THE POSSIBILITY OF INCREASING AGRICULTURAL PRODUCTIVITY IN EGYPT

BY

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ABSTRACT

It is often argued that the burden of providing surplus in the primary producing countries falls upon agriculture. By extracting this surplus to be utilized in clearing the way for rapid growth, economic development would be sustained. This raises an empirical question: how can agricultural production be increased? The logic of increasing agricultural productivity may be explained in terms of investment allocation among sectors, and resource allocation within the agricultural sector. Rapid growth in an early stage of economic development might be achieved through reallocation of investment in favour of agriculture. In a second stage agricultural resources must efficiently be allocated to ensure continuous development. These two aspects are investigated and tested with respect to the Egyptian economy, in an attempt to identify the possibility of increasing agricultural productivity under the present economic structure.

The study is therefore divided into an introduction and two broad parts. In the introduction we briefly sketch the characteristics of Egyptian agriculture in order to recognise its role in the national economy and to investigate the implication of the present agricultural policy.

Part one (two chapters) is devoted to testing investment allocation efficiency among the commodity sectors. In chapter II, the arguments for and against agricultural development are recalled to be analysed with respect to empirical evidence from the past. The necessity of agricultural development is investigated to be tested against the conditions under which the primary producing countries operate. A three sectoral approach emphasises on creating agricultural surplus in the early stages of economic development is suggested in Chapter III, to be tested with respect to the Egyptian economy during

the period 1960-65. Minimum capital-output ratio criterion is applied in reallocating investment among commodity sectors. Comparison between the actual outcome and that resulted from investment reallocation is made to justify the suggested approach. An input-output table is employed to show the interrelation between sectors and to ensure overall balance. A demand - supply table is used to determine sectoral surplus (or deficit).

Part two comprises five chapters to be devoted to testing resource allocation efficiency within the agricultural sector. In chapter IV, both technical and economic theory of production are reviewed with special referrence to the popular forms of production function analysing their limitations in both theoretical and practical terms, and showing the major statistical constraints to the application of production function approach. The previous empirical investigations of production behaviour in Egyptian agriculture are survied in chapter V.

In the remaining chapters, an attempt is made to identify agricultural potentiality in terms of resource allocation efficiency. The whole area is divided into five regions, North & West Delta, Middle Delta, East Delta, Middle Egypt and Upper Egypt. Production behaviour is examined for each region separately to test for resource allocation efficiency among regions. A production function approach is adopted to test technical efficiency. Three algebraic forms; linear function, Cobb-Douglas function and Constant Elasticity of Substitution function are tested against the numerical observations. A time series production function for the period 1960-75 is estimated in chapter VI. A separate production function (i.e. disaggrative production function) is fitted for the major crops (cotton, rice and wheat) in each region. Chapter VII is devoted to testing technical efficiency with respect to the various farm size classes and tenure forms. Estimates are based on cross sectional data collected directly from the farmers and confined to cotton, the major single crop. A two-stage model is applied to test resource allocation efficiency among as well as within stages of cultivation. A management index is derived to examine its impact on large farms efficiency. In the final chapter (chapter VIII) a maximisation approach for constrained extrema is adopted to determine the optimum level of output (i.e. maximum profit) for the various classes of farm size to be utilised in identifying the productivity gap under the present situation and to find out the relevant class of farm size to Egyptian agriculture. The implications of the findings are discussed.

CHAPTER I

INTRODUCTION

Egyptian Agricultural Background

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Egypt is a large mass of desert with all the cultivated area being compressed into less than 4 per cent of a total of one million square kilo metres (i.e. 386,000 square miles), that area of the country which lies along the fertile banks of the "River Nile".

The total area is usually divided into four regions. The Nile Valley, Delta, Eastern and Western deserts, and Sinai Peninsula. The cultivated land (i.e. 28,000 square kilometres) is concentrated in the former two regions, following the course of the River Nile, with a few additional small areas which are cultivated around the desert oasis or along the sea coast. Population is similarly concentrated in the Nile Valley and Delta.

In this introductory chapter, Egyptian agricultural resources are breifly featured in order to recognise its characteristics and potentiality. Agricultural policy is investigated to be evaluated with respect to the conditions under which Egyptian agricultural operates.

I - 1: Agricultural Resources

Agriculture comprises both physical and human resources.

(a) Physical Resources

The term "physical resources" as used, here, refers to the land and its physical and climatic features, water resources and man-made factors.

1-Land Resources

The current cultivated area in Egypt is estimated at 6.7 million Feddans (i.e. 7 million acres). It increased linearly by some 22 per cent over the period 1927-72 (table I-1). The average annual growth of the cultivated area increased from 19 thousand Feddans over the period 1947-60 to some 60 thousand Feddans during the period 1960-72, due to the increase in water resources and improvement of the irrigation and drainage system. Still the growth rate of land reclamation is relatively slow and perhaps less than the rate that could be achieved.*

The cropped area estimated at 10.8 million Feddans in 1972 increased by some 24 per cent over the period 1927-72, giving an annual increase of 47 thousand Feddans on average, against 26.7 thousand for the cultivated area, allowing Egypt to have one of the highest rates of multiple cropping in the world (1.6).

Soil is generally fertile. It contains organic matter, but not in sufficient quantities for the high nitrogen requirements of plants, though relatively rich in potasium. The nature of soil is fairly homogeneous

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* Agricultural horizontal expansion policy is examined in Section 3.

TABLE I - 1

The Growth of the Cultivated and Cropped Area

in Egypt (1927-72)

Year	Cultivated Area			Cropped Area		
	Mill.Feddan	Mill.Acre	Mill.Hectare	Mill.Feddan	Mill.Acre	Mill.Hectare
1927	5.5	5.7	2.3	8.7	9.1	3.6
1937	5.3	5.5	2.2	8.4	8.75	3.5
1947	5.8	6.0	2.4	9.2	9.6	3.9
1960	5.9	6.1	2.5	10.2	10.6	4.3
1966	6.0	6.25	2.6	10.4	10.8	4.4
1972	6.7	7.0	2.8	10.8	11.25	4.5

Source: Central Agency for Public Mobilisation and Statistics (CAPMS), "Statistical Yearbook", Cairo, various years.

all over the cultivated area, the only difference being in the proportion of fine clay to coarser materials which tends to increase from south to north and from the banks of the River Nile to the edge of the valley. [1] Crop allocation is therefore not significantly constrained. Climate is slightly varied from one area to another. It is, in general characterised by moderate and dry weather with a very few and irregular rainfall. Except for the variations in temperature, there is no climatic break between winter and summer, reflecting cultivation through the year. Humidity and temperature are the major constraints on crop allocation among Delta and upper Egypt. Humidity, though not high, exists only in Delta and Eastern shores.

Winter, summer and Nile are the main seasons of cultivation. Winter crops such as wheat, beans, barley, onion, clover etc. which occupy some 43.7 per cent of the total cropped area are planted in October-November to be harvested in April-May. In summer, the crops are planted from March to June, while the harvesting time ranges from August to October. The main summer crops which occupy some 43.6 per cent of the total cropped area are cotton, rice, maize,millet sugar cane, peanuts and sesame. In addition there exists the Nile season in which some summer crops such as maize and millet can be cultivated. Nile crops are usually planted in June and July and harvested in December. Vegatables can be grown all the year round and fruit-growing stretches over many years. With the completion of the High Dam in Aswan, which provides a regular supply of water during the year, the area occupied with Nile crops is diminishing (table I-2). Cultivation is arranged in two crop-rotation systems, a biennial system with one cotton crop each second year, and a triennial system with one cotton crop each third year.

TABLE I - 2

Cropped Area Classified to Seasons — Major Crops — 1952-74

Year	Winter Crops*				Summer Crops *					Nile Crops *				Orchards	Total
	Wheat	Clover	Others	Total	Cotton	Rice	Maize	Others	Total	Rice	Maize	Others	Total		
1952	1402	2202	760	4364	1967	362	26.8	670.2	3026	12	1677	135	1824	93.7	9307.7
1953	1790	2142	680	4612	1324	409	30.7	755.3	2519	14	1985	150	2149	97.8	9377.8
1954	1795	2268	742	4805	1579	592	32.5	770.5	2974	17	1872	139	2028	101.4	9908.4
1955	1523	2350	828	4701	1816	586	32.5	761.5	3196	13	1801	146	1960	108.6	9965.6
1956	1570	2318	820	4708	1653	678	46.8	811.2	3189	12	1789	157	1958	107.2	9962.2
1957	1514	2363	848	4725	1819	717	47.4	788.6	3372	14	1721	157	1892	110.6	10099.6
1958	1425	2380	847	4652	1905	506	72.2	778.8	3262	13	1883	164	2060	115.2	10089.2
1959	1475	2398	897	4770	1760	714	84.5	846.5	3405	15	1774	180	1969	125.6	10269.6
1960	1456	2414	938	4808	1873	695	127.9	837.1	3533	11	1693	194	1898	131.1	10370.1
1961	1384	2448	861	4693	1986	527	170.1	834.9	3527	10	1433	173	1616	137.7	9973.7
1962	1455	2442	925	4822	1657	823	347.6	875.4	3703	7	1484	204	1695	145.1	10365.1
1963	1345	2435	937	4717	1627	952	347.0	975	3901	7	1374	207	1588	152.2	10358.2
1964	1295	2480	983	4758	1611	955	364.9	985.1	3916	7	1295	234	1536	167.0	10378.0
1965	1144	2493	987	4624	1900	842	930.7	1024.3	4697	6	520	236	762	177.9	10260
1966	1291	2532	916	4739	1859	841	1053.2	1040.8	4794	3	522	235	760	195.1	10488.1
1967	1245	2716	815	4776	1626	1072	1095	1064	4857	3	390	229	622	207	10462
1968	1413	2679	837	4929	1464	1199	1169	1113	4945	5	385	256	646	225	10745
1969	1246	2726	877	4849	1622	1187	1143	1098	5050	5	341	255	601	232	10732
1970	1304	2748	783	4835	1627	1140	1153	1133	5053	3	351	264	618	244	10750
1971	1349	2770	752	4871	1525	1135	1171	1181	5012	2	351	257	610	249	10742
1972	1239	2819	864	4922	1552	1144	1210	1178	5084	2	321	253	576	253	10835
1973	1248	2874	821	4943	1600	995	1303	1177	5075	2	351	295	648	258	10924
1974	1370	2797	813	4980	1453	1051	1387	1210	5101	2	368	297	667	273	11021

* In thousand feddans

Sources : Ministry of Agriculture, "Agricultural Economics", Cairo, various years,
CAPMS, "Statistical Year Book", Cairo, various years, op. cit.

2-Water Resources

The main source of water is the River Nile, which irrigates some 99 per cent of the total cultivated area. The River Nile has a great annual fluctuation. During the flood, there is a large surplus of water, but in the absence of storage would not suffice to irrigate summer crops. The Nile supplies the land with an average of 8.2 milliard cubic metres per month, but it decreases to some 1.3 milliard cubic metres per month in the summer. (2) Efforts have therefore been made to store water during periods of surplus, to be released during periods of shortage. Thus an integrated system of barrages and dams has been built up. The High Dam project which started in 1958 to store some 157 milliard cubic metres with a waterhead of 97 m.m., would ensure a regular annual supply of 84 milliard cubic metres. (3)

Two systems of irrigation; basin and perennial, exist in Egyptian agriculture. For basin irrigation, water is supplied by a single flooding during the high-water period of the Nile and affords only one annual cropping season. The basin system has been gradually replaced by perennial irrigation which is becoming the dominant system on which a cultivated area of more than 5.9 million Feddan out of a total of 6.7 million Feddans depends. The perennial system involves an elaborate system of storage reservoirs to supplement the natural flow of the Nile during the annual low-water period and of barrages across the river to make it possible during this period to maintain the flow into the canals. It regulates both the timing of irrigation and the quantities of water supplied to the land, allowing an expansion of multicropping. One disadvantage of perennial irrigation is that it normally leads to a rise in the level of underground water which adversely affects plant growth.

Thus, attention has been paid to the drainage system in which two kinds exist; the first and more usual depends on surface drains, while the second depends on tile drainage. The length of drains in the two systems together is some 14,000 kilometres. While the majority of the cultivated area is drained by gravity, nearly one million Feddans have to be drained by pumping.

3-Man-Made Factors

The possibility of increasing agricultural production by increased use of chemical fertilisers is well recognised and appreciated by the Egyptian farmers and supported by government policy as many studies in this field suggest. (4) Since 1945, consumption of chemical fertilisers began to increase gradually, such that it becomes one of the major inputs in Egyptian agriculture. (Table I-3). After 1960, it was increasing at accelerating rates, reaching some 2.23 million tons (gross weight product) in 1974. Table I-4 shows that fertiliser use per unit of land in Egypt is the highest among the developing countries and even higher than many developed countries. This is, perhaps, due to what appears to be an efficient distribution system which takes the form of "pyramid", as will be discussed and justified below (Section 3).

Insecticides are of a particular importance to crops such as cotton (the major cash crop in Egypt) which is usually subject to severe plant deseases and insects. Past experience, however, shows that cotton production was seriously affected in several years, particularly in 1961 and 1966, due to the deficiency in handling plant protection operation. The annual losses resulted from such deficiency are estimated at some L.E. 60 million. (5) Recognising the importance of plant protection operation, Ministry of Agriculture undertook the whole operation completely. Both insecticides and sprayers are supplied,priced and

TABLE I - 3

Consumption of Fertilisers in Egypt (1952-74)

Year	Nitrate in * thousand tons of Gross weight product	Phosphate in * thousand tons of Gross weight product	Total in thousand tons
1952	612	106	718
1953	583	71	654
1954	631	81	712
1955	584.5	88.2	672.7
1956	570	130.4	700.4
1957	631.8	154	785.8
1958	624.6	150.5	775.1
1959	656.1	140.7	796.8
1960	673.6	141.7	815.3
1961	913.4	226.6	1140
1962	822.9	209	1031.9
1963	852.8	213.9	1066.7
1964	993	242.4	1235.4
1965	1424.9	287.3	1712.2
1966	1580.2	311.2	1891.4
1967	1377.2	258.6	1635.8
1968	1356	203	1559
1969	1558	223	1781
1970	1705	208	1913
1971	1854	212	2066
1972	1833	251	2084
1973	1992	285	2277
1974	1995	238	2233

* plant nutrient in Nitrate is approx 26% while it is only 15% in Phosphate.

Source:

Agricultural credit and Co-operative Bank "Unpublished Data" Cairo various years.

TABLE I - 4

Fertiliser use per Hectare of Cultivated Area in 1964-66

Country	Fertiliser use per Hectare *	Country	Fertiliser use per Hectare *
Argentina	2.2	U.S.	63.5
India	5.7	Greece	66.9
Pakistan	5.8	Italy	68.5
Turkey	6.7	Egypt	118.6
Brazil	9.2	Sweden	128.2
Canada	16.1	France	149.6
Mexico	18.5	Israel	162.1
Chile	28.1	Rep. of Korea	162.7
Australia	28.6	Denmark	183.6
South Africa	35.9	Austria	212.9
Spain	37.4	U.K.	220.3
Portugal	40.5	F.R. of Germany	347.1
Ceylon	50.8	Japan	326.3
Peru	53.1	New Zealand	556.5
Yugoslavia	58.1	Netherlands	593.0

* Figures in plant Nutrient (N+P+K)

Sourcs: FAC Fertilisers; An Annual review of world production, consumption, trade and prices, Rome 1969 subsidised (since 1972) by Ministry of Agriculture, while the manual operation (picking up insects) is done at the presence of official inspectors. However, insecticides applied to the whole crops was steadily increasing since 1960, except for the period 1967-70 due to what appears to be exceptional circumstances. (Table I-5)

Machines used in Egyptian agriculture are still limited, though they were increasing, but gradually over the years. Labour substitutes' machines are hardly applied. Apart from few large farmers, agricultural activities such as sowing, fertilisation and harvesting are completely done manually. Animals substitutes' machines which are confined to land preparation, irrigation, threshing and plant protection are partly used, covering some 50 per cent of the total cultivated area as shown in Tablt I - 6 against 25 per cent in 1960.(6) Data in Table I - 6 suggest that more than 200 million pounds are needed in order to mechanise the underlying activities. Such low degree of mechanisation might be attributed to the lack of finance, dominance of small farms, and relative availability of labour. In recent years, Ministry of Agriculture intorduced a new system aiming to encourage small farmers to use machines. Tractors, ploughs and threshers are made available on rental basis through the co-operatives within the villages themselves.

TABLE I - 5

The Consumption of Insecticides
in Egypt (1952-72)

Year	Amount in Tons
1952 - 53	2143
1959 - 60	15212
1964 - 65	20450
1965 - 66	28639
1966 - 67	30699
1967 - 68	28914
1968 - 69	25668
1969 - 70	24664
1970 - 71	20851
1971 - 72	35259

Source CAPMS, Statistical Year Book OPCIT various years.

TABLE 1 - 6

The Degree of Agricultural Mechanisation
in Egypt (1975)*

Operation	Type(1) of Machine	Price per Machine	Actual Level		Optimum Level		Degree of Mechanisation	Capital Requirements
			No. of Mach. Thousand	Feddan per Machine	No. of Mach. Thousand	Feddan per machine (2)	%	L.E.Million
Land Preparation	Tractor 50 H.P. Plough	L.E. 4500 300	23	280	43	150	53	96
Irrigation	Irrigation Machine 12-16 H.P.	600	40	167	135	60	36	57
Threshing	Thresher 3 feet	400	4.5	111	100	5	4.5	38
Plant Protection	Mechanical Sprayer 600 litres	700	15	107	32	50	47	11.9

* Confined to animal substitutes' machines.

(1) They are the most popular types of machines used in Egyptian agriculture. All other types are converted into standard units of the underlying types.

(2) As suggested by the Dept. of Agricultural Mechanisation, Ministry of Agriculture.

Sources:

(1) CAPMS, "Agricultural Mechanisation" Ref No. 2331 1AA1 1977, Sept 1977.

(2) Ministry of Agriculture, Dept of Agricultural Mechanisation, unpublished report.

(3) Personal contact with the Director of Agricultural Mechanisation Dept., Ministry of Agriculture.

