annual Change	Annual Average	Annual growth Rate (%)	R2 %	F	Significance of Annual Trend
Cotton	Area (000) ha	517.69	-11.591	338.03	-3.4	90.3	261.71	Significant at ² 5%
	Yield (tons/ha)	2.18	0.008	2.30	0.3	7.9	2.39	n. s.
Rice	Area (000) ha	374.22	11.41	551.07	2.1	79.5	108.59	Significant at ² 5%
	Yield (tons/ha)	4.98	0.193	7.96	2.4	96.6	803.25	Significant at ² 5%
Maize	Area (000) ha	713.64	3.234	763.77	0.4	18.5	6.36	Significant at ² 5%
	Yield (tons/ha)	3.95	0.162	6.47	2.5	94.4	471.75	Significant at ² 5%
Wheat	Area (000) ha	430.08	29.354	885.07	3.3	89.7	244.35	Significant at ² 5%
	Yield (tons/ha)	3.54	0.12	5.39	2.2	91.2	292.92	Significant at ² 5%
Sugar cane	Area (000) ha	83.41	2.128	116.39	1.8	86.0	172.57	Significant at ² 5%
	Yield (tons/ha)	93.88	1.055	110.23	1.0	94.0	439.44	Significant at ² 5%
Sugar beet	Area (000)ha	-13.74	3.543	41.18	8.6	81.4	122.82	Significant at ² 5%
	Yield (tons/ha)	34.95	0.555	43.55	1.3	54.4	33.35	Significant at ² 5%
Tomatoes	Area (000)ha	125.28	3.319	176.73	1.9	79.2	106.83	Significant at ² 5%
	Yield (tons/ha)	20.02	0.758	31.77	2.4	91.8	311.67	Significant at ² 5%
Potatoes	Area (000)ha	58.14	2.045	89.84	2.3	51.4	29.56	Significant at ² 5%
	Yield (tons/ha)	17.83	0.266	21.96	1.2	82.0	127.57	Significant at ² 5%
Onion	Area (000)ha	57.29	-0.183	54.46	-0.3	4.2	1.24	n. s.
	Yield (tons/ha)	11.11	0.537	19.44	2.8	93.0	370.19	Significant at ² 5%
Citrus	Area (000)ha	50.18	3.724	107.90	3.5	43.3	21.35	Significant at ² 5%
	Yield (tons/ha)	16.88	-0.04	16.29	-0.23	0. 93	0.265	n. s.

Source: Estimated from:
(1) Ministry of Agriculture and Land Reclamation (2009) Agricultural Statistics Bulletin, Issued annually by The Economic Affairs Sector, Cairo, Egypt.
(2) http://faostat.fao.org/site/570/default.aspx#ancor.

Table 7, therefore, presents the estimated average annual growth rate of the three variables (area, yield and farm prices) of the crops studied. Table 8, presents the ranking of the crops by their average annual growth rate of both area and yield. The average annual growth rate was calculated from equation 3. The estimated annual growth rate of the variables studied was ranked by its estimated value. Sugar beet has shown the highest rate of expansion of area over the period 1981-2010 (8.6%), which reflected the policy intended gradually to increase its area in order to replace sugar cane as a source of sugar for domestic supply, However, this policy has succeeded only partially in slowing down the growth in sugar cane area to 1.8% which put it at the 8th rank among the crops considered. Unfortunately, the growth of sugar beet yield has not matched the high expansion in its area. It was only 1.3% a year which placed it at the 6th rank. It seems that the price policy has not played a role in accelerating the expansion of sugar beet area or yield. As shown in Table, 7 the annual growth rate of local farm price of sugar beet was 0.4% over the period 1981-2010, while the comparable average world price increased at 3.1%.