(b) Human Resources

Egypt is one of the most densely populated country. On 28 thousand square kilometres more than 36 million people were living in 1974. Population was rapidly growing so that in less than forty years, it has more than doubled (Table I - 7) The annual rate of population growth has increased from 1.8 per cent between 1937-47 to 2.5 per cent between 1947-74. It seems to be uniquely due to a rise in the rate of natural growth, which in turn is largely due to what appears to be a significant fall in the death rates, as a result of the expansion of education and improvement in health facilities. Indeed, death rates have declined, from 2.1 per cent in 1947 to 1.5 per cent in 1970. (7) Since 1970, population growth rate was showing downward trend. During the period 70-74 annual rate of population growth accounted for 2.25 per cent, against 2.56 per cent over the period 1966-70 (Table I - 7). This is perhaps due to the observed decline of the birth rate in the last few years. Birth rates has decreased from 4.1 per cent in 1966 to 3.5 per cent in 1970 and then to 3.3 in 1974. (8) Still the annual rate of population growth in Egypt is higher than the world average (1.9 per cent) and perhaps, apart from Africa (2.6) higher than the figures for the world's continents: 2.1 per cent in America, 2.2 in Asia, 0.8 per cent in Europe (excluding Russia), and 2 per cent in Oceania.(9)

In 1974, some 20.6 million people were absorbed in the rural areas of which 18.4 million were engaged in agricultural activities. Data on population (Table I - 7) show that the share of the rural population to the total population has been decreased from 76 per cent in 1927 to 63 per cent in 1960, and then to 56.6 per cent in 1974, indicating gradual and perhaps regular movement from the country side.

TABLE I - 7

Population and Agricultural Population Growth in Egypt (1927 - 1974)

in Millions

Year	Total Population	Annual Rate of Growth	Rural Population						Urban Population	
			Agricultural Popul.		Non-agricultural Pop.		Total			
			Million	% of total Population	Million	% of total Population	Million	% of total Population	Million	% of total Population
1927	14.1		9.5	67.2	1.3	8.8	10.8	76	3.3	24
1937	15.9	1.2	11.1	69.8	0.8	5.2	11.9	75	4.0	25
1947	19.0	1.8	11.8	62.1	1.3	6.9	13.1	69	5.9	31
1960	25.8	2.4	15.0	58.1	1.1	4.9	16.1	63	9.7	37
1966	30.1	2.6	16.5	54.8	1.2	4.2	17.7	59	12.4	41
1970	33.3	2.56	17.5	52.6	1.7	5.1	19.2	57.7	14.1	42.3
*1974	36.4	2.25	18.4	50.5	2.2	6.0	20.6	56.6	15.8	43.4

* 1974's figures are initial estimates

Sources :

1. Population Censuses, various years (1927-60)
2. CAPMS, "Statistical yearbook", Cairo, various years
3. Ministry of Agriculture, Department of Agricultural Economics and Statistics, various years.

Only a small fraction of the rural population is engaged in non-agricultural activities, though it is increasing since 1960. It has increased from 6.8 per cent in 1960 to 10.7 per cent in 1974, perhaps due to the expansion of services and facilities which recently took place in the rural areas. Agricultural population has been increasing but at lower rates than total population reflecting a diminishing proportion of agricultural population to the total population. During the period 1937-74, agricultural population increased only by 65.8 per cent, while total population increased by more than 128 per cent. However, the relative share of agricultural population had decreased from 69.8 per cent in 1937 to 58.1 per cent in 1960, and then to 50.5 per cent in 1974. Out of a total increase of 6.8 million between 1947-60, 3.2 million, i.e. 47 per cent of the total increase of population were absorbed in agriculture, while only 32 per cent of the total increase of population over the period 1960-74 have been absorbed in agriculture. This could be attributed to many factors such as wage differential between urban and rural areas, greater job opportunity in the towns, flexibility of the informal sector in some urban areas, expansion of services, particularly education, and perhaps the so-called value of ruling elites. All these factors together influenced the desire of some rural population, mainly landless labourers to move to the urban areas. (10)

Out of a labour force of 8.9 million, 4.2 million were engaged in agriculture in 1973 representing some 47 per cent of the total labour force, against 16.6 per cent and 36.5 per cent in industry and services respectively (Table I - 8). Although agricultural labour force still accounts for a major part of the Egyptian total labour force, its relative size has been decreasing over the years. It decreased from 55.3 per cent in 1960-61 to 47 per cent in 1973. Only 23.7 per cent of the increase in labour force during the period 1960-73 were absorbed in agriculture

TABLE I - 8

Labour Force Growth by Sectors
1960-73

Sector / Year	Agriculture(1)		Industry(2)		Services(3)		Total	
	.000	% of Total	.000	% of Total	0.000	% of Total	.000	% of Total
1960/61	3600.0	55.3	804.7	12.4	2107.2	32.3	6511.9	100
1961/62	3600.0	53.4	957.1	14.2	2099.8	32.4	6656.9	100
1962/63	3623.0	52.9	1059.0	15.4	2177.2	31.7	6868.2	100
1963/64	3673.0	51.8	1141.8	16.1	2270.2	32.1	7085.0	100
1964/65	3751.0	50.9	1188.2	16.1	2434.7	33.0	7373.9	100
1965/66	3877.2	51.0	1188.2	15.6	2541.1	33.4	7606.5	100
1966/67	3864.6	50.6	1172.6	15.3	2596.6	34.1	7633.8	100
1967/68	3892.4	50.3	1144.6	14.8	2789.6	34.9	7827.6	100
1968/69	3964.9	49.3	1249.0	15.5	2837.3	35.2	8051.2	100
1969/70	4048.3	48.9	1326.8	16.0	2899.6	35.1	8274.7	100
1970/71	4056.9	47.7	1449.0	17.0	3000.1	35.3	8506.0	100
1972 *	4123.7	47.4	1470.7	16.9	3106.3	35.7	8710.7	100
1973 *	4163.8	46.9	1476.6	16.6	3245.9	36.5	8886.3	100

(1) Aggricultural employment seems to be restricted to adult males.

(2) Industry includes, manufacturing, electricity, mining and construction.

(3) Services includes the Government but not the army.

* Since 1972 estimation is made in Calendar years.

Source:

CAPMS, "Statistical year book" Cairo, various years, op·cit.

against 28.3 per cent and 48 per cent in industry and services respectively.* Such contunous labour migration from agriculture might be attributed to the employment policies in which the government commit itself in employing more people in services and public companies than they actually required. Still manufacturing capacity in absorbing labour is less than agriculture. It seems that the major part of the increase in labour force were employed in services and construction industries.

* Only 19.4 per cent were employed in manufacturing.

I - 2: Characteristics of Egyptian Agriculture

The major problem which Egyptian agriculture encounters, both in the past and at present time is the imbalance between input factors, land and capital being limited with low rate of growth, while population and labour are abundant with high rate of growth, reflecting deteriorating situation. This can be explained in factor input ratios.

Land/Man Ratio

In 1974 land/man ratio (ratio of cultivated area to the total population) accounted for 0.184 Feddan against 0.39 Feddan in 1927. In less than fifty years it decreased to less than one-half, due to the high increase of population (158 per cent) relative to the growth of cultivated area (only 22 per cent).

A low ratio of cultivated area to the total population is not necessarily a self-evidence indicator of population pressure on land. Some countries which have low land/man ratio such as U.K. and Japan do not face the problem of population intensity on agricultural land. A more appropriate indicator is to relate cultivated area to agricultural population. This latter ratio, though it is nearly as twice as land/man ratio, is also low compared with other countries and perhaps one of the lowest in the world. During the period 1927-74 agricultural population increased (by 93 per cent) nearly four times as fast as the cultivated area (by 22 per cent), leading to a dramatic decrease in land/man ratio in agriculture from 0.579 Feddan to 0.364 Feddan in 1974 (by some 37 per cent).

On the other hand, cultivated land ratios whether related to the whole population or agricultural population, may underestimate land resources. It is the cropped area which reflects the real available resources of land. The overall cropped land / man ratio and that in agriculture are estimated at 0.302 and 0.598 Feddan respectively (Table I - 9) Although these two latter ratios are higher than the cultivated land ratios, they are still low, even if we compare them with the cultivated land ratios in the other less developed countries.

However, the widening of the gap between population and land seems likely to continue. Unless a massive horizontal expansion (reclaiming and cultivating new land) takes place, land-population problem is not expected to be solved.

Capital / Man Ratio

The problem of insufficient amount of physical capital in existence is a characteristic feature of the Egyptian economy in general and the agricultural sector in particular. On average of 1960-73 capital / man ratio was just over 11 L.E. characterising Egypt as an economy of low capital intensity. It increased slightly from 10.9 L.E. on average 1960-65 to 11.2 L.E. on average of 1965-70, and then to 11.9 L.E. on average of 1970-73, showing a negligible improvement. Furthermore, capital per worker, which accounted for some 52 L.E. in 1973 is low comparted with other countries.

With respect to agriculture, the degree of capital intensity is extremely low and much lower than it is within the whole economy. Capital/ man ratio in agriculture accounted for 3.3 L.E. on average over the period under study, that is less than one-third of the whole economy (table I-10). Although it increased from 3.3 L.E. on average of 1960-65 to 3.5 L.E. on average of 1965-70 (by some 6 per cent) it deteriorated by 12 per cent to reach some 3 L.E. on average 1970-73, despite the relative slow rate of

TABLE I - 9

The Growth of Population and Agricultural Population Relative to Both Cropped and Cultivated Areas (1927 - 74)

Year	Cultivated Area Million Feddans	Cropped Area Million Feddans	Population Million	Agricultural Population Million	Land/Man Ratio	Land/Man Ratio in Agriculture	Cropped Land/ Man Ratio	Cropped Land/ Man Ratio in Agriculture
1927	5.5	8.7	14.1	9.5	0.39	0.579	0.617	0.916
1937	5.3	8.4	15.9	11.1	0.333	0.477	0.528	0.757
1947	5.8	9.2	19.0	11.8	0.305	0.492	0.484	0.780
1960	5.9	10.2	25.8	15.0	0.229	0.393	0.395	0.680
1966	6.0	10.4	30.1	16.5	0.199	0.364	0.346	0.630
1970	6.7	10.8	33.3	17.5	0.201	0.383	0.324	0.617
1974	6.7	11.0	36.4	18.4	0.184	0.364	0.302	0.598

Sources:

1. Population Censuses, various years op. cit.
2. CAPMS, "Statistical Year Book", Cairo, various years op. cit.
3. Ministry of Agriculture, Department of Agricultural Economics and Statistics, various years op. cit.

TABLE I - 10

The Growth of Population and Investment (1960 - 73)

Year	Total (1) Population Millions	Agricult.(2) Population Millions	Total (3) Investment L.E. Million	Agricultural Investment				Capital/Man Ratio	Capital/Man Ratio in Agricul-ture	Capital/Man Ratio with Vertical Expansion
				Total (4)		Vertical Expansion (5)				
				L.E. Million	% of total	L.E. Million	% of total			
1960/61	26.2	15.0	225.6	25.7	11.4	7.3	3.2	8.611	1.713	0.487
1961/62	27.0	15.3	251.1	34.3	13.6	9.6	3.8	9.300	2.242	0.627
1962/63	27.6	15.5	299.6	45.1	15.1	10.7	3.6	10.855	2.910	0.690
1963/64	28.3	15.8	372.4	74.6	20.0	10.0	2.7	13.159	4.722	0.633
1964/65	29.1	16.0	364.3	76.7	21.1	13.3	3.7	12.519	4.794	0.831
Average 1960-65	27.64	15.52	302.6	51.28	16.9	10.18	3.4	10.948	3.304	0.656
1965/66	29.8	16.3	383.8	63.3	16.5	11.7	3.0	12.879	3.883	0.718
1966/67	30.5	16.5	365.8	65.7	18.0	8.2	2.2	11.993	3.982	0.497
1967/68	31.3	16.8	298.0	50.0	16.8	5.2	1.7	9.521	2.976	0.310
1968/69	32.1	17.0	343.5	58.1	16.9	7.4	2.2	10.701	3.418	0.435
1969/70	32.9	17.3	355.5	56.1	15.8	9.5	2.7	10.805	3.243	0.549
Average 1965-70	31.32	16.78	349.2	58.6	16.6	8.4	2.4	11.150	3.492	0.501
1970/71	33.7	17.5	361.0	49.9	13.8	9.8	2.7	10.712	2.851	0.560
1972 *	34.8	17.8	410.1	55.1	13.4	9.8	2.4	11.784	3.096	0.551
1973*	35.6	18.1	465.2	57.6	12.4	12.3	2.6	13.067	3.182	0.680
Average 1970-73	34.7	17.8	412.1	54.2	13.2	10.6	2.6	11.876	3.045	0.596
Average 1960-73	30.69	16.53	345.79	54.77	15.8	9.59	2.8	11.261	3.313	0.580

Sources: 1) Table III - 7.

2) Ministry of Planning,'The Main Feature of the Five Year Plan (1960-65)', Cairo, 1966, p.76, 93, 104.

3) CAPMS, "Statistical Year Book", various years op. cit.

Notes : See over

Notes to Table I -10.

1. Number of population is usually estimated at mid-year (calendar year). In order to adopt population data (in calendar years) with Investment data (in fiscal years). The average of each two calendar years is used to estimate the number of population in the fiscal years.

2. Data on agricultural population after 1970 is not available. Agricultural population is estimated on the basis of 1.7 per cent rate of annual increase from 1965 - 70.

3. Including capital invested on services (at current prices).

4. Excluding expenditures on High Dam.

5. Capital invested only on existing resources of land (includes maintenance expenses on irrigation and drainage system).

6. Since 1972 investment is estimated in calendar years.

agricultural population that prevailed during the same period (1970-73).

The problem will be seen more severe, if the amount of capital only invested on the existing land* is related to agricultural population. Such investment accounted for L.E. 9.6 million, giving L.E. 0.58 per man in agriculture on average of 1960-73. It was not only significantly low, but it also decreased by some 9 per cent during the period (1960-65)-(1970-73) on average. Given agricultural labour force of 4.2 million in 1973, capital per agricultural labour is estimated at 2.9 L.E. indicating a very low capital intensity in the agricultural sector.

Capital/Land Ratio

Capital/land ratio as used here refers to the change in the amount of capital invested in a given unit of land (i.e. the incremental capital invested in agriculture divided by the cultivated area). On average of 1960-73, capital/land ratio estimated at L.E. 1.6 per Feddan (Table I-11), showing slow improvement of capital intensity. Apart from the dramatic decline during the period 1967-70, capital-crop ratio (i.e. incremental capital invested in agriculture divided by the cropped area) was nearly constant over the period under study (Table I - 12). This would explain the slow growth of agricultural mechanisation.

It appears that both capital and land are limited relative to population. In order to reduce population density, new land has to be put under cultivation, but this would require a great deal of capital which is in short supply. Increasing agricultural productivity of the existing land could therefore be the solution to such a dilemma, at least in the short-run. To what extent can this be done? This is the subject of the present study.

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* excluding capital invested on building up new irrigation and drainage channels, but including maintenance cost.

TABLE I - 11

The Growth of Cultivated Area and Investment in Agriculture (1960 - 73)

Year	Investment* Million L.E.	Cultivated Area** Million Feddan	Capital/Land Ratio
1960	7.3	5.9	1.237
1966	11.7	6	1.933
1970	9.5	6.7	1.418
1973	12.3	6.7	1.836
Average 1960 - 73	10.2	6.325	1.613

* Capital invested on the existing land.

** Data on population with respect to capital is available only for these years

Sources :

1. CAPMS, "Statistical Year Book", various years, op. cit.

2. Ministry of Planning, "The Main Features of the Five Year Plan", op. cit.

TABLE I - 12

The Growth of Cropped Area and Investment in Agriculture (1960 - 73)

Year	Investment* Million L.E.	Cropped Area Million Fed.	Capital/crop Ratio
1960/61	7.3	10.17	0.718
1961/62	9.6	10.17	0.944
1962/63	10.7	10.36	1.033
1963/64	10.0	10.37	0.964
1964/65	13.3	10.32	1.289
Average 1960/65	10.18	10.278	0.99
1965/66	11.7	10.37	1.128
1966/67	8.2	10.48	0.782
1967/68	5.2	10.60	0.491
1968/69	7.4	10.74	0.689
1969/70	9.5	10.74	0.885
Average 1965-70	8.4	10.586	0.794
1970/71	9.8	10.75	0.912
1972	9.8	10.84	0.904
1973	12.3	10.92	1.126
Average 1970-73	10.6	10.837	0.978
Average 1960 - 73	9.59	10.525	0.911

* Capital invested on the existing land. (at current prices)

Source : Tables I - 2 and 10

I - 3: Agricultural Policy in Egypt (1952-75)

Agricultural policy in Egypt is controlled by the Government, in the sense that both inputs and outputs are sold to and purchased from farmers through public authorities at stabilised and perhaps subsidised prices. Government intervention is not only confined to agricultural inputs and outputs, it is also concerned with land tenure and land reclamation. In 1952, the Government has brought about radical changes in the ownership structure (Land Reform Law of 1952), and since 1953, land reclamation activities are carried out by public firms.

As far as agricultural policy in Egypt is concerned, two complementary aspects, though distinguished, are to be considered; horizontal expansion (land reclamation) and vertical expansion (agricultural productivity of the existing land). The present pattern of ownership is also examined to identify its implication on farm size and agricultural productivity.

(a) Agricultural Horizontal Expansion Policy

Land scarcity is perhaps one of the major constraints to agricultural development in Egypt. It is, however, believed that agricultural horizontal expansion (land reclamation) is the key factor to higher production and rapid agricultural growth in the future. Hence, since 1953 Agregrain Authority took over such activity to be government monopoly centerelized in a few public agencies, in an attempt to utilize the available resources and to allocate them efficiently. Unfortunately, the implementation of such agencies was rather disappointing due to the so-called bureaucratic red tape that often characterises government agencies. [11] Data on land reclamation show that less than 50 per cent of the planned area was actually reclaimed over the period 1953-72 (Table I - 13). Moreover, the situation was getting worse since

1965. During the period 1965-70, less than one-third of the planned area was reclaimed, due to the considerable increase in reclamation cost (per Feddan) which increased by 127 per cent between 1960-65 and 1965-70.(12)

TABLE I - 13

The Planned and Actual Reclaimed Area
1953 - 72

	Planned (in thousand Feddan)	Actual (in thousand Feddan)	Actual - planned ratio
1953-59	99.370	78.900	0.794
1960-65	723.400	536.200	0.741
1965-70	935.750	269.100	0.288
1971-72	213.00	21.00	0.099
TOTAL (1953-72)	1,971.520	905.200	0.459

Sources:

1. Ministry of Land Reform and Land Reclamation, Report on the Five year plan of Agricultural Horizontal Expansion, 1962 p.p.17-18
2. Ministry of planning "Follow-up Reports" various issues.
3. CAPMS "Statistical yearbook" various years.

This high cost might be attributed to factors such as lack of experience and management deficiency. Most of the reclaimed area was selected in the absence of soil investigation, the potential resources of water were overestimated, and invested capital was misallocated and badly used. (13)

Unless land reclamation cost is remarkably reduced, a significant expansion in the cultivated area will not be feasible in the near future. Indeed many studies suggest that the cost can be reduced at least by 20 per cent if the resources available to land reclamation are reallocated efficiently. (14) However, past experience shows that private sector whether local or foreign was more successful in handling such activity.(15) It is, therefore, suggested that co-operation between the Government and private sector and perhaps experienced foreign investors could be effective in increasing productivity and reducing cost. Government's role is restricted to supervision and partial finance.