Tab. 7 - The Estimated Average annual Growth Rates in Area, Yield, Local and World Prices from 1981 to 2010 (%)

Crops	Area (%)	Yield (%)	Local Price (%)	World Price (%)
Cotton	-3.4	0.0	0.0	0.0
Rice	2.1	2.4	-1.7	1.3
Maize	0.4	2.5	-1.7	1.1
Wheat	3.3	2.2	-1.6	0.1
Sugar cane	1.8	1.0	0.2	-0.1
Sugar beet	8.6	1.3	0.4	3.1
Tomatoes	1.9	2.4	3.1	-2.9
Potatoes	2.3	1.2	2.0	-1.4
Onion	0.0	2.8	2.0	-3.8
Citrus	3.5	0.0	2.1.	1.8

Source: Abstracted from: Time Trend Models in (Table 5).and (Table 6)
When the regression coefficient of the time trend equation is not significant, the estimated growth rate was recorded as zero
All variable trends for the period (1981-2010), But the world Prices for the period (1991-2010)

Even though the area under oranges has grown at 3.5% a year over the last two decades, which brought it to the 2nd rank area-wise after sugar beet (Table 8), its yield has not shown any significant growth over the same period. Farm price has shown a significant moderate annual growth of 2.13%, which could be an incentive to expand the area. Orange is not only a promising exportable product: it is also a fruit commonly consumed in Egypt.

Wheat is most important as a subsistence food crop. The growth rate in its area occupied the third rank among the crops investigated, with a value of 3.3% a year. This expansion may be at the expense of the other main competitive winter season crop of cultivated green fodder (Egyptian clover). Even though the growth rate in yield of wheat occupied 5th place (Table 8), it was significant at 2.2% a year. However, the area and yield expansion corresponded with a significant annual decrease in the farm price of wheat, of 1.6% a year.

Tab. 8 - Ranking of Average annual Growth Rate of Area and Yield (%) of Major crops

Crops	Area (%)	Rank	Crops (%)	Yield (%)
Sugar beet	8.60	1	Onion	2.80
Citrus	3.50	2	Maize	2.50
Wheat	3.30	3	Rice	2.40
Potatoes	2.30	4	Tomatoes	2.40
Rice	2.10	5	Wheat	2.20
Tomatoes	1.90	6	Sugar beet	1.30
Sugar cane	1.80	7	Potatoes	1.20
Maize	0.40	8	Sugar cane	1.00
Onion	0.00	9	Citrus	0.00
Cotton	-3.40	10	Cotton	0.00

Source: table 7

Surprisingly, the area allotted to onion, an exportable crop, has almost stagnated but the annual growth rate in its yield, at 2.8%, comes in first place among those of the crops studied (Table 8) and farm price increased at 2% a year, (Table 7).

The area under cotton has shown a significant decrease, of 3.4% a year, and there has been no increase in either the yield or farm price over the last two decades, in spite of the outstanding quality of this extra-long staple fine cotton. Until the early 'seventies it was the first exportable cash crop. However, it was the victim of the economic reform program and a poor foreign trade policy. During the central planned economy (1952-1986), the government used to buy cotton from farmers at much lower a price much lower than its world price, assuming that providing inputs at a subsidized price would compensate such differences. However, economic analysis has shown that until the mid 'seventies of the last century there was a net tax on cotton Therefore, the domestic spinning plants had the opportunity of getting raw cotton at a low price and of superior quality and were capable of delivering the output of cotton textiles at low price to consumers, even though they had old technology that was not suitable for this high quality cotton, leaving much waste and a high rate of loss of raw cotton. Exports were secured under permanent contracts with Eastern Europe at that time. The trading process was conducted using an accounting exchange rate for the US$, but the trading of cotton, rice and oranges were effectuated as required imports from Eastern Europe, as physical commodities without actual monetary payments. Sometimes such exports were delivered to Eastern Europe markets as repayment of imported military equipment. After the open market economy and privatization strategy was adopted the existence of an export policy lacking in rationality, particularly for cotton, has encouraged adoption of the advice of some international organizations to reduce the area under cotton, on the grounds that the domestic demand and world market could not provide enough incentives to make reasonable profit. Therefore, the distorted price policy for cotton, both for domestic and foreign trade, have exposed this important crop to considerable decline over the last three decades.

Degrees of instability in Egyptian agriculture

The instability coefficient of crop area, yield per hectare and farm price per ton of each crop was estimated using Equation 1 and the time trend models presented in Tables 5 and 6 over the period 1981-2010. These instability coefficients are presented in Table 9. For comparative analysis they were ranked by magnitude of the instability coefficient for crop area and yield in Table 10 and for local and world farm price in Table 11.

Sugar beet has shown the highest area instability, of 28.8%, followed by the citrus area with an instability coefficient of 27.7%, then potatoes with an instability coefficient of 15.5%. The least crop area instability occurred in maize, tomatoes and sugar cane, of about 7%, for the first two crops and 5% for the third. The instability in crop yield was generally less than that of the crop area. The highest yield instability was for citrus, about 17.4%, followed by cotton 8.2% then sugar beet 7.5%. The lowest instability coefficients were associated with rice (3.5%), potatoes (3.3%) and sugar cane (1.7%)

The instability in farm price for onion has been quite high over the last two decades, about 33%, followed by rice, wheat, and cotton, which ranged from 24.5% to 20.4%. The least instability of farm price is associated with maize, 3.5%. There was no association between local farm price instability of the 10 crops concerned and the comparable world price, except for citrus.

Tab. 9 - Estimated Instability coefficients of performance of major crops in Egypt				
Crops	**Area (%)**	**Yield (%)**	**Local Price (%)**	**World Price (%)**
Cotton	7.9	8.2	20.4	14.8
Rice	7.5	3.5	24.5	12.3
Maize	6.9	4.5	3.5	13.8
Wheat	8.4	5.2	21.0	15.3
Sugar cane	4.9	1.7	14.7	16.3
Sugar beet	28.8	7.5	19.1	12.3
Tomatoes	6.8	5.2	12.3	18.5
Potatoes	15.5	3.3	18.5	12.3
Onion	11.4	5.6	33.1	13.4
Citrus	27.7	17.4	13.2	13.5

Source: Estimated from:
Time Trend Equations in (Table 5).and (Table 6) using
trends for all varuiables for the period 1981-2010 except for world prices which are for the period (1991-2010)

Tab. 10 - Ranking of major crops by instability coefficient of area and yield					
Crops	**Area (%)**	**Rank**	**Crops (%)**	**Yield (%)**	**Rank**
Sugar beet	28.80	1	Citrus	17.40	1
Citrus	27.70	2	Cotton	8.20	2
Potatoes	15.50	3	Sugar beet	7.50	3
Onion	11.40	4	Onion	5.60	4
Wheat	8.40	5	Tomatoes	5.20	5
Cotton	7.90	6	Wheat	5.20	6
Rice	7.50	7	Maize	4.50	7
Maize	6.90	8	Rice	3.50	8
Tomatoes	6.80	9	Potatoes	3.30	9
Sugar cane	4.90	10	Sugar cane	1.70	10

Source: (Table 7)

Tab. 11 - Ranking of local and world farm price of major crops by instability coefficient					
Crops	**Local Price (%)**	**Rank**	**Crops**	**World Price (%)**	**Rank**
Onion	33.10	1	Tomatoes	18.50	1
Rice	24.50	2	Sugar cane	16.30	2
Wheat	21.00	3	Wheat	15.30	3
Cotton	20.40	4	Cotton	14.80	4
Sugar beet	19.10	5	Maize	13.80	5
Potatoes	18.50	6	Citrus	13.50	6
Sugar cane	14.70	7	Onion	13.40	7
Citrus	13.2.	8	Rice	12.30	8
Tomatoes	12.30	9	Sugar beet	12.30	9
Maize	3.50	10	Potatoes	12.30	10
Source: Table 7					

Crop area supply response

As mentioned earlier, changes in weather can not explain instability either in area or yield of the crops considered, as Egypt enjoys an apparently stable climate. The existence of a fully irrigated agricultural system also excludes the possible impact of fluctuations in rainfall on instability in production of the major crops cultivated in Egypt. The study, therefore, has tried to estimate the impact of the farm price response on the crop area, using a lag-response model to simulate the ordinary supply response.

The study, however, has considered the dramatic socio-economic changes that the Egyptian economy has experienced over the last three decades in which there were three stages: an economy which tended to be fully centrally planned until 1996; it then moved to what was called the economic reform program until1995 and this was associated with policies and instruments applied in the Egyptian economy after 1990, and particularly, in agriculture after 1986/1987.

A covariance analysis model was therefore applied to compare supply response models of each crop in the three periods, i.e. 1981-1986, 1986-1995 and 1995-2010. The purpose was to see whether there has been interaction between price response and policy changes, or whether the policy impact was independent. The test of homogeneity of the variances of the three regression lines was applied (Equation 8) that showed heterogeneity of the variances of regression models the three periods. Therefore, the analysis was restricted to the period (1995-2010), i.e. after the end of the economic reform program of the agricultural sector. This period also reflects the present performance of the Egyptian economy, except for the two years of the 25th of January Revolution, i.e., privatization of economic enterprise, free output and input prices, free exchange rate and free interest rate and free market mechanism with limited subsidy of some food items and fuel.