However, it is, perhaps, true that an expansion of the current cultivated area is of a particular importance to agricultural development, but in the long-run. Some time (5-7 years) must elapse before any returns can be obtained on the investment in reclaiming and cultivating new land. Until these returns are forthcoming, there will be an urgent need to increase agricultural productivity of the existing land. A short-run solution is needed as well.

(b) Agricultural Vertical Expansion Policy

Realising the necessity of agricultural development in the short-run, Egyptian Agregrain Authority initiated controlled policy concerning the distribution of inputs, marketing outputs and stabilising prices of both inputs and outputs. The aim of such controlled agricultural policy is to ensure income stability and input availability and to minimise uncertainty that often characterises agricultural production, in order to motivate farmers for further production. The farmer gets the required amount of input in the prescribed quality at the right time and at incentive price, and sells his crop at stabilised price.

1. Inputs Distribution System

Since 1960, the distribution of inputs such as chemical fertilisers, insecticides and seeds has become a government monopoly centralised in one public agency; the Agricultural Credit and Co-Operative Bank (ACCB), which was given the exclusive franchise for procuring and wholesaling inputs. Thus, from the national supply level all the way down to village level, the distribution of agricultural inputs is controlled by one public organisation. Once the amount of inputs become available, the ACCB together with the Ministry of Agriculture determine the quota to be sent to each region on the basis of the land areas to be cultivated and the types of crop rotations practised. Such centeralised system allows Agregrain Authority to control and determine the dosage and quality of inputs used and to uniformly stabilise prices throughout the whole country. The farmer is not allowed to buy less than the prescribed quota, though he might buy an extra amount over his quota, but at pre-subsidy price (if price is subsidised). Inputs can also be purchased on credit, if they are within the prescribed level. This, of course, encourages the small farmer, who have no sufficient purchasing power to procure his input needs on a cash basis, to use the prescribed amount.

Such centeralised system overcame the problem of small scale and high cost which have been raised when several small firms were dealing with input distribution. On the other hand ACCB by its large scale and improved equipments is able to deliver input stocks at the time of plantation. Furthermore, such a system ensures that the farmers are using the prescribed dosage and the recommended quality of inputs (through supervision in each village).[16] Of course this in itself does not guarantee that all farmers use the prescribed quota, but at least, it restricts their irrational behaviour. The ACCB's highly centralised distribution system would also be advantageous, especially for primary and secondary movement in the events of shortage and where rationing of inputs must be resorted to, e.g. where the country is cut off from external supplies due to war or where local production brakes down (as happened during the 1967 and 1973 wars). In such emergencies, as the ACCB has control over total supply, it would be in a position to concentrate the flow of inputs towards more strategic crops.[17] Finally, the social cost would be considered as a normal operating cost of a public service organisation. This would not be so for private firms.

These advantages must be weighted against the relative inefficiency with which public institutions operate. Such public agency by its bureaucratic routine might slow down the ability of a nationally centralised distribution system to respond to changing supply and demand conditions. Nevertheless, ACCB is more efficient than several samll firms working below capacity and at higher cost. However, past experience shows that the private small firms that existed in the forties and fifties were unable to deliver agricultural inputs in the required quantities at the right time and perhaps at high price, becuase of the limitation of capital and equipments. On the other hand, it is evident that the use of inputs such as fertilisers and insecticides increased remarkably when ACCB took over input distribution (Tables I - 3 and 5)

Perhaps the most valid critisism of the present system is that it produces difficulties in examining whether price sensitivity affects input consumption because of the absence of market forces. This situation rules out the possibility of incentives having any effect on input sales and leads to the problem of determination of the appropriate subsidy.

2. Output Marketing Policy

Since 1950, Government agencies have been increasingly active in the market for agricultural products and since the nationalisation policy of 1961, agricultural products trade has been almost completely in the hands of authorities. In 1963, the co-operative marketing system was introduced to replace the private intermediaries, so that co-operative societies become the only intermediary between the farmer and exporter, producer, or consumer. All the individual farmers cash transactions connected with production are now recorded by the co-operative societies. (18)

Government intervention concerning the production and price of agricultural products have been most extensive with respect to the major crops such as cotton, rice, wheat. The whole production of such major crops whether exported or locally consumed is now purchased at fixed prices by the co-operative societies. Agricultural product prices are usually fixed and announced at the beginning of the season to be valid for the whole season. (19) The purpose of such policy is to stabilise farmers incomes to be subsidised when export prices fall and taxed if export prices rise (in the case of cash crops such as cotton and rice).

Government intervention in agricultural products market is accompanied by area restriction and imposed crop rotation. For instance cotton is restricted to one-third of the total cropped area. This allows the authority to control local supply and exports, and thus enables her to ensure the balance between local supply and demand, and to control the size of exports in order to prevent dramatic fall in export price (in the case of long staple cotton which represents some 40-50 per cent of the world supply). On the other hand, it is argued that domestic stabilisation policies may be in conflict with the general optimisation targets and lead to a misallocation of resources.[20] However, if the number of policy instruments equal or less than the numbers of targets and these instruments are chosen and used in an appropriate manner, no conflict need to rise between such targets as domestic stabilisation, optimum use of resources, and an acceptable distribution of income.[21]

However, such stabilisation policy enabled the Aggregrian Authority to control price formation and products' quantity and to create a reform system for taxing farm incomes. Perhaps the wrong timing of policy is one of the major practical drawbacks of this stabilisation policy. The timing of policy has not always been successful with respect to changing international conditions.[22] This is, however, inevitable problem due to the difficulties in forecasting international movements.

(c) Land Tenure

Land tenure refers to the economic, social, political and legal aspects of the ownership and management of agricultural land. The pattern of ownership is perhaps one of the major factors that can not only control agricultural income distribution, but it could also affect agricultural productivity. Indeed, the social and political objectives of a tenure system may conflict with the economic objectives. The ideal form of land tenure from the social and political standpoint should provide equality and justice in distributing land ownership and agricultural income, while it is ideal form from the economics point of view only if it permits farmers to achieve optimum production from their land and allows capital to flow.[23]

Equality in distributing land will certainly reduce farm size, and this might reduce agricultural productivity if large farmers are more productive than small farmers. This is, of course, an empirical question and the answer differs from one society to another. For instance, it was found that small farms are more productive than large farms in India, while many studies showed the opposite in U.S.

In Egypt, most of the presently cultivated area is owned by individuals. The share of the area owned by Government and public organisation is very small. Land tenure forms are, therefore, individual owner-occupation, landlord-tenant and share-cropping. Owner-occupation is the system of land tenure where the landowner and farmer are the same person, so that there is no division of functions between them. In the landlord-tenant system, there is a clear distinction between landowner and farmer. The former provides the land in exchange for an annual rent (either in cash or kind) paid by the latter. Share-cropping system presents a relationship between the landlord who provides land and fixed capital, and sometimes a proportion of the working capital, and the tenant who provides the working capital and management. The return is divided between both of them.

In dealing with land tenure forms in Egypt, it would be useful to distinguish between two periods; the period before and that after 1952, that year on which Agrarian Reform law was held.

Since 1893, all landowners enjoyed the complete privileges of full property rights. However, since that date and until Sept. 1952 land tenure system in Egypt was characterised by a few large landlords controlled and owned a major part of the land, reflecting a considerable inequality in distributing land ownership. In 1952 (before the land reform), out of an agricultural population of 12 million, 2.8 million owned a land. Only two thousand landlords (0.1 per cent the total landowners) held some 20 per cent of the total area (177,000 Feddans) giving an average size per owner of 588.5 Feddans, while more than two million representing some 72 per cent of the total owners, owned between themselves 670,000 Feddans or 13 per cent of the total area (the average size per owner is less than one Feddan). The pattern of ownership in 1952 before the land reform is shown in Table I - 14. Some 30 per cent of the owned area was being tenanted in July 1952. Unfortunately, sources about share-cropping are not available because the agreements are seasonal and limited to duration of one crop, but another 30 per cent of the area may have been leased in this way in every season. On the other hand, landless peasants formed a sizeable group estimated at 1.3 million families. (24) However, the agrarian system in Egypt before the Land Reform Law of September 1952, could be described as a free market system, so that the movements of rents and wages over time, changes in input use and crop reallocation are consistent with the hypothesis of profit-maximising behaviour.

The main objectives of the Land Reform Law of September 1952, and the supplementary laws of 1961, 64 and 69 are to correct the maldistribution of ownership, settle the relationship between landlords and tenants, and increase and stabilize the income of the poorer peasants. The personal ownership fixed at a ceiling of 200 Feddans (208.3 acres) in 1952, reduced to 100 Feddan (104.15 acres) in 1961, and was lowered again to 50 Feddan in 1969.(25)

The requisitioned land was to be distributed in small lots 2-5 Feddans, depending on land quality and the beneficiaries needs. The order of priority was tenants and permanent workers of the estate, farmers with large

TABLE I - 14

Distribution of Land Ownership before the Promulgation of the 1952 Land Reform Law*

Land Area in Feddan	Land Owners '000	Area Owned "000 Feddans	Percentage		Average size per Owner
			Land Owners	Area Owned	
Less than one Feddan	2011	770	71.8	12.9	0.383
1 under 2	328	450	11.7	7.5	1.372
2 under 3	153	354	5.5	5.9	2.314
3 under 5	150	548	5.3	9.1	3.653
Less than 5 Feddan	2642	2122	94.3	35.4	0.803
5 under 10	79	526	2.8	8.8	6.658
10 under 20	47	638	1.7	10.7	13.574
5 under 20 Medium	126	1164	4.5	19.5	9.238
20 under 50	22	654	0.8	10.9	29.727
50 under 100	6	430	0.2	7.2	71.667
100 under 200	3	437	0.1	7.3	145.667
200 and over	2	1177	0.1	19.7	588.5
20 and over Large	33	2698	1.2	45.1	81.758
Total	2801	5984	100	100	2.136

* State lands, desert, praire are not included.

Sources:

(1) CAPMS "Statistical yearbook" Cairo 1973 P.54

(2) Ministry of Agriculture "Agricultural Economic" Cairo 1965.

families, and the poorest number of the village.(26) It is, however, obvious that land reform laws reflected a reduction in the degree of land ownership inequality, showing a significant movement towards greater equality as shown in Tables I - 15, 16 and 17.

TABLE I - 15

Distribution of Land Ownership after Promulgation of 1952 Land Reform Law

Land Area (Brackets)	Land Owners '000	Area owned '000 Feddan	Percentage		Average size per owner
			Land Owners %	Area Owned %	
Less than 5 Feddans	2841	2781	94.4	46.5	0.979
5 under 10 Feddans	79	526	2.6	8.8	6.658
10 under 20 Feddans	47	638	1.6	10.7	13.574
5 under 20 Feddans	126	1164	4.2	19.5	9.238
20 under 50 Feddans	30	818	1.0	13.7	27.267
50 under 100 Feddans	6	430	0.2	7.2	71.667
100 under 200 Feddan	3	437	0.1	7.2	145.667
200 *	2	354	0.1	5.9	177.000
20 and over	41	2039	1.4	34	49.732
Total	3008	5984	100	100	1.989

* Limiting landholding to 200 Feddans per person.

Sources; CAPMS, "Statistical yearbook" Cairo 1973 P.55

TABLE I - 16

Distribution of Land Ownership after the Promulgation of 1961 Land Reform Law

Land Area BRACKETS	Land Owners '000	Area Owned '000 Fed.	Percentage		Average size per Owner
			Land Owners %	Area Owned	
Less than 5 Fed.	2919	3172	94.1	52.1	1.087
5 - under 10 Fed.	80	526	2.6	8.6	6.575
10 - under 20 Fed.	65	638	2.1	10.5	9.815
5 - under 20 Fed.	145	1164	4.7	19.1	8.028
20 under 50 Fed.	26	818	0.8	13.5	31.462
50 under 100 Fed.	6	430	0.2	7.1	71.667
100 and over *	5	500	0.2	8.2	100
20 and over	37	1748	1.2	28.8	47.243
TOTAL	3101	6084	100	100	1.962

* Limiting land holding to 100 Feddan per person.

Source: CAPMS, "Statistical Year Book", op. cit. p.56

TABLE I - 17

Distribution of Land Ownership in 1965

Land Area BRACKETS	Land Owner '000	Area Owned '000 Fed.	Percentage		Average Size per Owner
			Land Owned	Area Owned	
Less than 5 Fed.	3033	3693	94.5	57.1	1.218
5 - under 10 Fed. 10 - under 20 Fed.	78 61	614 527	2.4 1.9	9.5 8.2	7.872 8.639
5 under 20 Fed.	139	1141	4.3	17.7	8.209
20 under 50 Fed. 50 under 100 Fed. 100 and over	29 6 4	815 392 421	0.9 0.2 0.1	12.6 6.1 6.5	28.103 65.333 105.25
20 and over	39	1628	1.2	25.2	41.744
Total	3211	6462	100	100	2.012

Source : CAPMS "Statistical Year Book", op. cit. p.57

The situation of land ownership in 1965 (the latest year for which data is available) reveals some changes. The number of landowners increased from 2.8 million in 1952 to 3.2 million in 1965. The very large estate which covered some 20 per cent of the area in 1952 have entirely disappeared. The area owned by small owners (less than 5 Feddans) increased from 2.1 million in 1952 (35.4 per cent of the total area) to 3.7 million in 1965 representing some 57 per cent of the total area, while the area owned by large landlords (above 20 Feddans) dramaticly decreased from 2.7 million in 1952 (45 per cent the total area) to 1.6 million in 1965 (25per cent of the total area). Other brackets remianed more or less unchanged between these two dates. The percentage distribution of land owners among the three classes (small, medium and large land owners) has not significally changed simply because the number of large owners affected by the land reform laws is very small (two thousand). However, it appears that the average size per large landlord has decreased from 81.8 Feddan in 1952 to 41.7 Feddans in 1965. On the other hand the average size per small owner (less than 5 Feddan) increased from 0.8Feddan to 1.2 Feddan between 1952 and 1965. This is because the average size of the distributed land per owner (2.5 Feddan) is farily higher than the average size per small owner (0.8 Feddan) in 1952. Thus, the average size per Egyptian land owner remained constant between these two dates.

Indeed, the area controlled by small owners is expected to be increased after 1969, the year at which personal ownership was restricted to 50 Feddans. Some 813 thousand Feddans (large estates above 50 Feddans in 1965) would be transfered to small owners and the share of the area owned by them (small owners) should now be at least 70 per cent. Moreover, small farms area might be larger than the area owned by small farmers. The present tenure system leads to actual holdings being even smaller on average than the average property owned, in the sense that the land is split up by tenancy even more than the ownership statistics suggest. This was not the case before Land Reform Law. The tenure system before 1952 has actually tended to concentrate the land into larger production units than the freeholds. The many very small properties are rented by large farmers who already have land themselves.* Such situations is inhibited by land reform law. Tenancy holding is restricted into 50 Feddans. Thus many landlords were obliged to replace the large tenant by a number of small tenants.

However, the gross total areas distributed during the period 1953-74 amounted to 1,045,577 Feddans out of which 831411 Feddans from agregian reform lands, and 184411 Feddans from the land belonging to organisations, while 29755 from inning lands. Beneficiaries from land reform accounted for 400 thousand families who had been given by 1974, an average of 2.5 Feddans per family. (27)

Thus, one might expect that both tenanted area and landless peasants are reduced. Tenanted area decreased to 25 per cent of the owned area in 1972 against 30 per cent in 1952, while landless peasants declined from 1.3 million families in 1952 to less than one million families in 1972. (28)

Land reform law also fixed land rent at seven times of the basic land tax and the tenants share in the crop at 50 per cent, and the minimum duration of tenancy agreements was fixed at three years. On the other hand minimum daily wages were stipulated.

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* Data on land property and holdings in 1952, before the land reform suggest that the average size of small ownership (less than one Feddan) was 0.4 Feddan against 0.5 Feddan for the average size of holding for the same group. (B. Hansen, G. Marzouk 1965 Opcit P.58)

Although the land reform law has succeeded in reducing the degree of inequality of wealth and income, and improving the social conditions of tenants and landless labour, it tends to reduce the average size of production unit.* In order to overcome the problem of small-scale management, the Agregian Reform Authority administers the land through supervised co-operatives to substitute the large landowners. The new owners are compulsory members of co-operatives which plan overall production and take care of sales. The co-operative under the supervision of the Ministry of Agrarian Reform supplies the beneficiaries of land reform with inputs and credit, markets their crops and allows them to rent some fixed equipments.

In principal, such a combination of collective farming and individual ownership could be an efficient system, allowing productivity to increase and resources to be efficiently allocated. Whether the co-operative small farms are, in practice, more or less productive than the large farms. This is the question to be examined. An empirical investigation is held in part 2 to test the relative efficiency of farms of different sizes and tenures.

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* To prevent further fragmentation, the land reform stipulated that in cases where agricultural land is to be divided as a result of inheritance, sales etc. the parties concerned must agree to a single person assuming ownership of the land.

PART 1

INVESTMENT ALLOCATION EFFICIENCY AMONG COMMODITY SECTORS

PART I

Investment Allocation Efficiency Among Commodity Sectors

It is debatable whether a less developed country should give priority to industrialisation, agricultural development or both simultaneously. During 1950's rapid industrialisation was often advocated. Most development economists argued that industrialisation is a crucial element in economic development and it offers a substantial benefits of a dynamic character that are important for changing the traditional structure of the economy. Experience, however, has shown the limitation of overemphasising on industrialisation and it is increasingly recognised that agriculture with its dominance could play a vital and effective role in removing the constraints to economic development in the whole society if resources are efficiently allocated.

Part I is devoted to investigate the confrontation of industrial development versus agriculture. The basic arguments for industrialisation are recalled to be examined and analysed against those for agricultural development. (Chapter II). In chapter III, a three sectoral approach emphasising on agricultural development is suggested to be tested with respect to the Egyptian case during the period 1960-65. An empirical investigation is made to test investment allocation efficiency among commodity sectors.

CHAPTER II

Arguments against and for Agricultural Development

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Arguments against and for Agricultural Development

II - 1: Arguments for Industrialisation

It is often argued that there is close relation between low per capita income and the dominance of agriculture, while industrialisation can be regarded as a self-evident for economic progress. This is, perhaps, the basic argument for industrialisation. Emphasis on industry is, however, based on two main arguments.