It should be mentioned that, the supply response for sugar cane and orange was not estimated. This is because both crops are permanent crops. Special treatment is needed to estimate supply response models in these cases, which is beyond the scope of this study.

Among the eight estimated crop supply responses, maize, potatoes and cotton models were statistically insignificant. Therefore, the farm price changes over the concerned period could not

explain the variations in area. The reasons behind such insignificant supply response are as follows: for maize, no explicit price policy has been practiced over the last three decades to encourage farmers to expand maize area by providing price incentives or guaranteed price. For potatoes, it seems that the plant diseases, particularly, the "brownish rotten" have been behind instability in area as the infection blocks the possibility of exporting which is assumed to be the main objective behind the farmers' economic decisions. The case of insignificant farm price-area response of cotton is probably due to the continuous decrease in area due to stagnating domestic and foreign demand for Egyptian extra-long staple, which in turn was due to the imposed practice of a distorted cotton price and marketing policy.

Area response to farm gate price for tomatoes and onions has corresponded with a polynomial curvilinear model, where 74% and 31% respectively of the variation in the area of the two crops, were explained by the changes in the one year lagged farm price. The significant polynomial response reflected the market behaviour of Cobweb theory because both crops have 2-3 cultivation seasons a year. Rice and wheat are almost the only two crops that have shown an ordinary supply response of a one year lagged farm price, where 39% and 36% of the variation in crop area was explained by the changes in farm price. However, the magnitude of the price response of wheat was almost three times that of rice, i.e., 2.1 and 0.82 ha for additional increase of 1-US$ per ton of output. The lower response of rice to price changes was due to other governmental intervention policies that affect the rice area. These included limits to the maximum rice area to save irrigation water in summer and prohibition of rice cultivation in certain areas, restriction of exportation of rice in some seasons to limit the increase in domestic market price, and sometimes the guaranteed price was announced after the farmers' decision to cultivate and some other times such guaranteed price was not satisfactory, i.e., much lower than the world price or not considering the sudden increase in costs of production.

On the other hand the government, usually, provides a guaranteed price of wheat higher than the world price to encourage farmers to expand wheat area and also to secure a certain domestic quota of wheat supply to produce the subsidized local bread and limit the quantity imported (Table 12).

Tab. 12 - Area supply response of major crops in Egypt									
Crop	**Estimated Parameter**	**Estimate**	**S.E.**	**t Stat**	**P-value**	**Lower 95%**	**Upper 95%**	**Adjusted R2 (%)**	**Fcal**
Rice	Intercept (b0)	453.87	55. 80	8.13	<0.001	336.64	571.10	29.7	9.10
	Farm Price P(t-1)	0.82	0.27	3.00	0.01	0.25	1.39		
Maize	Intercept (b0)	761.59	55.14	13.81	< 0.01	645.75	877.43	-5.1	0.79
	Farm Price P(t-1)	0.08	0.30	0.27	< 0.79	-0.55	0.71		
Wheat	Intercept (b0)	662.45	116.93	5.67	< 0.01	416.78	908.12	36.4	0.0029
	Farm Price P(t-1)	2.10	0.61	3.45	< 0.01	0.82	3.37		
Sugar beet	Intercept (b0)	-44.80	17.19	-2.61	< 0.05	-80.91	-8.68	65.1	36.38
	Farm Price P(t-1)	3.47	0.58	6.03	< 0.01	2.26	4.68		
Tomatoes	Intercept (b0)	-53.62	44.98	-1.19	0.24	-146.08	38.85	73.9	0.04
	Farm Price P(t-1)	2.59	1.16	2.23	0.03	0.20	4.98		
	P2(t-1)	-0.02	0.01	-2.36	0.03	-0.04	0.00		
	P3(t-1)	0.0001	0.00	2.35	0.03	0.00	0.00		
Potatoes	Intercept (b0)	81.52	27.48	2.97	0.01	23.53	139.50		
	Farm Price P(t-1)	0.12	0.19	0.65	0.53	-0.28	0.52		
Onion	Intercept (b0)	-36338.25	11414.23	-3.18	0.00	-59800.52	-12875.97	31.1	5.36
	Farm Price P(t-1)	638.67	202.14	3.16	0.00	223.17	1054.16		
	P2(t-1)	-3.73	1.19	-3.13	0.00	-6.18	-1.28		
	P3(t-1)	0.0072	0.0023	3.0973	0.0046	0.0024	0.0120		
Cotton	Intercept (b0)	368.63	92.59	3.98	0.00	168.60	568.66	3.3	1.49
	Farm Price P(t-1)	-0.14	0.11	-1.22	0.25	-0.38	0.11		

Source: Estimated from:
(1) Ministry of Agriculture and Land Reclamation (2009) Agricultural Statistics Bulletin, Issued annually by The Economic Affairs Sector, Cairo, Egypt.
(2) http://faostat.fao.org/site/570/default.aspx#ancor.

Yield-price response of the major crops

Only five crops have demonstrated a significant effect of the one year lagged farm price on crop yield: rice, maize, wheat, onion and tomatoes. The variation in the yield of the other three crops (cotton, sugar beet and potatoes) has not apparently been affected by the changes in farm prices, (Table 13). These results may reflect the Egyptian market situation and policies.

Tab. 13 - Estimated yield response of major crops in Egypt

Crop	Estimated Parameter	Estimate	S.E.	t Stat	P-value	Lower 95%	Upper 95%	Adjusted R2	Fcal
Cotton	Intercept (b0)	2.51	0.27	9.25	0.00	1.94	3.09	0.016	0.276
	Farm Price P(t-1)	-0.0002	0.0003	-0.53	0.61	-0.0009	0.0005		
Rice	Intercept (b0)	7.48	0.74	10.06	0.00	5.91	9.05	18.4%	5.05
	Farm Price P(t-1)	0.008	0.00	2.25	0.04	0.00	0.02		
Maize	Intercept (b0)	4.16	0.51	8.08	0.00	3.08	5.25	69.0%	41.15
	Farm Price P(t-1)	0.02	0.00	6.41	0.00	0.01	0.02		
Wheat	Intercept (b0)	5.10	0.50	10.29	0.00	4.05	6.14	15.9%	4.41
	Farm Price P(t-1)	0.005	0.003	2.101	0.051	-0.00002	0.011		
Sugar Beet	Intercept (b0)	49.93	2.62	19.06	0.00	44.40	55.46	2.3%	1.42
	Farm Price P(t-1)	-0.103	0.087	-1.19	0.25	-0.29	0.08		
Potatoes	Intercept (b0)	24.57	2.41	10.20	0.00	19.49	29.65	-3.7%	0.36
	Farm Price P(t-1)	-0.010	0.017	-0.60	0.56	-0.04	0.03		
Onion	Intercept (b0)	-87.90	8.90	-9.88	0.00	-106.67	-69.13	89.5%	153.75
	Farm Price P(t-1)	0.63	0.05	12.40	0.00	0.52	0.74		
Tomatoes	Intercept (b0)	46.01	3.99	11.53	0.00	37.59	54.43	22.2%	6.15
	Farm Price P(t-1)	-0.096	0.039	-2.479	0.02	-0.18	-0.01		

Source: Estimated from:
(1) Ministry of Agriculture and Land Reclamation (2009) Agricultural Statistics Bulletin, Issued annually by The Economic Affairs Sector, Cairo, Egypt.
(2) HYPERLINK "http://faostat.fao.org/site/570/default.aspx" \l "ancor"http://faostat.fao.org/site/570/default.aspx#ancor.

Rice, onion and tomatoes are the main cash crops and also exportable ones. Farmers are therefore keen to raise the yield to secure higher cash income, as long as there are market incentives to do that in terms of higher farm-gate price. Wheat is not only a subsistence crop for domestic consumption of the farm household: it is also a source of farm income, by selling the surplus either to the free market traders or to milling plants for processing for subsidized bread at a price guaranteed by the mills. In this respect, the Egyptian government used to follow a certain policy to encourage farmers by determining a domestic wheat price usually higher than the world price, and also with an added bonus for a better quality of wheat. Maize is also a subsistence food crop in some rural areas and also a source of livestock and poultry feed. As a summer crop, there is no scope for expanding its area at the expense of rice because the latter is more profitable. Therefore, when rice cultivation is forbidden, particularly, in southern governorates, farmers have only one opportunity, which is to increase their revenue from the maize area by raising the yield in response to higher farm gate price.