In the first place, agriculture is associated with diminishing marginal returns, owing to fixity of the supply of land and the scarcity of capital. If there is rapid population growth and little employment opportunity elsewhere, a stage may be reached where the land cannot give further production. In this case, the marginal product of labour may be zero, or even negative, so that this surplus labour can be withdrawn without any loss in the total agricultural output, even if no change in production techniques or use of other productive resources occurs. If industry is not developed to absorb redundant labour, the inevitable outcome will be more disguised unemployment or even open unemployment in either rural or/and urban sector, reflecting a low productivity of labour in both sectors.(1)

This is the basic issue in the classical approach in the sense that by applying an appropriate public policy, the agricultural sector can supply the other sectors with labour, food and capital, even if its output is not rising. This view, however, has been fully explained by Lewis who presents a classical model of a dual economy, emphasising the crucial role of the capitalist surplus in the development process.(2) On the assumption that the supply of labour in the subsistence sector is unlimited at a constant real wage, Lewis argues that labour movement from the subsistence sector would not reduce agricultural output. The large pool of unskilled labour enables new industries to be created or old industries to expand in the capitalist sector. Labour employed in the capitalist sector will initially be paid the traditional wage due to the existence of surplus labour in the subsistence sector (although,sometimes a wage above the traditional level would have to be paid to motivate agricultural labour to move to the capitalist sector). The low and constant wages permit large profits for potential reinvestment in the capitalist sector, allowing it to expand. Accordingly, more labour withdraws from the subsistence sector to be employed in the capitalist sector, permitting further profits to be gained, which, in turn, will be reinvested, and so on until surplus labour no longer exists. The driving forces in Lewis approach is, however, generated by the reinvestment of the capitalist of surplus in creating new capital. Fei and Ranis follow the same approach suggested by Lewis.(3) In the Fei-Ranis model, disguised unemployment is considered to exist when the marginal product of labour is less than its average product; when labour has a marginal product of zero, it is termed redundant labour.

Nurkse adopts the same view and argues that if peasant family labour predominates - as is the case in many less developed countries - excess population implies that the contribution of the marginal workers to output is less than intake of food and other necessities. Thus some labour could be withdrawn from subsistence farming without reducing the total farm output.(4)

However, it seems that the above argument is based on two related elements; the assumption of disguised unemployment in agriculture and the crucial role of the industrial sector in reducing population pressure on land and creating new capital.

Economists such as Leibenstein, Rosenstein-Rodan, Buck, Lewis define disguised unemployment as zero marginal product of agricultural labour and the condition of certis paribus (static surplus labour). They assert that in Asia, where population has doubled and techniques, capital supplies, and cultivatable land have remained too much the same, the theory of zero marginal product of labour in agriculture can be applicable. Lewis states that "This phenomenon is rare in Africa and in Latin America, but it repeats itself in China, Indonesia, Egypt, and in many countries of Eastern Europe".(5) In supporting their approach, Fei and Ranis suggest that the phonemenon of zero marginal productivity in agriculture is relevant to the case of Japan in the nineteenth century and contemporary India.(6) Studies made by Buck on China in 1930 (7), Rosenstein-Rodan (8) and Mandelbaum (9) on Southeastern Europe in 1943 and 1945 respectively, Warriner on Egypt in 1948 (10), Mellor and Stevens on Thialand in 1956 (11), and Rosenstein-Rodan on Southern Italy in 1957 (12) provide evidence supporting the applicability of zero marginal productivity of agricultural labour in the areas understudy.

Various interpretations of the existence of static surplus labour in some parts of the less developed world are given by some economists. One interpretation is suggested by Lewis (13) who argues that wage offered for hired labour is not higher than average product of family labour because employment opportunities in the wage payment system is quite limited. Since each familys' member receives the familys' average product - which is greater than the marginal product - there are no motivation for family labour to offer his work elsewhere. Leibenstein (14) claims that an increase in wage rate will raise productivity through nutrition improvement. It is, therefore, profitable for the landlords to hire all available labour to prevent wage rate declining in order to increase per capita output. Georgescu-Roegen introduces another explanation. He points out that employment of the peasant family is governed by maximizing total family output rather than by the principle of marginal productivity. Thus, one might expect that the total output of the familys' farm is miximized though marginal product is zero. (15)

Another version of zero marginal productivity of agricultural labour, in dynamic terms, is provided by Sen (16) who argues that disguised unemployment takes the form of small number of hours worked per person. In this case the same total product could be produced by fewer people working normal hours, without a reorganisation of production through a change in production techniques, or an increased supply of other factors, though it requires some sacrifice of leisure. Hence, total output would fall if labour was withdrawn from the land unless those remaining worked larger hours to compensate (dynamic surplus labour). Nurkse (17), however, believes that significant savings of labour can only be made by better use of labour time. Those who remain in agriculture should reorganise their farms into more efficient, large-scale and mechanised operating units.

On the assumption that disguised unemployment prevails, industrial development must take place in order to absorb this surplus labour allowing labour productivity to increase in both sectors, adding net increase in the national income (18). Kuznets defends industrialisation as a prerequisities for higher productivity by maintaining, "Given relatively constant land, migration of labour force from agriculture to the other sectors would be required to allow agriculture to grow and productivity of labour to be increased. This transfer of workers means a sizeable capital contribution because each migrant is of working age and represents some investment in past rearing and training maturity. This must have been quite large in the early and even in late phases of modern economic growth. Thus, internal migration of labour from agriculture represents a large contribution to the countrys' economic growth. This will not be valid unless employment capacity of the urban areas is increasing".[19]

On the other hand, labour transfer from agriculture to the industrial sector is often advocated as a vehicle for more saving and investment. This view is based on the assumption that consumption in the society as a whole is held constant as Nurkse explains, "where disguised unemployment prevails in agriculture, it would be desirable to transfer the surplus labour off the farms to produce capital goods while keeping the consumption of food by the population as a whole constant through taxation or direct controls"[20]. This could be relevant to Fei-Ranis approach. They argue that, as redundant workers leave farms, consumption per capita among those remaining should held constant in order to create surplus to be used in financing the industrial sector.[21] Lewis, however, suggests different explanation.[22] He argues that more calories are usually needed for farm work compared with factory work. In this case labour transfer from agriculture to the industrial sector might reduce consumption. It seems that Lewis' interpretation is based on natural financing of industry while Nurkse and Fei and Ranis support forced saving in financing the industrial sector.

Secondly, it is often argued that international trade does not work to the equal advantages of the industrial countries and primary producing countries. Since primary products dominate the balance of payments of most less developed countries, and their share of world trade in manufactures is very small, international market forces will transfer income from the less developed countries to the developed industrial ones, through a secular deterioration in the terms of trade for the first group. Due to the dominance of primary exports in the presently less developed countries, the forces in the market,Myrdal believes, (23) will in acumulative way tend to cause ever greater international inequalities between countries, as to their level of economic development and average national income per capita. In the same line, Prebisch argues that "technical advance in primary production as an alternative to industrialisation in order to improve standards of living defeats its own purpose as some of the fruits of such technological advance will usually be transferred from the peripheral countries to the outer world, (24) unless it is butteressed by vigorous process of industrialisation and increasing productivity in industry." (25) Prebischs' major claim is that the advantages of resources allocation efficiency (comparative advantage) in the less developed countries is accumplished by the unfavourable impact of unrestricted trade on the terms of trade and balance of payments of these countries.

The above argument is, rightly or wrongly, based on two, though related, phenomena. The first is that demand for primary commodities, in general, in relation to supply has expanded much less than in the case of manufactured commodities. Schultz supports this phenomenon by showing the demand for all raw materials whether imported or domestically produced has lagged far behind the increase of output in the United States. (26) This view is defended by Nurkse who argues that "it can hardly be said that primary producing countries are enjoying a dynamic expansion in world demand for their exports". (27) Data on 1950s and 1960s suggests that the volume of exports from less developed countries grew at a rate of some 5% per year against 8% for developed countries, reflecting a considerable reduction in the less developed countries share of the total value of world trade from 28% in 1950 to 18% in 1968. (28) However, economists such as Prehisch,Myrdal and Singer attribute that to the technological progress in the industrial countries. While investment in the less developed countries is directed to the primary sector, offering less scope for technological progress in internal and external economics, (29) technological progress in the developed countries is mostly concentrated in the industrial sector reflecting direct as well as indirect consequences on slowing down the growth of demand on primary exports. (30) In direct terms it (technological progress) leads to the development of synthetic substitutes for raw materials and results in a small amount of inputs of raw materials per unit of output. On the other hand the proportion of the increased per capita income due to technological progress spent on primary products is small relative to that spent on industrial goods and services. In the United States, Prebisch maintains, the demand for wheat has remained almost constant since the beginning of the century, in spite of the rise in both population and per capita income. (31)

The basis of the second phenomenon is that, while any increase in productivity in the industrial countries accrue to them in the form of wages increases, pushing prices upwards, a part of the increase in productivity in the primary producing countries will be transfered to the industrial countries in the form of reduction in the world prices of primary goods. This view is suggested by Prebisch (32) as well as by Myrdal who argues that the industrial countries do not only enjoy the benefit of their own technological progress, but also gain a part of the fruits derived from the technological improvement of the primary producing countries. (33)

Theoretically, one might expect that the ratio of primary product prices to industrial good prices should rise showing a movement in the terms of trade in favour of the less developed countries. On the assumption that prices are related to costs, this is true, so long as diminishing marginal returns operate with respect to the primary sector and productivity is growing at higher rates in industry than in agriculture.

By showing data on the ratio of prices of primary commodities to those of manufactured goods (U.K. data in 1876-1938)*, Prebisch asserts that the price relation moved against the primary producing countries, contrary to what should have happened in theory. (34) The explanation of this, as Prebisch suggests, is that during the upswing, part of the profits is absorbed by an increase in wages in the developed countries due to the competition between the entrepreneurs, and because of the pressure of trade unions. When profits have to be reduced during the downswing, the trade unions will not allow wages to fall. In the primary producing countries, the trade unions are weak, or even may not exist, and due to the competition among the primary producing countries, the prices will fall. This downward trend of the prices of primary products in the overpopulated countries during the downswing is supported by population pressure and surplus labour. Flanders (35) explains Prebisch's view by stating that primary product prices fall more than industrial prices during the downswing and by more than they rose during the upswing, reflecting a ratchet coupled with divergence between the trend of prices of both sets of goods.

On the other hand, Kindleberger suggests that price trends have been unfavourable to the less developed countries due to "systematic differences in the capacity of the two types of countries to shift resources. (36) The less developed countries are said to be less able to shift their resources off downward price escalators and on to upward price escalators than are developed ones. This study - of course - lends some support to the view that the poorer countries' terms of trade have shown a tendency to deteriorate.

(*) The reliability and interpretation of U.K. data during the period 1876-38 are questionable as shown below.

11 - 2: Evidence against the relevance of Industrialisation

At first sight, it seems that the advocacy of industrialisation may be convincing for primary export countries that confront problems of a lagging export demand, while having to provide employment for surplus labour. In such countries, industrialisation is, therefore, inevitable and a dynamic element during the course of economic development. With careful investigations and more understandable version of the situation in these less developed countries, it might appear that the defenders of industrialisation undervalue the agricultural sector. They wrongly ignore its capacity in raising labour productivity and increasing production, taking the diminishing agricultural marginal returns for granted, assuming that disguised unemployment prevails in agriculture, and the terms of trade are deteriorating for the agricultural exports.

In my view, there are many doubts of the validity and relevance of these assumptions to the presently less developed countries. Thus, they are reconsidered with respect to the conditions under which agriculture in the majority of the presently less developed countries operates.

First of all, one might suggest that the extreme of disguised unemployment* (the theory of zero marginal productivity of agricultural

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* Since the presence or absence of disguised unemployment is a matter of definition, it might be useful to review the possible interpretations of this concept:-

(a) Static surplus labour or zero marginal productivity of labour, so that the total output will not be reduced if this surplus labour is released, though other factors remain constant (the gap between the actual number of workers available for employment and the level of employment at which the marginal product of labour is zero). =

labour) overstates the degree of population pressure on land in many less developed countries, such as China, India, Egypt etc. Convincing theoretical arguments as well as reliable statistical evidence can be raised in supporting our view. Theoretically, it is unlikely that hired labour would be used up to the point where its marginal product is zero. If the wage rate is positive, so will be the marginal productivity of labour. Static surplus in agriculture may only occur for self-employed labour. This is an important limitation of the applicability of the concept of disguised unemployment - either if it is considered as zero marginal productivity of labour, or as positive marginal productivity of labour lying below the wage rate - in the countries which have a good deal of plantation agriculture. In the case of a mixture in agriculture of hired and family labour, marginal productivity of labour would rise above zero in peasant farming, since there is labour mobility which allows a number of peasants to be employed on a nearby plantation. (37) It is true that family labour might remain on their farms, since each family's members receive the average product which is higher than the marginal product regardless of his contribution. Nevertheless, if this average is less than the subsistence level, the farmers will have motivation to leave their farms looking for other opportunities elsewhere. Even if labour mobilisation and employment opportunities elsewhere are limited, there are, still, some doubts on the

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=(b) The marginal productivity of labour is positive, but equal or less than the institutional or subsistence wage or MPL < APL (the gap between the number of workers available for work and the amount of employment which equates the marginal product of labour and the subsistence wage).

(c) Dynamic surplus labour, or if surplus labour is released, the total output will remain constant, since the remaining workers work harder.

However, the strict interpretation of disguised unemployment is the zero marginal productivity of labour under the static conditions (Certis Paribus).

relevance of the theory of zero marginal productivity of labour in peasant farming. Today, where education substantially expands in most less developed countries, one might expect that the degree of disguised unemployment is diminishing. The presence or absence of disguised unemployment is, however, an empirical issue, which should be considered with respect to the statistical evidence within the underlying countries.

Recognising the fiction of zero marginal productivity of labour in agriculture, the Neo-classical approach dropped the concept of disguised unemployment in that sense, assuming that the marginal productivity of agricultural labour is always positive, so that labour is never redundant in static terms. Jorgenson supported this view by showing evidence collected within some countries in Latin America, Africa, Southeastern Europe and Southeast Asia. (38) In the same line, Viner suggests that labour in agriculture would have positive marginal productivity, even if every product has technically and economically fixed ingredients. (39) In many cases, however, the release of labour from agriculture seems to reduce agricultural output, unless technology has made further progress, skill and training have been further improved etc., or the remaining workers have worked harder to compensate. In this respect, Schultz asserts, "I know of no evidence for any poor country anywhere that would even suggest that a transfer of some small fraction say 5 per cent of the existing labour force out of agriculture, with other things equal could be made without reducing agricultural production." (40) Even those who defend the classical model argue that the purpose of it is to draw attention to the fact that the industrial product far exceeds the opportunity cost of labour in agriculture and this may require some dynamic change as migration takes place. There is, in fact, little reliable empirical evidence to support the existence of disguised unemployment anywhere by more than 10 per cent. (41)

Indeed, the empirical studies supporting the concept of disguised unemployment were rather poorly conceived, based on improper methods of measurement (i.e. indirect method of measurement). Most of the studies have excluded the seasonal unemployment from the required labour. Since the agricultural work is highly seasonal, a substantial part of agricultural labour may be unemployed during a part of the year without being redundant. The release of this part of labour will not result a reduction in the total output, only if the available labour exceeds that required during the peak periods such as planting and harvesting. When the estimates of the degree of disguised unemployment are corrected to take into account the seasonality of demands for agricultural labour, Jergenson maintains, the situation in Southeastern Europe, Egypt, China and Southeast Asia appears to be one of labour shortage rather than labour surplus. (42) By taking the seasonal unemployment into account in Southern Italy, Kenadjian (43) adjusted the degree of disguised unemployment estimated by Rosenstein-Rodan at 10-12 per cent to less than 5 per cent. Hsieh(44) has corrected Buck's estimate of disguised unemployment for some parts of China by taking the seasonal unemployment into consideration. He found that there is a shortage of male labour at the seasonal peak. In Greece, an attempt has been made by Pepelasis and Yotopoulos (45) aiming to estimate the degree of disguised unemployment during 1953-60. The study indicated that, except 1953, and 1954 in which disguised unemployment existed at 3.4 and 2.3 per cent respectively, there was a shortage of labour during the planting and harvesting time. It is note worthy that Mandelbaum (46) in 1946 estimated the disguised unemployment (excluding the seasonal unemployment) in Greece at some 25 per cent. Warriner reversed her earlier estimation of disguised unemployment in Egypt (50 per cent) by noting that it should be less than that if other factors are considered. (47) The degree of disguised unemployment could also be exaggerated due to the inclusion of the younger members of agricultural population (from 8 to 15 years old) in the available labour force equating their productivities with the adult workers. Today primary education in most less developed countries becomes a compulsory one, so that children are now part time workers. Abou-El-Dahab, by applying the indirect method of measurement, estimates the disguised unemployment in Egyptian agriculture at 41 per cent of the available labour force in 1970. (48) Using his data, but excluding 50 per cent of the children up to 15 years old from the available labour force, and including the seasonal unemployment in the required labour, I found that the disguised unemployment is less than 5 per cent of the agricultural labour force in the same year. (49) In 1964 a sample survey undertaken by ILO and Institute of National Planning shows that Egyptian agriculture is characterised by full employment and very long hours of work during the seasonal peak (harvesting and manual plant protection), and little disguised unemployment during the slack. (50) This could be relevant to the believes of both Hansen (51) and Mabro (52) who convincingly argue against the existence of disguised unemployment during the peak seasons in Egyptian agriculture. However wage rate during the peak season is considerably higher than the minimum wage rate determined by the government implying the absence of disguised unemployment during the peaks.(53)

Empirically, it is more accurate to measure the extent of disguised unemployment in static terms by examination of instances where substantial numbers of agriculture labour force have been withdrawn from the land for a short period of time. It appears, however, that quite few studies have been made in this respect. The best known attempts made by Schaltz who found that, by withdrawing labour from agriculture to work in public projects in Tingo-Maria (Peru)(54) and in Belo-Horizonte (Brazil),(55) agricultural production dropped sharply. In his study "The effects of the Influenza epidemic of 1918-19 in India on agricultural production", Schultz concludes that while agricultural labour force have been reduced by about 8 per cent the production dropped promptly by some 14 per cent in 1918-19 compared with 1916-17. (56) The difficulty in this measure is, that it cannot be generalised, each case should be studied separately.

Oshima, (57) by reviewing eighteen anthropogical studies of peasant agriculture in India, China and Southeast Asia, asserts that labour requirement during peak seasons exceeds the supply of adult males, so that release of a part of agricultural labour is expected to result in reducing total output, given the existing technology and organisation. Again this type of test cannot be generalised from particular cases.

Due to the corrected indirect estimates of disguised unemployment in countries such as Egypt, China, Southern Italy, and Greece etc., and evidence from both historical and anthropological studies in several areas of many less developed countries such as India, China, Southeast Asia, Brazil and Peru etc., it appears that disguised unemployment in static terms is not applicable in most less developed countries. This would be relevant to Kao, Anschel and Eichers' view, who conclude that "It is an understatement to say that the development literature was optimistic about development through the transfer of redundant agricultural labour to other occupations".(58)

Perhaps, Japan in nineteenth century is the only country for which data provide evidence supporting the concept of unlimited supply of labour that cited in Lewis model as well as Fei- Ranis approach. Undoubtedly, the Japanese case is an important test for the classical approach to the theory of development of a dual economy. It is quite obvious that Fei-Ranis approach relies on the empirical evidence which is extracted from the Japanese experience. It is, however, misleading to rely on one or even a few cases in approaching a general model. One might argue with Jorgenson who concludes that "the evidence against disguised unemployment does not demonstrate that it never exists in any historical or geographical circumstances, but only that the scope of applicability of the classical approach to the development of duel economy is severely limited." (59)

On the other hand, some economists (60) suggest that agricultural disguised unemployment in the less developed countries surely exists in the sense that farmers work less hours (dynamic disguised unemployment), so that the release of labour from agriculture seems to reduce agricultural output unless the remaining people work harder. Indeed disguised unemployment in this sense might occur in all societies, either developed or undeveloped, even in the most advanced urban areas. In this respect Habeler argues, "there always was disguised unemployment in developed as well undeveloped countries, since production will be increased when changes and improvements are done." (61) In India, it is evident that some industrial employee work 270 days a year, which is the same working days of the Indian farmers, if such conferences, trade union meeting etc. are excluded from the official working days. This would be relevant to Viner(62) who rejects the statement that, "disguised unemployment would be unnecessary to maintain product undiminished if intensity of work per hour were raised", then he concludes, "there is disguised unemployment in the most prosperous American Urban industries. It is, however, difficult to establish the presence of disguised unemployment in dynamic sense.

In relative terms, agricultural surplus labour is likely to exist in an overpopulated country in the sense that marginal productivity of labour in agriculture is usually less than that in industry. If it is so, the argument for industrialisation is still valid. This is, theoretically, true, as far as the industrial sector is expanding enough to absorb this relative surplus labour, allowing it to have higher productivity, and surplus agricultural output is sufficient to feed those who migrate out of agriculture, to supply industry with inputs, and to finance the new established industries, through either domestic savings and taxation, or exports.

Experience, however, has shown that the performance of the industrial sector in many less developed countries had been very disappointing, reflecting a slow rate of growth. For instance, some industries in countries such as Pakistan, India and Egypt are characterised by negligable, zero, or even negative value added. In an unpublished paper, Agwah (63) found that quite a few Egyptian consumption industries have a negative value added. This indicates that some industries in the earlier stages of economic development have been established without foundation, reflecting low productivity of the newcomers to the industrial sector. This is, perhaps because agricultural development was neglected and pre-condition stage of industrialisation was not fulfilled. The problem of low agricultural productivity that commonly exists in most less developed countries will retard productive industrial expansion. Unless agricultural output, of which food is most important, is increased, labour migration from agriculture to urban sectors will cause food bottleneck, reflecting an increase in food prices and collapse in the terms of trade for urban population, inhibiting productive industries to take place. Without allowing agricultural productivity to increase, the available capital will not be sufficient to finance the new established industries, introducing serious obstacles facing industrial expansion (as shown below). On the other hand, while some time must elapse before a productive industry can absorb the relative surplus labour in agriculture, many less developed countries adopt wrong policy by encouraging labour to move from the land to settle in urban areas without improving labour mobility. This creates unproductive informal urban sector or industrial sector with low productivity, shifting disguised unemployment from the agricultural to urban sectors producing more critical and severe problems. Direct absorption of agricultural labour in the industrial sector has very limited scope, because migrants out of agriculture need some time to be trained, to gain skills, and to adapt themselves with the new routine of factory employments. Unless this is efficiently done in the earlier stages of economic development, disguised unemployment will be shifted to the urban sector.

On the other hand, it seems that the argument supporting the movement of terms of trade against primary goods have limited relevance in both theoretical and empirical grounds to policy in the less developed countries.

On theoretical basis, two major arguments may be raised:

1. It seems that pro-industrialisation economists give particular attention to the income elasticity of demand as a crucial factor in determining the trend of the ratio of primary goods prices to industrial goods prices, underestimating the impact of the other factors. It is, perhaps, true that a small proportion of the increased income generated from technological progress in the industrial countries is spent on primary goods, reflecting a downward trend of the primary - industrial goods price ratio. But, it is, also, true that price elasticity of demand for agricultural goods is, generally lower than that for industrial goods pushing the price ratio into the opposite direction. Moreover, the elasticity of supply of agricultural goods, either in the short run (production period) or in the long run (growth rate of productivity) is lower than that of industrial goods. The production period is usually longer in agriculture compared with industry, while the industrial productivity is growing at higher rates than agricultural productivity. This might allow agricultural prices to increase at higher rate than industrial prices.

However if technical improvement in the industrial countries leads to a reduction in the growth of demand for primary goods, it simultaneously would permit the supply of industrial goods to increase substantially. Indeed, the elasticity of supply and demand of agricultural and industrial goods should jointly be considered. The direction of price ratio trend depends on the relative extent of both the elasticity of supply and demand with respect to a certain agricultural good in a particular less developed country against an industrial good in a certain developed country. In this respect, Morgan argues that "emphasis ought to be centered on the heterogeneity of price experience. Particular supply influences particular demand changes for different commodities, countries and times, have dominated the historical picture". (64)

2. Higher money wages do not necessarily cause higher domestic prices. They do so only if they rise faster than productivity. Even if a higher money wage results in increased domestic prices, international forces will not allow world prices to follow the same trend, since higher export prices in any country result in a fall of its export volume, and hence a reduction in the exchange value of its currency. So far as the industrial goods are exported, they meet the same conditions of international competitions as do agricultural products and this prevents industrial prices from rising.

The statistical evidence on which the pro-industrialisation economists relied is that of U.K. during the period 1876-1938 in which there appears to have been a decline of 36 per cent in the terms of trade of primary for industrial products, so that with the same amount of primary products only 63.5 per cent of the finished manufactures which could be bought from U.K. in the 1860s were bought in 1930s. (65) On the strength of this downward trend, predictions have been made that primary products in future years continue to follow this trend, and economists such as Prebisch, Myrdel and Kindleberger have formulated theories in explaining this phenomenon.

It is, however, misleading to rely on an experience of one country in a particular period of time as a general case. The supply and demand movements are quite changeable for particular commodities in a certain period from one country to another. Moreover there are still some doubts about the reliability and accuracy of the U.K. data themselves. In one sense, no allowance is made for quality improvements in both primary and manufactured products. It is, generally accepted that quality improvements have been far less in primary than in industrial goods. Viner has pointed out that "long-period comparisons are largely vitiated by the fact that the price indices used for manufactures give no weight to the gain in utility from new commodities which have become available. Moreover, even where the manufactures are nominally the same, they have over the years become incomparably superior in quality, whereas the primary commodities used in their price indices are not for the most part superior in quality and in some cases are perhaps inferior". (66) Secondly, since British import prices based on C.I.F. (inclusive of transportation costs) and export prices estimated at F.O.B., one might argue that the first set of prices do not entirely reflect the changes in the prices that were received by primary producing countries. If transportation costs have been falling, changes in terms of trade will appear more unfavourable to the primary exporting countries than they actually were. Indeed a large proportion of the fall in British prices of primary products during the period under study can be attributed to the great decline in inward freight rates. Cairncross shows that freight rates fell about 50 per cent during the period 1870-1913. (67) Another statistical evidence states that an average of 10 per cent of the value of total world trade before the second world war, probably went into transportation costs. (68) A large part, if not all, the downward in the terms of trade of primary producers during the period 1876/80 - 1901/05, Ellsworth suggests, accounted for by the sharp decline in railway and shipping rates. (69) Some correction in British data is, however, needed to eliminate the substantial decline in transportation costs.

Thus, changes in the terms of trade of U.K. as manufactured exporting and primary importing country appear more favourable than they actually were. Relying on United States statistics for wholesale prices of imported primary goods and imported manufactured goods (both F.O.B.) during the period 1913-48, Morgan argues that "primary productions has gained greatly-by 300 to 400 per cent - vis-a-vis manufactures by a drastic shift of relative prices in its favour". (70) U.S. wholesale price data, he adds, is not exaggerated, and it might even be understated.

Using data for India, Japan, New Zealand, the Union of South Africa and Brazil, Morgan found that price series from those countries appear to fulfill the result obtained from U.S. data. (71) These studies are convincing samples of world experience, since they do not fall short on one country.

Even if the less developed countries experienced a secular deterioration in their barter terms of trade, they will still have opportunities to stimulate development through increased agricultural productivity. In this case, resources can be released for further exports reflecting an expansion in export volume at higher rate than the fall in export price, allowing the country's income terms of trade to improve. This will, in turn, ease development efforts, regardless the trend of barter terms of trade. In this respect Meier suggests, "When due weight is given to the increase in productivity in export production and the rise in export volume, it would appear that the income terms of trade actually improved for many poor countries, not with standing any possible deterioration in their commodity terms of trade." (72)

II - 3: Sectoral Balanced Growth

From the above arguments, it appears that there is no valid evidence for the necessity of large scale industrialisation in the early stages of economic development. Alternatively it may be suggested that simultaneous efforts to promote agricultural and industrial development is the solution to the problem of underdevelopment. Since any sector is part of an interdependent system represented by the country's economy what a sector does is not fully attributable or credited to it, but depends on what happens in the other sectors. Raising agricultural productivity permits agriculture to supply industrial development with labour, food and raw materials, and to gain a foreign exchange which can be used to import capital goods necessary for industrial development. Furthermore, agricultural development that results in a higher per capita farms income creates the rural purchasing power, removing the constraints on effective demand for industrial goods. Agriculture also plays a crucial role in financing industrialisation through both farm saving and lower food prices. (73) On the other hand industrialisation accelerates the rate of agricultural progress by increasing the demand for agricultural wage-goods, supplying farmers with agricultural inputs and wider range of consumption goods, creating more productive non-agricultural employment opportunities and encouraging the reorganisation of agriculture on an efficient way. Moreover, industrialisation provides a new form of saving (capitalist surplus) and sets up incentives to innovation, allowing agriculture to apply advanced technological process. Industrial development would also contribute to greater stability in the international terms of trade.

This interdependent relation between agriculture and industry is the major claim of the argument for sectoral balanced growth. The concern should rather with the inter-relationships between the agricultural and nonagricultural sectors in the development process. Emphasis on balanced growth between industry and agriculture in Lewis model is based on the importance of both food and capital as crucial factors in the growth of industrial sector, which in turn provides incentives to agricultural growth and creates a new form of saving (capitalist surplus). Lewis states, "it is not profitable to produce a growing volume of manufacturers unless agricultural production growing simultaneously. This is also why industrial and agrarian revolutions always go together". (74) He supports this view in observing, "if the balance between industry and agriculture is neglected as in Australia or Argentina, or bungled as in the U.S.S.R., further progress is held up; the superiority of the development planning of Japan over that of the other countries mentioned stands out clearly in this respect." (75)

Empirically, the issue of sectoral balanced growth is exceedingly difficult to establish. Given the scarcity of capital, shortage of skilled labour, lack of sufficiently widespread managerial and entrepreneurial ability, inadequate social overhead facilities, and relative fixed land in such countries as India, Pakistan, Egypt and many others in Asia and Latin America, there will be severe limitations on the capacity of these countries to do everything at once. The problem is, in fact, that these countries have limited resources which are not sufficient to increase productivity and income if they are divided between the agricultural and non-agricultural sectors, so that resource allocation in both sectors is below certain crucial minimum level. (76) In such countries any attempt to adopt balanced growth policy at an earlier stage of economic development may not only slow down the rate of growth in the short-run, but might also retard the achievement of long-run objectives. However, it seems that choice between the development of the two sectors is unavoidable, and one might suggest that some priorities should be given to one sector in the earlier stage of economic development. This is not to say that all investment should be devoted to develop one sector. There is probable no less developed country which can at any stage afford to concentrate all of its investment on either agricultural and industrial development. The point is to give some priorities to one sector allowing it to grow at higher rate than the other. This will permit both sectors to develop in the long-run, since priorities are given to the right sector in the short-run (an earlier stage), allowing resources to be efficiently allocated.

Experience has shown that the performance of economic development in the less developed countries which adopted sectoral balanced growth plans in the earlier stages had been disappointing, reflecting slow rate of growth. For instance, while Egypt planned to achieve agricultural and industrial development jointly, in an attempt to double the Gross Domestic product (GDP) by the end of the first ten year plan (1960-70), it increased only by 62 per cent during the period under study.(77) Sectoral balanced growth was projected before an adequate agricultural development has been achieved.

It appears that economic advice to such countries has been faulty because it emphasised the sectoral balanced growth before the preconditions of economic development are fully met. My argument is not against sectoral balanced growth. It is acceptable policy in the long-run, but not before a reliable food surplus exists. There is no conflict between some priorities to one sector in the earlier stages of economic development and sectoral balanced growth in the late stages, the two policies, in fact, are complementary. This is true only if the right choice in the earlier stage has been made. Once agriculture emerges from its stagnant, subsistence state and starts to specialise and produce goods for export and industry develops under the impact of growth in the agricultural sector, the society can be deemed to have reached a stage at which the two sectors of agriculture and industry become interdependent. At this stage balance growth policy is required to promote simultaneous development of both sectors. This policy was adopted by Japan in the nineteenth century, and this is perhaps one of the major reasons for the spectacular Japanese economic development. It may be argued that Japanese agricultural development occured side by side with industrialisation, and both sectors were grown at high and homogeneous rate during the period 1878-1917.[78] This is true, but partly. Agricultural development in Japan started at a much earlier date. In this respect,I re-call Smith's study on Japanese economic development.[79] The study shows that the achievement of agriculture before World War I, were part of a long chain of events beginning in the eightenth century. Hence, one might conclude that the impressive sectoral balanced growth in Japan during the period 1878-1917 has been sustained by agricultural development in a preceeding period.

II - 4: Emphasis on Agricultural Development

Recognising the necessity of choice between the two sectors, economists have fallen into two groups. Kahn, Viner, [80] Coale and Hoover, [81] Bauer, Nicholls [82] and others argue for an initial agricultural development. They believe that unless efforts to increase food supply receive top priority in the earlier stages of economic development, the fundamental precondition for sustained growth will not be fulfilled. Others such as Hirschman, Leibenstein, [83] Higgins [84] and others, though they recognise the necessity of increased agricultural productivity, argue that it can be accomplished only by giving a "big push industrialisation programme" top priority. The logic of Higgin's position necessitates emphasis on industrialisation, since without it, land consolidation and farm mechanisation could hardly increase the scarcity of labour. [85] However, one wonders how can a country having limited resources afford the so-called "big push industrialisation" or "sectoral balanced growth." The contradiction of Higgin's view can be seen in his review about India's experience. While he argues that the second plan was too small to fulfill the requirements of big push, states-elsewhere, that the plan was beyond the capacity of the Indian economy. [86] In my view, those economists who defend a large scale industrialisation in the earlier stage of economic development, though they present a systamatic and impressive theory, overestimate the capacity of the industrial sector and underestimate the potentiality of agriculture in the presently less developed countries. It is perhaps theory without reality. The long history of economic development in the various countries and under different circumstances hardly shows any successful trial of economic progress on the absence of an initially reliable food surplus. Even the experience of Russia (the Soviet Model) which is taken by some economists in the presently less developed countries (e.g. India and Egypt), as a strong case for large-scale industrialisation approves the necessity of a sizable agricultural surplus in the early stage of economic development as a prerequisities to a sustained industrialisation. (87)

As mentioned above, Egypt is now facing bottlenecks in its plan because it started industrial development before solving the problem of food deficit. Perhaps the problem of India is a convincing example of the necessity of agricultural surplus as a precondition for sustained economic development. The targets of India's first five year plan (1951-56) have, successfully, been achieved. Priorities were given to agricultural development which permit agricultural productivity to increase satisfactory. The second plan (1956-61) which shifted emphasis toward industrialisation, right from the beginning was in trouble. It seems that India emphasised on large-scale industrialisation before achieving an adequate and reliable food surplus. While Ford Foundation's report on India's food crisis shows that Indian food production per acre can be double if known improvements are adopted in effective combinations, the second plan started with huge food deficit. (88) This is, indeed a premature shift of resources. Economists such as Bawer (89) and Nicholls (90) argue against the emphasis on industrial development at this stage of India's economic development, and maintain that India's decision to reduce its emphasis on agriculture in its second plan probably was not only shortsighted, but meant the loss of some of the valuable comulative effects which might otherwise have occurred in the later period from its agricultural investment. Even Higgins, though argues for "big push industrialisation" admits that the large-scale industrialisation programme in the second plan was beyond India's capacity. (91) While food deficit retard the economic development in India, the superior increase of agricultural productivity in Japan sustained the high growth rate of the whole economy in a later stage. (92) Recognising the importance of achieving agricultural surplus, China by adapting the Soviet model to its special conditions, succeeded in solving the problem of underdevelopment. [93] Even in the Western countries which started their economic development with vast resources, a substantial agricultural surplus occured in a previous date of their industrial revolution.[94]

However, the choice between agriculture and industry must be considered with respect to the conditions under which the presently less developed coun tries operate. Most of these countries are faced by scarcity of capital, shortage of skilled labour, limited land and a lack of managerial and entrepreneurial ability and institutional arrangements, but having a distinct comparative advantage in agricultural products. And due to their long experience in the field of traditional export sector, the world markets for their agricultural products have been established, showing promising opportunities to expand their exports. Such conditions would favour the emphasis on agricultural development in the early stages of economic development. Since agriculture in most less developed countries is highly labour intensive, operating under simple though it could be advanced - techniques, a considerable increase in agricultural productivity can be achieved with little capital. In Japan, agricultural labour productivity and crop yield were significantly increased with relatively small capital invested in further use of fertilizer, selective breeding, propagation, improved methods of water and pest control, and of cultivating, transplanting and weeding the growing plants. [95] By applying labour intensive techniques in agriculture, China has succeeded in increasing agricultural productivity. [96] It is perhaps true that agricultural technical improvement sometimes requires structural changes, but many of them such as land saving techniques (i.e. land reforms) can be carried out without prior industrialisation. In this respect Johnston argues that Japanese agricultural output has remarkably increased because it necessitated a minimum social dislocation since it was accomplished by largely land-saving methods which could be applied effectively even on existing very small farms with a super-abundance of labour and a minimum of mechanisation. (97) Land saving techniques would induce further increase in agricultural productivity if it is accompanied by a gradual run-down of labour force to be absorbed in the rural sector itself through improvements on the level of services in the countryside. Furthermore, agricultural development, unlike industrialisation does not require widespread entrepreneurial ability, large scale of social overhead facilities, and a great deal of skillness.

On the other hand, agricultural development in an earlier stage of economic development can be achieved independently of domestic industry if agricultural exports expand enough to connect domestic agriculture with industries in the developed countries. An expanding foreign market can contribute both by putting cash in hands of the farmers and by producing competitive element that may make technical change in agriculture more acceptable. It supplies the agricultural sector with equipments and inputs needed to sustain its growth and consumption goods needed for nutrition improvement. Foreign sector can therefore play the same role that the domestic industrial sector could do in sustaining agricultural development. Moreover, the foreign sector may be more efficient in creating an intellectual environment, since equipments and ideas imported from the developed countries are more advanced and improved than that could be produced by the new domestic industries. In time a high proportion of the inflow foreign exchange can be directed to finance the new industries that might exist in a later stage.