The effect of world prices on domestic prices of the major crops

Table 14 shows that only four crops, cotton, maize, rice and onion demonstrate a positive impact of the average world price on the domestic farm price. These results are apparently logical for three of the four crops, onion, cotton and rice, because they figure significantly in revenue from agricultural exports. Therefore, their prices have been affected by world market price inflation and fluctuations. However, Egypt is a main importer of corn, mainly for processing for

poultry and livestock feed. The effect of the world price on the domestic maize price fluctuations and inflation could therefore be indirectly a result of demand pressure. When the world market demand for yellow corn increases and faces a shortage in world supply, the domestic market would shift some of its demand to domestic maize production which might raise its price.

Tab. 14 - World price effect on domestic farm price of major crops in Egypt

Crop	Estimated Parameter	Estimate	S.E.	t Stat	P-value	Lower 95%	Upper 95%	Adjusted R2 (%)	Fcal
Cotton	Intercept (b0)	153.76	173.92	0.88	0.39	-213.17	520.69	41.5	13.79
	World Farm Price (Pt)	0.47	0.13	3.71	0.00	0.20	0.74		
Maize	Intercept (b0)	-24.38	39.56	-0.62	0.55	-107.83	59.08	57.7	25.59
	World Farm Price (Pt)	0.85	0.17	5.06	0.00	0.50	1.21		
Rice	Intercept (b0)	2.94	47.57	0.06	0.95	-97.42	103.30	46.0	16.35
	World Farm Price (Pt)	0.52	0.13	4.04	0.00	0.25	0.80		
Wheat	Intercept (b0)	112.77	43.99	2.56	0.02	19.95	205.59	8.1	13.79
	World Farm Price (Pt)	0.31	0.19	1.61	0.13	-0.10	0.71		
Sugar Beet	Intercept (b0)	13.56	7.72	1.76	0.10	-2.73	29.86	12.4	3.56
	World Farm Price (Pt)	0.21	0.11	1.89	0.08	-0.02	0.44		
Tomatoes	Intercept (b0)	106.05	42.14	2.52	0.02	17.14	194.95	-2.3	1.43
	World Farm Price (Pt)	0.11	0.14	0.77	0.45	-0.18	0.39		
Potatoes	Intercept (b0)	106.05	42.14	2.52	0.02	17.14	194.95	-2.3	0.59
	World Farm Price (Pt)	0.11	0.14	0.77	0.45	-0.18	0.39		
Onion	Intercept (b0)	1.67	20.11	0.08	0.93	-40.75	44.10	34.0	10.27
	World Farm Price (Pt)	0.17	0.05	3.20	0.01	0.06	0.28		
Oranges	Intercept (b0)	139.32	34.48	4.04	0.00	66.22	212.41	-3.8	-0.04
	World Farm Price (Pt)	0.05	0.09	0.61	0.55	-0.13	0.24		

Source: Estimated from:
(1) Ministry of Agriculture and Land Reclamation (2009) Agricultural Statistics Bulletin, Issued annually by The Economic Affairs Sector, Cairo, Egypt.
(2) http://faostat.fao.org/site/570/default.aspx#ancor.

In other words, Egypt's agricultural resources, with a fully irrigated system, fertile soil, moderate climate and human resources with profound and long standing experience, should not display significant fluctuations or instability in output. It seems that a lack of proper management and farm practices, as well as irrational policies have been behind this degree of risk in agricultural production

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Politica Agricola Internazionale

INTERNATIONAL agricultural POLICY

La rivista trimestrale "Politica Agricola Internazionale / International Agricultural Policy" (PAGRI/IAP) nasce con l'obiettivo di riprendere il dibattito scientifico sui tanti temi che interessano le scelte politiche del sistema agricolo allargato, allo scopo di agevolare il confronto con gli operatori ed i policy-makers. Proponendo contributi di autori nazionali a fianco di quelli stranieri, la rivista vuole aprire la riflessione a un contesto internazionale. La rivista si vuole inoltre caratterizzare per un forte e continuo collegamento con l'attualità, aprendosi ai contributi di coloro che partecipano alla costruzione o alla applicazione delle scelte politiche. Il rigore scientifico degli articoli, sottoposti a referee esterni anonimi, potrà giovarsi del confronto con l'esperienza operativa presente in sezioni specifiche della rivista.

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