There is of course the problem of marketing agricultural surplus in the wold markets, but it may happen that it is more productive to export agricultural goods rather than to produce industrial goods at home, so long as the comparative differences in production cost of industrial goods and primary goods between developed and less developed countries are very great. International trade has been and still one of the basic factors promoting economic well being and increasing national income of every participating country. It enables every country to specialise and export those things that it can produce cheaper in exchange for what others can provide at a lower cost. One obstacle is the deterioration in the barter terms of trade for agricultural goods. There is, however, no valid evidence for this phenomenon as shown above. On the other hand, income terms of trade is likely to move in favour of agricultural goods if agricultural productivity is increasing more rapidly than export prices are falling. In any case the country's capacity to export depends largely on the nature of its export base. Less developed countries are required to pursue policies that ensure specialisation in agricultural exports with the highest growth prospects.

To sum up, one might argue that efforts to incease agricultural productivity should receive top priority in an earlier stage of economic development. At a later stage agricultural expansion will clear the way for industry. It is perhaps true that industrialisation at an early stage of economic development also makes considerable contribution towards the creation of " external economics " for the whole economy. Indeed one must distinguish between the ideal theoretical solution and what can be done in practical terms with respect to the existing circumstances. The latter is the only available choice. It is essential to make our choice both feasible and consistent. Under all circumstances, increasing agricultural productivity makes important contribution to general economic development and that is one of the pre-condition which must be established before a take-off into self-sustained economic growth becomes possible.

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CHAPTER III

Investment Allocation and Sectoral Growth with special reference to the Egyptian Economy

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III-1: A Suggested three sectoral approach

The purpose of the present attempt is not to approach a general model to be valid for all societies, but only to suggest an approach which could be relevant to the growth of some overpopulated countries having particular characteristics corresponding to our assumptions.

The approach adopted, in this context, is to give priority to agriculture using the existing resources to improve and increase agricultural productivity in the earlier stages of economic development. As agricultural surplus occurs an expansion in exports might take place, making foreign exchange available to finance both agriculture and industry in a second stage. So long as both agricultural surplus and exports are not expected to grow very fast, industry will gradually be developed. In a third stage industrial productivity increases creating surplus to be reinvested in both agriculture and industry, allowing the economy as a whole to grow at higher rates. As the society moves into the third stage, the agricultural sector undergoes a secular decline relative to the industrial sector.

Let us assume that the country is composed of three sectors; agricultural, foreign and urban sectors, though the first two sectors are closely related. Agriculture is dominant, having relative surplus labour and produces for both exports and home consumption. Agricultural surplus is not high enough to create trade surplus. Foreign sector is the most advanced sector with long experience in agricultural exports. The urban sector absorbs a small proportion of the total population, employed in a few small industries and crafts, and in the services sector. The economy as a whole is faced with a scarcity of capital and lack of foreign exchange.

At an initial stage, agricultural productivity can be increased by applying land saving and labour intesive techniques such as greater use of fertilisers, multiplication and distribution of better seeds varieties, improved methods of water control, insecticides and pesticides, and better cultivation. Both production and labour productivity would therefore be improved at relatively low cost, utilising the use of scarce land and capital, and preventing rapid migration from agriculture to the urban sector which is-in the short-run-not prepared to absorb agricultural emigrants in a productive way. Although the application of such techniques does not require harder work, farmers' consumption is likely to be increased as agricultural productivity increases because the majority of farmers are living at the subsistence level. Some increase in consumption is, indeed, needed for nutrition improvement and to allow labour to have higher productivity, but it should be far less than the increase in agricultural productivity in order to create agricultural surplus to be exported.

However, at this stage, consumption should be controlled either directly or through taxation. If agricultural taxation is carefully approached, saving can be increased without introducing discentive effects on farmers' desire for further production. In order to encourage farmers for further increase in productivity, taxes should be imposed independantly of the size of production. Land tax at relatively high but fixed rate could be effective in saving a considerable proportion of the increase in production without discouraging farmers for increasing productivity. This is only true if the new practices are made available to all farmers, particularly to those who live at subsistence level. For instance land tax should be accompanied with an efficient input distribution system, to supply farmers with fertilisers, seeds, insecticides etc. at low cost and at the proper time. Agricultural inputs and outputs may also indirectly be taxed through price stabilisation process, if a high proportion of the inputs and outputs is internationally traded. It is, however, not feasible to generalise one recommanded tax system for all societies, since saving capacity differs from one society to another according to internal distribution of export earnings the structure of demand, saving propensities and agricultural policy. Indeed agricultural policy and taxation system should be consistent, in the sense that they are jointly approached with respect to the nature of farmers behaviour in a particular society.

Agricultural labour is not expected to re-act in the short-run, not only because labour intensive techniques are applied in agriculture, but also due to the lack of immediate labour mobility in the industrial sector. Employment and real wage in industry, and internal terms of trade between agriculture and industry are then expected to remain unchanged.* The trend of international terms of trade depends on the share of the country's exports in the world supply. In the case of a small country, barter terms of trade are usually unaffected while they might deteriorate in the case of a large country. However, this can be overcome, since export productivity is increasing at higher rate than price is falling, inducing an improvement in the income terms of trade.

As foreign exchange earnings begin to flow in, some new industries might develop in the urban areas. The choice of the relevant industries in this stage is essential. It seems that labour intensive industries relying on

* Industrial production is assumed to be constant.

raw materials produced domestically such as food industries and textile are relevant to the present circumstances in the overpopulated countries. Thus, labour mobility in the urban sector would be improved encouraging labour to migrate from agriculture, and production cost is likely to be reduced, permitting industrial imports to compete in the world market. This is to say that a less developed country would have to develop a comparative advantage for goods of a type which is an extention of which it is at present producing with a great success. In the meantime, further improvement in agricultural productivity should continue to sustain industrial development. Choice of agricultural techniques must be consistent with industrialisation process in this second stage. Agricultural machines of less capital intensity such as tractors and irrigation machines could be used. Such machines are rather animals substitutes than labour substitutes. This will not only increase animals' production (meat and milk), but also might reduce the rate of labour migration from agriculture. Labour mobility in the industrial sector is not expected to improve sharply in a few years, and unless agricultural migration is controlled, disguised unemployment might exist in the urban areas in the form of an unproductive informal sector or / and overcrowding services. Thus, some capital should be invested in financing agricultural horizontal expansion and facilities improvement in the rural sector itself in order to absorb a part of surplus labour resulted from agricultural development. In this respect some priorities must be given to importing capital goods needed for agricultural development and selected industries. Tax allowance or even subsidy (from land tax) to imports of capital goods is advised at this stage. Both capital and labour should grow simultaneously and proportionally to allow productivity to increase without facing bottlenecks.

As labour moves from agriculture to industry internal terms of trade may change. The trend of terms of trade depends on the change of agricultural surplus per industrial worker (average agricultural surplus). Given a certain number of industrial workers, average agricultural surplus will, in turn, depend on the size of increase in agricultural productivity, and the proportion that is exported. If a small proportion of agricultural surplus is exported, average agricultural surplus (for industrial workers) may increase reflecting a deteriorating situation in the terms of trade for agriculture. Hence, discentive effects with respect to the farmers' desire for further increase in agricultural productivity might be introduced. A high proportion of agricultural surplus should then be exported to permit internal terms of trade to move in favour of agriculture (lower average agricultural surplus), creating incentives for farmers to further production and to allow capitalist in the industrial sector to gain higher profits (lower real industrial wage), encouraging them for further investment. Moreover, foreign exchange earnings are likely to increase to be invested in both agricultural and industrial sectors.

Once industrial production becomes available and capitalist surplus occurs, the society can be deemed to have reached the third stage. Now the growth of agricultural productivity is expected to slow down reflecting some decline in agricultural surplus, since the technological process already applied in agriculture have been exhausted. As capital surplus is reinvested in further industrial expansion, the marginal productivity of industrial labour might shift upward, allowing labour to have a higher real wages. In this stage, industrial development should be directed towards more sophisticated industries with less labour - intensive techniques, where surplus labour is becoming smaller.

On the absence of a cheap food policy, internal terms of trade might improve for agricultural goods, since surplus and wages in industry are increasing. This would encourage both capitalists and landlords to reinvest in agriculture which in turn may lead to an upward shift in marginal productivity of agricultural labour. The new advanced technological process in agriculture now could be applied with less labour and higher capital. As the society moves into this stage, the agricultural sector is gradually losing ground, while a high proportion of population will be engaged in the industrial sector which becomes more advanced and is able to compete in the world markets. At the same time, foreign sector, is expanding to include industrial exports in a larger proportion , and to have higher capacity in importing investment goods and perhaps consumption goods. One might expect that the society is, now, having higher ability in shifting its resources off downward price trends and on to upward price trends. In this case, international terms of trade is likely to be stable in the short-run and improving in the long-run.

Capital accumulation and / or innovation in the industrial sector will permit it to grow rapidly to catch up with agriculture. By the end of this final stage both sectors become, more or less, developed of the same level. Hence, a sectoral balanced growth should take place in the sense of simultaneous efforts to promote agriculture and industry for further development, allowing each sector to contribute to the other. The circle, then, will keep running for more rapid growth in the economy as a whole. Indeed, in real world such procedure operates simultaneously rather than sequentially.

III-2: An Empirical Investigation of Investment Allocation Efficiency Among Commodity Sectors

An attempt is here made to examine and investigate investment allocation efficiency among commodity sectors. A simplified arithmetic exercise is carried out to justify the suggested approach (III-1) and to test its relevance to the Egyptian economy. The purpose of the underlying exercise is not to state the exact outcome if investment is efficiently reallocated among sectors, but to indicate the probable order of magnitude. It is, however, confined to the period 1960-65* (corresponding to the first stage in the suggested approach) for which data are available, and only with respect to capital and goods flow. 1959/60 is taken as a base year, the date at which economic development planning took place. It would be more useful if we start from 1952, but unfortunately the available data on 1950s are not sufficient nor reliable for the purpose under consideration. However, it seems that our assumptions as stated in III-1 are relevant to the conditions under which the Egyptian economy was operating even in the late fifties. In 1959/60, agriculture was dominant in the sense that it occupied the primary position in the labour force, national income, production and foreign trade.** Surplus labour in agriculture exists only during the slacks. The marginal productivity of agricultural labour is positive, but it may be, for family labour, lower than wage rate. (1) Still relative surplus labour might exist, since agricultural production is highly labour intensive techniques (chapter I). Although agricultural exports, of which raw cotton accounted for the major part, was dominant in 1959/60, Egyptian economy was

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* The five year plan. Data used in the present exercise were originally derived from the follow-up report of the five year plan, but re-classified and adjusted to fit the purpose under investigation. In some cases of which data are not available in sufficient details, some rough approximation based on data extracted from Ministry of Planning, Central Planning Dept. is made.

**Agriculture employed some 55 per cent of labour force, and contributed 30 per cent of national income, 77 per cent of exports and 30 per cent of imports in 1959/60 (source: Yearbook of International Trade Statistics,1960) faced by a large food deficit. Agricultural imports (mainly food and particularly wheat) represented some 34 per cent of the total imports. The contribution of manufacturing was relatively small and less than that of agriculture. In 1959/60, manufactural exports accounted for only 20 per cent of the total exports, of which textile and processed food industries produced the major part.(2) However, these two major industries rely largely on raw materials and food produced locally in the agricultural sector.

Scarcity of capital, particularly foreign exchange is perhaps the major constraint to economic development in Egypt (Chapter I-2). Thus, an efficient allocation of investment will utilise this limited capital, removing partly the barriers to economic development. In the present attempt, it is, however, assumed that the actual invested capital over the five year plan is the only available capital, and investigation is confined to investment reallocation among and within the two commodity sectors. For the sake of simplicity and feasability investigation is restricted to the broad and rather aggregate activities.* The approach adopted is therefore to reallocate investment in favour of activities with relative low capital output ratio and less demanding for foreign exchange. The actual output in 1964/65 is weighted against the derived one from the suggested reallocation of investment to test investment allocation efficiency and to justify the necessity of agricultural development. In order to have uniform prices,

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* Capital invested in agriculture is classified into: vertical expansion (i.e. all inputs used in the short-run). irrigation and drainage, land reclamation and High Dam. Industrial investment is classified into consumption industries. (i.e. food processing and textile), Intermediate industries including mining and construction, capital good industries and electricity.

all commodities whether produced locally, imported or exported are valued at constant ex-service prices of 1959/60. Imports and exports are revalued to have the same average price as the ex-service price of similar commodities produced at home.(3) The ex-service price is the price of a commodity less any transportation, wholesaling, retailing or other service costs. It embodies only value added in one or more commodity - producing industries plus imports.(4) The reason of using ex-service prices for our purpose is to exclude services sector (for simplicity) and hence to determine the total value of available commodities directly through the estimate of the value added in commodity sectors.

Some crude assumptions, though could be realistic in the short-run, are made to simplify the underlying estimates.

1. Minimum capital-output ratio criterion (MCOR) is employed in reallocating investment among activities. This criterion is perhaps useful in approaching a short run policy, but ignores the impact of social return particularly in the long run which could have wide ranging effects on the profitability of other activities.(5) Investment reallocation is therefore confined to the activities which are involved in direct production (i.e. agricultural vertical expansion, consumption industries, intermediate industries and capital goods industries). Testing investment allocation efficiency among long terms projects, intrastructure and social capital is not feasible under such criterion. Capital invested in irrigation and drainage, land reclamation, High Dam and electricity is held constant as actually allocated in the five year plan.

2. Lower bounds are imposed to investment allocated in intermediate and capital industries. Some minimum requirements of intermediate and capital goods are needed to sustain the growth of other activities. It is initially assumed that the minimum requirements for intermediate and capital industries

are L.E. 242.8 million and L.E. 47 million respectively, to be tested by employing input-output tables as shown below.(6)

3. Investment reallocation is based on the estimated capital-output ratio from the actual achievement for each activity during the five year plan.* It is, therefore, assumed (for simplicity) that the proportion of investment distribution among the various industries within each activity remains constant (i.e. constant capital - output ratio over the whole period). Investment is reallocated among but not within activities.

4. Foreign exchange is the dominant scarcity and balance of payment is perhaps a major constraint on economic growth in Egypt. It is, therefore, restricted to a level at least equal to the available foreign exchange as stated in the five year plan. (L.E. 379.3 million).

5. As far as output is concerned, agriculture is subdivided into three activities; cotton, food and fodder. Since capital-output ratio is similar in the three activities.(7) the proportion of investment allocated among agricultural activities is assumed to be the same as it actually held during the five year plan.

6. Value added-output coefficient for each activity is assumed to remain constant at a rate equivelant to that actually prevailed during the five year plan.**

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* Before excluding services from prices.

** It is not constant over the whole sector, since investment is reallocated within each sector.

A maximisation approach is used in reallocating investment among activities and in determing the corresponding value added. (8)

The objective function is

$$dy = \sum_{i=1}^{n} \frac{1}{CORi} Ii, \quad i = 1,\ldots\ldots,n$$

Where

Ii is the actual investment allocated to activity i

CORi is the capital-output ratio and dy is the change in the value added for the whole commodity sectors.

Subject to

1. $C = \sum_{i=1}^{n} I_i$

Where C is the capital constraint

$C = D + F$

Where D is domestic capital and F is foreign exchange

2. $I_2 = 138.0$

$I_3 = 97.1$

$I_6 = 112.6$

Where I_2 is investment allocated to irrigation and drainage

I_3 is investment allocated to land Reclamation.

I_6 is investment allocated to electricity

3. $I_5 \geq 242.8$

$I_7 \geq 47.0$

Where I_5 and I_7 are investment allocated to intermediate and capital goods

Using an iterative method and solving for Iis, investment is reallocated as shown in table III-1. The foreign exchange constraint is checked by comparing the actual available foreign exchange (L.E. 379.3 million) with that needed (L.E368 million). This was expected because the activities with low capital-output ratio are also less demanding for foreign exchange.

Planned, actual and suggested investment allocation among the underlying activities, and corresponding capital-output ratio and foreign exchange are shown in table III-1.

TABLE III- 1

Planned, Actual and Suggested investment allocation Among Commodity Sectors in 1960-65

Sectors	Investment in L. E. Million			% Foreign Exchange	Capital Output Ratio
	Planned	Actual	Suggested		
Agriculture	392	355	388.7	14.3	-
Vertical expansion	51.9	21.3	55	28.9	0.8
Irrigation and Drainage	119.4	138.0	138.0	10.4	4.9
Land Reclamation	173.4	97.1	97.1	15.2	6.1
High Dam	47.4	98.6	98.6	10.4	-
Industry	574.7	516.5	482.8	64.7	-
Consumption industries	79.8	71.7	80.4	61.1	1.4
Intermediate industries *	293.3	275.5	242.8	63.0	2.4
Electricity	138.5	112.6	112.6	66.0	7.4
Capital goods industries	63.1	56.7	47.0	77.0	5.7
TOTAL	966.7	871.5	871.5	42.2	-

* Includes Mining and Construction.

Sources :

1. "General Frame of Five Year Plan for Economic and Social Development July 1960 - June 1965". Cairo, 1960, p.15.
2. Ministry of Planning, "Follow up Reports", Cairo, 1960-65.
3. Ministry of Planning, Central Planning Dept., .

Change in the value added of the underlying activities is determined by (Table III - 5):

$$dy_i = \frac{1}{COR_i} I_i$$

Where $dy = \sum_{i=1}^{n} dy_i \quad i = 1, \ldots, n$

The value added is therefore obtained by adding the value added in 1959/60 in each activity to the corresponing change in the value added;

$$y_i = y_{i-1} + dy$$

Given the value added-output coefficient as prevailed during the five year plan, gross output, inputs and the value added are estimated to be converted into ex-service prices (Tables III - 2 & 3 & 4).

During the five year plan (1960-65), some L.E. 871.5 million invested on commodity sectors, of which L.E. 516.5 million (i.e. 60 per cent) devoted to industry (table III - 1). The industrial sector absorbed some 88 per cent of the foreign capital allocated to commodity production. The value added of the whole commodity sectors increased by 37.5 per cent (at constant prices) during the period 1960-65, giving an annual rate of growth of 6.6 per cent (tables III - 3 & 5). Industrial value added increased by more than 59 per cent (i.e. an annual rate of growth of 9.8 per cent) against only 17.7 per cent for agricultural value added or an annual growth rate of 3.3 per cent over the same period. Nevertheless, agricultural surplus remarkably decreased from L.E. 38.5 million in 1959/60 to L.E. 6.4 million in 1964/65, and industrial deficit increased by some 50 per cent during the period understudy (at ex-serivce prices). Hence, trade deficit considerably increased from L.E. 33 million in 1959/60 to L.E. 108 million in 1964/65. (9) Thus, one might argue that investment allocation among commidity sectors and perhaps within each sector was not efficient enough to sustain economic development. Given the growth rate in the following period, this view is confirmed and supported. During the period 1965-70, the average annual growth rate of commodity sectors

TABLE III-2

Gross Output, Value Added and Inputs Used in 1959/60

At ex-service prices L.E. Million

Sector	Gross output	Inputs	Value Added
Agriculture	418.9	126.9	292
Cotton	98.9	15.2	83.7
Food (1)	271.9	104.5	167.4
Fodder	48.1	7.2	40.9
Industry	995.7	728.6	267.1
Consumption goods Industry	574.0	459.4	114.6
Intermediate goods (2) Industry	403.5	261.9	141.6
Capital goods Industry	18.2	7.3	10.9
Total	1414.6	855.5	559.1

(1) Includes field crops, vegetables, fruits, animal products (livestock), fishing and hunting.

(2) Includes also raw materials, mining, construction and electricity.

Sources

1. General Frame of Five Year Plan for Economic and Social Development (1960-65), op.cit. pp 44-45

2. Ministry of Planning, Central Planning Department

TABLE III-3

Gross Output, Value Added and Inputs Used in 1964/65

At Constant ex-service prices (1959/60) L.E. Million

Sector	Gross output	Inputs	Value Added
Agriculture	494.7	151.1	343.6
Cotton	113.0	15.9	97.1
Food	324.8	126.7	198.1
Fodder	56.9	8.5	48.4
Industry	1465.5	1040.3	425.2
Consumption goods Industries	759.5	601.3	158.2
Intermediate goods Industries	674.3	426.2	248.1
Capital goods Industries	31.7	12.8	18.9
Total	1960.2	1191.4	768.8

Sources

1. Ministry of Planning "Follow Up Report" op.cit.
2. S. A. El-Bauab "The Major Problems of Economic Growth During The Five Year Plan (1960-65)", INP, Memo, 957 Cairo, 1970, p.12

TABLE III-4

Gross Output, Value Added and Inputs Used as suggested in 1964/65 at Constant ex-service prices (1959/60)

L.E. Million

Sector	Gross output	Inputs	Value Added
Agriculture	539.6	165.3	374.3
Cotton	123.4	17.7	105.7
Food	353.9	138.0	215.9
Fodder	62.3	9.6	52.7
Industry	1476.7	1061.4	415.3
Consumption goods Industries	791.3	627.9	163.4
Intermediate goods Industries	656.1	421.6	234.5
Capital goods Industries	29.3	11.9	17.4
Total	2016.3	1226.7	789.6

accounted only for 3.5 per cent. Indeed such deterioration in growth rate is perhaps attributed to the dramatic decrease in industrial development* (i.e. an annual rate of growth of 3.6 per cent against 9.8 per cent during the period 1960-65).(10)

When investment at this earlier stage is reallocated in favour of activities with low capital-output ratio and low demand for foreign exchange (as suggested in table III - 1), the value added of the whole commodity sectors is increased by 41.2 per cent in five years, giving an annual growth rate of 7.1 per cent (table III - 4 & 5)against 6.6 per cent during the five year plan. Although the industrial value added increased slightly less than the increase in the five year plan (an annual growth rate of 9.3 per cent against 9.8 per cent), agricultural value added remarkably increased. The annual rate of growth of agricultural value added approached 5 per cent against 3.3 per cent during the five year plan (table III - 3). Thus, priority should be given to agricultural development in the early stages of economic development. Investment could be reallocated in favour of agricultural techniques such as animals substitutes' machines (i.e. tractors and irrigation machines), fertilisers, high yielding variety seeds and insecticides. Such techniques have high potentiality in the short-run as well as rather labour intensive techniques. Investment within the industrial sector might also be reallocated (second priority) in favour of industries with low capital-output ratio and relatively low need for foreign capital such as textile and food industries. Such industries are, in fact, an extension of which it is at present producing with a great success (i.e. comparative advantage).

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* The 1967 war could be one, but not all the reasons for such deterioration in the rate of growth.

TABLE III-5

Change in the value added of the two commodity sectors between 1959/60 - 1964/65

At constant ex-service prices L.E. Million

	Actual		Suggested	
	Increase	Percentage	Increase	Percentage
Agriculture	51.6	17.7	82.3	28.2
Cotton	13.4	16.0	22.0	26.3
Food	30.7	18.3	48.5	29.0
Fodder	7.5	18.3	11.9	28.9
Industry	158.1	59.2	148.2	55.5
Consumption Industries	43.6	38.0	48.8	42.6
Intermediate Industries	106.5	75.2	92.9	65.6
Capital Industries	8.0	73.5	6.5	59.6
Total	209.7	37.5	230.5	41.2

Source: Tables III-2, 3 and 4

It is perhaps useful at this stage to investigate the impact of the suggested reallocation of investment on the structure and balance of foreign trade as well as sectoral surplus or deficit. Investigation is confined among sectors.

At macro-level (i.e. national accounts) it is necessary to ensure an overall balance, so that;

Production (i.e. value added) + net imports = Consumption + Services* + Investment. Consumption is split into four components;

$$C = C_{RF} + C_{RN} + C_{UF} + C_{UN}$$

Where,

C_{RF} is food consumed by rural population

C_{RN} is other goods consumed by rural population.

C_{UF} is food consumed by urban population.

C_{UN} is other goods consumed by urban population.

Estimate of consumption is based on the income elasticity of demand for each component as prevailed during the five year plan. (11) It is assumed to remain constant.

$$E_d = \frac{\partial\left(\frac{C}{P}\right)}{\partial\left(\frac{Y}{P}\right)} \cdot \frac{\frac{Y}{P}}{\frac{C}{P}}$$

Where C is consumption

Y is value added

P is population size

and $\frac{Y}{P} \cdot E_d$ is consumption per capita (table III - 6)

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* Commodities used by the services sector.

TABLE III-6

Consumption of Commodities at ex-service prices
Constant prices (1959/60)

(a) Actual 1964/65

Sectors	Food	Other Consumption Goods	Total
Agriculture	172.8	139.8	312.6
Industry	148.4	224.1	372.5
Total	321.2	363.9	685.1

Source: Ministry of Planning, Central Planning Dept., 1966

(b) Suggested 1964/65

Sectors	Food	Other Consumption Goods	Total
Agriculture	186.3	151.3	337.6
Industry	144.9	218.8	363.7
Total	331.2	370.1	701.3

TABLE III-6 (Cont'd)

(c) Suggested
(if agricultural consumption is controlled)

Sectors	Food	Other Consumption Goods	Total
Agriculture	172.8	139.8	312.6
Industry	144.9	218.8	363.7
Total	317.7	358.6	676.3

Commodities absorbed by investment and services sectors are assumed to remain constant at the same proportion as prevailed during the five year plan. [12]

Net imports (i.e. imports - exports) is estimated as a residual.

Further investigation is carried on by using both input-output table and supply-demand table.

The input-output table is employed in the present analysis to show the interrelationship between commodity sectors (agricultural, industrial and foreign sectors) and to ensure consistency and balance among as well as within sectors. The interrelationships among sectors and activities are introduced by considering the simultaneous determination of all the outputs and inputs. [13] Input-output functions are here applied because they are, unlike the neoclassical functions, useful tool for empirical analysis of general equilibrium system. The input-output model is particularly useful in showing the effect of a change in the final demand for sector (or activity) j on the output of sector (or activity) i. [14] It is however, based on three major assumptions; each sector or activity produces a homogenous product, having a fixed input-output coefficients and is subject to constant return to scale. [15] Constant input-output coefficient assumption is rather restrictive particularly in the less developed countries; [16] though it may be accurate approximation of reality in the short-run.

The input-output table is constructed and tested for consistancy by applying the following functions:

$$x_j = \sum_{i=1}^{n} x_{ij} + y_j \qquad (1)$$ "Reading down the columns"

Where

x_j is the gross output of sector or activity j

y_j is the value added of sector or activity j.

x_{ij} is the input used by sector or activity j and purchased from sector or activity i.

Given the value of x_j and the correlation coefficient between x_j and both x_{ij} and y_j; the value of x_{ij} and y_j can be obtained. Hence;

$$\left.\begin{aligned} x_{ij} &= a_{ij}\ x_j \qquad 1 - 1 \\ y_j &= b_j\ x_j \qquad 1 - 2 \end{aligned}\right\} \qquad \text{Subject to} \qquad \sum_{i=1}^{n} a_{ij} + b_j = 1.$$

A matrix of input-output coefficients, A, was basically constructed for 8X8 interindustry transaction; cotton, food, fodder, manufactural consumption goods, intermediate goods, capital goods, agricultural imports, and industrial imports, to be computed from data on the actual achievement during the five year plan (table III - 7). Applying equation 1 - 1 (i.e. $x_{ij} = a_{ij}x_j$), the value of intermediate inputs x_{ij} are estimated. Due to the lack of knowledge on the final demand components within each sector, the input-output table is reduced to 4 X 4 table and confined to agricultural goods and industrial goods, with two entries, domestic and import components in each sector. A 4 X 4 matrix of input-output coefficients is therefore obtained, i.e. $\frac{xij}{xj} = aij$ (table III - 8). The realism of the assumption of constant input-output coefficient is subject to challenge. Since investment is reallocated in favour of agricultural production and manufactural consumption industries, input-output coefficients might slightly change. The development of agriculture may increase that sector demand for intermediate inputs such as high yielding variety seeds, fertiliser, insecticides and machines provided mainly by foreign sector (imports). The development of manufactural consumption industries such as textile and food processing might also increase the supply of agricultural raw materials (cotton and food) to the industrial sector, while the reduction in investment allocated to intermediate and capital industries would reduce industrial sectors' demand for imports. Thus

TABLE III - 7

Input - Output Coefficients Matrix

8 x 8 Matrix

Commodity	Cotton	Food	Fodder	Cons. Goods	Interm. Goods	Capital Goods	Agric. Imports	Industrial Imports
Cotton	0.051	-	-		0.159	-	-	-
Food	-	0.079	-	0.179	-	-	-	-
Fodder	0.004	0.137	0.065	0.002	-	-	-	-
Consumption Goods	-	-	-	-	-	-	-	-
Intermediate Goods	0.055	0.106	0.051	0.515	0.295	0.142	-	-
Capital Goods	0.006	0.01	0.007	0.013	0.033	-	-	-
Agricultural Imports	-	0.018	-	-	-	-	0.527	
Industrial Imports	0.024	0.04	0.026	0.083	0.145	0.262	-	0.603

Source :1.Ministry of Planning "Follow Up Report"(1960/61 - 64/65), op. cit.
2. Ministry of Planning, "Central Planning Dept." Op.cit.

TABLE III - 8

Reduced Input-Output Coefficients Matrix

4 x 4 Matrix

Commodity	Domestic Agriculture	Agricultural Imports	Domestic Industry	Industrial Imports
Domestic Agriculture	0.162		0.167	-
Agricultural Imports	0.012	0.527	-	
Domestic Industry	0.097		0.428	-
Industrial Imports	0.035		0.115	0.603

an arbitrary assumption is made to update the original matrix of input-output coefficient by allowing for some increase in agricultural imports of intermediate inputs on the expense of local agricultural inputs, and for some increase of agricultural inputs (Cotton and Food) on the expense of both industrial and imported inputs in industry. The correction is based on data for the succeeding years of 1965.[17] The adjusted matrix of input-output coefficients is shown in table III - 9. Two general observations on the input-output table emerge:

1. All production of cotton is treated as intermediate inputs purchased by industry. Cotton exports are therefore considered as industrial exports.

2. Food purchased by industry is treated as intermediate goods rather than final goods, since it has to be modified, though slightly before reaching the consumer. It is therefore considered as industrial consumption goods.

However, final demand for both agricultural and industrial goods is computed by applying the following function:

$$x_i = \sum_{j=1}^{m} x_{ij} + u_i \qquad (2)$$ "Reading across the rows".

Where ui is the final demand of sector or activity i.

For each sector or activity xi must equal xj (i.e. xi - xj = 0), thus

$$x_j = \sum_{j=1}^{m} x_{ij} + u_i$$

Or

$$u_j = x_j - \sum_{j=1}^{m} a_{ij} x_j$$

The final demand is therefore determined as a residual. And the balance over the whole table is tested by ensuring that: [14]

$$\sum_{j=1}^{m} u_i = \sum_{i=1}^{m} y_j$$ for the whole commodities.

Final demand is split into five components:

$$Ui = Ci + Ii + Ri + Ei - Mi$$

Where

Ci is consumption of commodities.

TABLE III - 9

Adjusted Input-output Coefficients Matrix

Commodity	Domestic Agriculture	Agricultural Imports	Domestic Industry	Industrial Imports
Domestic Agriculture	0.160	-	0.181	-
Agricultural Imports	0.014	0.613	-	
Domestic Industry	0.095	-	0.421	-
Industrial Imports	0.037	-	0.117	0.626

I_i is investment

Ri is commodities used by services sector

Ei is exports

Mi is imports

Consumption, investment and services are known from previous information but rearranged to fit observation '2' above. Consumption of agricultural goods is confined to food consumed in its original nature. Food purchased by industry is treated as industrial consumption goods. Net import (or net export) for either agricultural or industrial goods is the residual. It is assumed (for simplicity), that imports remain constant as held during the five year plan, so that exports would reveal the change in net imports. The input-output tables in 1964/65 (actual and suggested) are shown in tables III - 10 and 11.

The consistency of the whole input-output table is tested by using the Leontief matrix in re-estimating the gross output of each sector from the pre-estimated final demand (i.e. reverse order).(18) The matrix of input-output coefficients, A, is substracted from the unit or identity matrix I to obtain the corresponding Leontief matrix, I-A. (19)

Equation (2) might be rewritten as

$$X = (A \cdot X) + U$$

Or

$$(X - AX) = U$$

$$(I - A) X = U, \text{ thus}$$

$$X = (I-A)^{-1} U$$

Where $(I-A)^{-1}$ is the invert of Leonfief matrix which is calculated by using the following formula

$$(I - A)^{-1} = \frac{1}{(I - A)} \text{ adj } (I-A)$$

The calculation for obtaining the inverse is checked by computing

TABLE : III - 10

Input - Output Table
1964/65 (Actual)
At Ex-Service Price (1959/60 = 100)

L.E. MILLION

Sector		Agriculture	Industry	Gross Output	Inputs	Consumption	Service*	Investment	Exports
Agriculture	National	80.2	244.5		324.7	139.2			
	Imports	5.8	-		5.8	5.2			
	Total	86.0	244.5	494.7	330.5	144.4	0.2	24.4	6.2
Industry	National	47.9	626.8		674.7	417.9			
	Imports	17.2	169.0		186.2	122.8			
	Total	65.1	795.7	1465.5	860.9	540.7	25	142.1	205.8
Value Added		343.6	425.2		1191.4	685.1	25.2	166.5	212
Gross Output		494.7	1465.5	1960.2					

Source: Derived from Ministry of planning, Central planning dept. Op.cit.

* Commodities used by Services Sector.

TABLE III - 11

Input - Output Table as suggested in 1964 / 65
At Ex-Services Prices (1959/60 = 100)

L.E. MILLION

Sector		Agriculture	Industry	Gross Output	Inputs	Consumption	Services*	Investment	Exports
Agriculture	National	86.4	267.2		353.6	152.4			
	Imports	7.6	-		7.6	4.8			
	Total	94.0	267.2	539.6	361.2	157.2	0.2	26.2	7.2
Industry	National	51.3	621.5		672.8	429.2			
	Imports	20.0	172.7		192.7	114.9			
Total		71.3	794.2		865.5	544.1	24.4	139	211.3
Value Added		374.3	415.3	1476.7	1226.7	701.3	24.6	165.2	218.5
Gross Output		539.6	1476.7	2016.3					

* Commodities used by Services Sector.

$$(I-A)^{-1}\ (I-A) = I$$

Given the value of $(I-A)^{-1}$ and u, the gross output, X, for the underlying sectors is obtained to be checked against that estimated from knowledge on investment and capital-output ratio.

The input-output model is perhaps useful in analysing the interrelationship among commodities, but do not show the magnitude of sectoral surplus(or deficit). Surplus is here, defined as the difference between total supply and total demand for each sector as well as for the whole commodity sectors. The supply-demand table is therefore designed to estimate surplus or deficit in each sector, and to investigate the impact of investment reallocation on the balance of foreign trade. The relation between supply and demand is considered for the three commodity sectors (agriculture, industry and foreign), so that 3 X 3 table is constructed of which each cell has two entries, inputs and final goods (except for exports). Total supply of each sector is defined as gross output minus commodities absorbed by investment and services sectors (domestic sectors) and as imports (foreign sector).

Thus

$S = XJ - I - R$ Domestic sector

$S = M$ Foreign Sector

Where S is the total supply

Total demand of each sector comprises two aggregate components; inputs purchased from other sectors and final goods consumed. In the case of foreign sector, demand is confined to one component; exports. Thus

$D = Xij + C$ Domestic sectors

$D = E$ Foreign sector

Where D is the total demand

It is worth noting that agricultural surplus (or deficit) plus industrial deficit (or surplus) are equal foreign trade surplus which is also the national commodity deficit.

Information on X_j, X_{ij} , I_i, R_i, M_i and E_i are obtained from input-output tables. C is identified through the following two equations:

$$C_R = C_{RA} + C_{RN} + C_{RM}$$

$$C_U = C_{UA} + C_{UN} + C_{UM}$$

Where,

C_R is final goods consumed by rural population

C_U is final goods consumed by urban population

C_{RA} and C_{UA} are agricultural goods consumed by rural and urban population respectively.

C_{RN} and C_{UN} are industrial goods consumed by rural and urban population respectively.

C_{RM}, C_{UM} are imports consumed by rural and urban population respectively.

C_R and C_U are known from table III - 6, C_{RA}, C_{RM}, C_{UM} are known from input-output table and C_{UA} is zero. Thus C_{RN} and C_{UN} are obtained as a residual in the underlying two equations.

Supply-demand tables 1964-65 (actual and suggested), are shown in tables III - 12, 13.

From the above investigation it appears that if investment was allocated in favour of agriculture as suggested, agricultural surplus will increase at a higher level than the increase in industrial deficit, allowing trade deficit for the whole society to be reduced. Since the major crops (cotton and rice) are competitive in the world market, it is feasible to export such increase in agricultural surplus to be utilised in financing

TABLE III - 12

Supply - Demand Table

1964/65 (Actual)

At Ex-Services Prices (1959/60 = 100)

Demand (L.E. Million)	Sector		Supply (L.E. Million) Agricultural Sector	Industrial Sector	Foreign Sector (Imports)	Total Demand	Surplus or Deficit
	Agricultural Sector	Inputs	80.2	47.9	23.0	151.1	
		Final Goods	139.2	168.2	5.2	312.6	
		Total	219.4	216.1	28.2	463.7	+6.4
	Industrial Sector	Inputs	244.5	626.8	169.0	1040.3	
		Final Goods		249.7	122.8	372.5	
		Total	244.5	876.5	291.8	1412.8	-114.4
		Foreign Sector (Exports)	6.2	205.8		212.0	+108.0
		Total Supply	470.1	1298.4	320	2088.5	0

Source: Tables III - 2, 6 and 10

TABLE III - 13

Supply - Demand Table as
Suggested in 1964/65 at Ex- Services
Prices (1959/60=100)

Demand (L.E. Million)	Sector	Supply (L.E. Million): Agricultural Sector	Industrial Sector	Foreign Sector (Imports)	Total Demand	Surplus or Deficit
Agricultural sector	Inputs	86.4	51.3	27.6	165.3	
Agricultural sector	Final Goods	152.4	180.4	4.8	337.6	
Agricultural sector	Total	238.8	231.7	32.4	502.9	+ 10.3
Industrial sector	Inputs	267.2	621.5	172.7	1061.4	
Industrial sector	Final Goods		248.8	114.9	363.7	
Industrial sector	Total	267.2	870.3	287.6	1425.1	- 111.8
Foreign Sector (Exports)		7.2	211.3		218.5	+ 101.5
Total Supply		513.2	1313.3	320	2146.5	0

economic development in the future. On the other hand the structure of foreign trade could be improved in the sense that net imports of consumption goods would be reduced on the expense of the imports of investment goods whether for agriculture or industry, permitting the society to have higher potentiality to production in the future.

If consumption in agriculture (agricultural population) is restricted at a level equivalent to that actually consumed during the five year plan, the whole increase in agricultural production could be utilised for further reduction in trade deficit and in saving a good deal of foreign exchange or in importing capital goods.* Land taxation might be a useful policy in absorbing a high proportion of the increase in agricultural income without introducing discentive effects with respect to farmers productivity. In some cases, an increase in land taxation would encourage farmers for further increase in production. The farmer may attempt new practices in order to compensate the increase in land taxation. However, since 1952 land taxation in Egypt is fixed at some L.E. 4-5 per feddan on average, while agricultural land price is progressively increasing.[20] Thus, one might suggest that an increase in land taxation by some L.E. 2-3 per Feddan (some 4-5 per cent of the land value) would do no real harm to farmer motives for further increase in production, if agricultural inputs are made available to farmers at stabilised prices.** On the other hand agricultural inputs and outputs may also be taxed in the good years or / and when world prices move in the farmers' favour, through price stabilisation process. This could be relevant and effective policy, since a high proportion of agricultural inputs and outputs is internationally traded.

If consumption of the agricultural population is controlled as suggested (table III - 6) the agricultural surplus will increase to L.E. 35.3 ......

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* Input-output table and supply-demand table under constant consumption are shown in tables III-14 & 15 respectively.

** Centerilised distribution system and stabilised policy were initiated in 1960.

TABLE III - 14

Input-Output table as
Suggested in 1964/65 if Consumption
in Agriculture is held Constant
at Ex-Services Prices (1959/60=100)

L.E. MILLION

Sector		Agriculture	Industry	Gross Output	Inputs	Consumption	Services	Investment	Exports
Agriculture	National	86.4	267.2		353.6	142.0			
	Imports	7.6	-		7.6	4.8			
	Total	94.0	267.2	539.6	361.2	146.8	0.2	26.3	17.6
Industry	National	51.3	621.5		672.8	414.6			
	Imports	20.0	172.7		192.7	114.9			
	Total	71.3	794.2	1476.7	865.5	529.5	24.4	139	225.9
Value Added		374.3	415.3		1226.7	676.3	24.6	165.2	243.5
Gross Output		539.6	1476.7						

TABLE III - 15

Supply - Demand Table
as suggested in 1964/65 if consumption in Agriculture
is held Constant at Ex-Services Prices (1959/60=100)

Demand (L.E. Million)		Supply (L.E. Million)				
Sector		Agricultural Sector	Industrial Sector	Foreign Sector (Imports)	Total Demand	Surplus or Deficit
Agricultural Sector	Inputs	86.4	51.3	27.6	165.3	
	Final Goods	142.0	165.8	4.8	312.6	
	Total	228.4	217.1	32.4	477.9	+35.3
Industrial Sector	Inputs	267.2	621.5	172.7	1061.4	
	Final Goods		248.8	114.9	363.7	
	Total	267.2	870.3	287.6	1425.1	-111.8
Foreign Sector Exports		17.6	225.9		243.5	+76.5
Total Supply		513.2	1313.3	320	2146.5	0

Sources: Tables III - 3,6 and 14.

million (table III - 15) against L.E. 6.4 million in 1964-65 (the actual situtation), as shown in table III-12. If such increase in agricultural surplus is exported, a further improvement in the structure of foreign trade will be feasible, and trade deficit would be reduced to L.E. 76.5 million or further investment goods may be imported to finance the strategic projects in the succeeding periods.

So long as the whole increase in agricultural surplus (L.E. 28.9 million)* is exported, internal terms of trade between the agricultural and industrial sectors is likely to remain unchanged, if imigration out of agriculture is controlled. However, agricultural labour is not expected to react in the short-run, simply because techniques applied to agriculture are rather labour intensive, and industrial expansion is not enough to absorb a large number of workers (lack of mobility in the urban areas in the short-run). Indeed some restriction on labour movement from agriculture should be directly or indirectly imposed at this stage.

On the other hand, the trend of international terms of trade will depend on the proportion of the exported goods to the world supply. Apart from long staple cotton, barter terms of trade are not expected to change because Egyptian agricultural exports represent a negligable proportion of the world supply. In the case of long staple cotton, barter terms of trade might be deteriorated for Egypt, if exports are increased, since it contributes some 40-50 per cent of the world supply. This could be compensated as far as productivity is increasing at a higher rate than export price is falling inducing an improvement in the income terms of trade.

Once the relevant surplus is created in this early stage of economic development, the circle will keep running for more rapid growth in the succeeding stages as shown above (III-1). It would be useful to test

* Tables III -13 & 15

such hypothesis empirically, but unfortunately the lack of reliable data restrained our attempt.

Indeed, the relevance and feasibility of such approach depends largely on the potential productivity of agriculture. Our attention is therefore directed towards investigating and measuring the possibility of increasing agricultural productivity, and to test resource allocaction efficiency within the agricultural sector itself. This is the major aim of the present study which is the subject of part two.

PART 2

RESOURCE ALLOCATION EFFICIENCY WITHIN THE AGRICULTURAL SECTOR

PART 2

Resource Allocation Efficiency Within the Agricultural Sector

In part one, it is generally argued for the necessity of agricultural development in the early stages of economic growth, discussing and analysing the reasons behind it, and showing empirical evidence from the past. Indeed, it is equally necessary to ensure that agricultural development is a continuous process and agricultural productivity keeps improving at a satisfactory rate. This is particularly true if agriculture is still dominant.

Although the place of agriculture in the Egyptian economy is declining over the years, it is still the most important activity.* Some 47 per cent of the total labour force are engaged in agricultural activity, against 16.6 per cent and 36.5 per cent in manufacturing and services respectively, while agricultural income contributes more than 30 per cent of the national income. Agricultural exports account for 63 per cent of the total exports, of which raw cotton alone represents 46 per cent (i.e. 73.2 per cent of the agricultural exports) allowing agriculture to be responsible for a large share of the supply of foreign currency.** Besides, agriculture supplies the main two industries; spinning and weaving and food industries (i.e. produce more than 60 per cent of the total industrial output) with a major part of raw materials.

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* Egyptian Government, CAPMS,"Statistical Yearbook" Cairo, 1977. Also Ministry of Planning, "The Evaluation of Economic Growth in Egypt." Cairo 1976.

** Agricultural trade surplus is estimated at L.E.105 million against non-agricultural trade deficit of L.E. 189 million. Egyptian National Bank."Economic Report", Cairo 1975.

While the economic structure in Egypt still depends largely on agriculture, agricultural productivity (i.e. crop yield) of the major crops was hardly improving over the last few years. These two elements would urge the necessity of improving agricultural productivity. Data on crop yield of cotton and rice (appendix A) suggest that it was rather stagnant since 1970. Perhaps the significant increase in wheat yield is attributed to the invitation of Mexican high variety seeds. However, it is often argued that productivity gap in Egyptian agriculture might be small since yields of the major crops are relatively high compared with other countries. Indeed, a relatively high yield with low rate of growth is not self-evident of low agricultural productivity gap. The size of productivity gap should be measured with respect to the technical and economic conditions under which agriculture operates. High crop yield might be attributed to favourable land fertility, and weather conditions or / and availability of water, while stagnation could be resulted from resource misallocation, inefficient pattern of ownership and size of holdings, traditional production process, and / or low quality of the used inputs.

The following chapters are devoted to investigate the possibility of increasing agricultural productivity. Potential agricultural productivity is tested in terms of resource allocation efficiency with respect to the various classes of farms, in an attempt to identify productivity gap, and then to suggest the relevant pattern of resource allocation. Production aspects in theory and practice are analysed (chapter IV), and the previous empirical investigations are reviewed (chapter V). The final three chapters are devoted to estimate both time series and cross sectional production functions to be tested for resource allocation efficiency.

CHAPTER IV

PRODUCTION ASPECTS IN THEORY AND PRACTICE

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PRODUCTION ASPECTS IN THEORY AND PRACTICE

The purpose of constructing an econometric model in production is to specify the real world situation in an economic sense. In order to do so, production theory and economic principles are expressed in mathematical forms based on the methdology of statistics. Such mathematical transformation of the theory is often confronted with statistical problems and perhaps practical constraints. Unless mathematics and statistics are carefully ulitised in expressing economic principles without disturbing both the theory and reality, the econometric models will not reveal the correct features of the phenomena under investigation.

The present chapter aims to discuss the conflict that might exist between the application of production theory and the prevailing statistical and econometric methods. The first section is devoted to a brief review of the theory of production in technical and economic terms to be specified in mathematical equations. In the second section, the application of production theory is investigated. The specific and simplified production function (i.e. linear homogeniety), with special reference to Cobb-Douglas, and Constant Elasticity of Substitution functions is analysed and weighted against some alternative forms. The practical statistical restraints to the application of production function are dealt with in a third section.

IV - 1: The Theory of Production

Economic efficiency refers to the level of output at which resources are efficiently allocated and used. "Resource use efficiency" might be achieved when a given output is obtained through minimum use of resources, or maximum output is produced from a given set of resources.

In order to measure resource use efficiency and to determine the optimum level of output, two sets of information; the technical theory of production (i.e. the physical production function or technical efficiency), and the economic theory of production (i.e. price ratio or price efficiency) are needed. Technical efficiency and price efficiency are necessary and sufficient (if they occur jointly) conditions for economic efficiency.

The Technical theory of production (Technical Efficiency)

The technological relationship between a set of inputs and output is usually expressed in a physical production function of engineering type. A production function, which may be specified in a mathematical or tabular form, shows the maximum output attainable from any specified set of inputs.[(1)] Such a production function is based under certain assumptions. The set of inputs and outputs must be non-negative. It is smoothly continuous and at least twice differentiable with the marginal products usually positive and continuously diminishing. None of the input variables is in a fixed supply. Finally, the production function takes place under a common technology. It is given and fixed. Also the inputs remian unchanged in characters and are assumed to be homogeneous within themselves.

Given the production function as:

$$Y = f(x_1, x_2, \ldots\ldots\ldots x_n)$$

Where Y and x are the output and inputs respectively. A set of physical quantities of a particular importance in decision - making can be derived.

1. Marginal and Average Product

The marginal product indicates the amount added to total output by each successive unit of the input variable. It is the partial derivative of the production function with respect to the input under consideration (i.e. the slope over the production surface or along the input-output curve). Thus.

$$MP_i = \frac{\partial Y}{\partial x_i} = f_i(x_1, x_2, \ldots\ldots\ldots x_n)$$

Indeed the total increment of output is equal to the sum of input increments each multiplied by its marginal product ,(2) so that

$$dY = \frac{\partial Y}{\partial x_1} dx_1 + \frac{\partial Y}{\partial x_2} dx_2 + \ldots\ldots\ldots + \frac{\partial Y}{\partial x_n} dx_n$$

The behaviour of the marginal product function is examined through the application of the second partial derivative (i.e. the marginal returns).

$$\frac{\partial^2 Y}{\partial x_i^2} = f_{ii}(x_1, x_2, \ldots\ldots\ldots x_n)$$

Marginal returns are increasing or decreasing if $f_{ii} > 0$ or $f_{ii} < 0$ respectively.

The average product is the quantity of output per unit of the input used (output-input ratio).

$$AP_i = \frac{Y}{x_i} = \frac{f(x_1, x_2 \ldots\ldots\ldots, x_n)}{x_i}$$

Its behaviour is examined through the application of the first partial derivative of the average production function (i.e.average returns).

$$\frac{\partial AP_i}{\partial x_i} = \frac{\partial (y/x_i)}{\partial x_i} = \frac{1}{x_i} \left(f_i - \frac{Y}{X_i} \right) = \frac{1}{x_i} (MP_i - AP_i)$$

Thus, there are increasing or diminishing average returns to the ith input at a given input point according as the marginal product is greater than or less than the average product. Hence, the average product function is maximised when the marginal and average products are equal.

2. Production Elasticities

Given the marginal product and average product of the input under consideration, its production elasticity (i.e. input coefficient) can be determined. It indicates the changes in output relative to the change in input. In other words, the elasticity of production at an input point is the ratio of the marginal product to the average product.

$$EP_i = \frac{MP_i}{AP_i} = \frac{\partial Y}{\partial x_i} \div \frac{Y}{x_i} = \frac{\partial Y}{\partial x_i} \cdot \frac{x_i}{Y}$$

There will be increasing, constant, or diminishing returns if $EPi > 1$, $EPi = 0$, or $EPi < 1$ respectively.

This is on the assumption that only one input is varied, while all other inputs being held constant at some specified level. If all inputs are varied at an equipropartional level, the function coefficient (i.e. return to scale) can be determined. Thus, the function coefficient is the proportional change in output relative to the proportional change in the whole inputs for movements along a ray from the origin in input space, hence it is the elasticity of production with respect to scale. (3)

$$EP = EP1 + EP2 + \ldots\ldots\ldots\ldots + EP_n$$

Since

$$EP_i = \frac{\partial Y}{\partial x_i} \cdot \frac{x_i}{Y}$$

Then

$$EP = \frac{\partial Y}{\partial x_1} \cdot \frac{x_1}{Y} + \frac{\partial Y}{\partial x_2} \cdot \frac{x_2}{Y} \ldots\ldots\ldots\ldots \frac{\partial Y}{\partial x_n} \cdot \frac{x_n}{Y}$$

Or

$$EP = \frac{\Sigma fixi}{Y}$$

The production is subject to increasing, constant or decreasing returns to scale according as EP > 1, EP = 1 or EP<0.

3. The marginal rate of technical substitution (MRTS)

It is the rate at which one variable input can be substituted for another in order to maintain a constant level of output. MRTS is, then obtained by differentiating one variable input with respect to another,

$$\frac{\partial x_i}{\partial x_j} = \frac{f_i' (x_1, x_2, \ldots\ldots, x_n)}{f_j' (x_1, x_2, \ldots\ldots, x_n)}$$

It is, the ratio of the marginal product of xi to the marginal product of xj, thus

$$MRTS = \frac{\partial Y}{\partial x_i} \div \frac{\partial Y}{\partial x_j}$$

The marginal rate of technical substitution is represented by the slope of Isoquant which is a locus of input combination each of which is capable of produc ing the same level of output. (4) That is, one input may be substituted for another while maintaining a constant level of output. The isoquant allows continuous substitution between inputs. Every possible level of output represented by an isoquant. The isoquants do not intersect, this property follows immediately from the assumption that the production is single valued.

An input level on the isoquant at a specified level of output can be obtained, given the level of the other inputs.

$$x_1 = f' (Y, x_2, x_3, \ldots\ldots\ldots\ldots x_n)$$

As an input xi is substituted for another xj, so as to maintain a constant level of output, MRTS declines. This is true since the isocline is curved. Thus, the slope of an isocline is negative.

Given

$$dy = \frac{\partial Y}{\partial x_i} dx_i + \frac{\partial Y}{\partial x_j} dx_j = 0$$

Thus

$$- dxi \frac{\partial Y}{\partial x_i} = dx_j \frac{\partial Y}{\partial x_j}$$

$$\frac{dxi}{dxj} = - \frac{\frac{\partial Y}{\partial xj}}{\frac{\partial Y}{\partial x_i}} = \text{MRTS}$$

Within each isoquant, there is diminishing marginal rate of technical substitution, and hence the concavity of the iso quant depends upon the second derivative

$$\frac{d^2 x_j}{dx_i^2} = \frac{d \left(- \frac{f_i}{f_j} \right)}{dx_i}$$

If it is positive; the isoquant is concave from above, if negative, it is concave from below.

Given an isoquant map, there are unique points (i.e. one point in each isoquant) of equal slope on successively higher isoquants. The line (curve) which connects such points is the <u>Isocline</u> which denotes constant marginal rate of technical substitution for the various levels of output. Isocline shows the path which the mix of inputs should follow, if output is to be expanded. (5) Thus

$$\frac{dxi}{dxj} = - C \qquad \text{where} \qquad C \text{ is constant}$$

Substitution between two inputs is restricted within certain range at which both marginal products are non-negative (i.e. in which all isoquants are negatively slopped). This <u>substitution region</u> is determined by finding the two isoclines corresponding to infinite and zero marginal rate of technical substitution. The two isoclines serve as <u>ridge lines</u>. (6) They indicate that additional input quantity will not place any of the other in producing the specified level of output. Thus

$$\frac{dx_i}{dx_j} = 0$$

Both marginal productivity and MRTS are zero at this point. Over the substitution region all isoquants are concave from above. Within it $fi > 0$ and $fii < 0$.

4. Elasticity of Substitution

If the rate at which two inputs are substituted, is changed, the input ratio (i.e. factor proportion) between these two inputs might be changed. Such relation can be expressed in substitution curve. The elasticity of this curve is known as the elasticity of substitution, σ ,which is defined as the proportionate change in input ratio (i.e. factor proportion) attributed to the change in the ratio of their marginal physical products (MRTS).

Given

MRTS $= -\frac{d\,x_i}{d\,x_j}$ and input ratio $= \frac{x_i}{x_j}$

Then, the elasticity of substitution of xj for xi is

$$\sigma = \frac{d\left(\frac{x_j}{x_i}\right)}{\left(\frac{x_j}{x_i}\right)} \div \frac{d\left(-\frac{dx_j}{dx_i}\right)}{-\frac{dx_j}{dx_i}} = \frac{d(\text{MRTS})}{\text{MRTS}} \cdot \frac{\frac{x_i}{x_j}}{d\left(\frac{x_i}{x_j}\right)}$$

Elasticity of substitution is defined only for measurement along an isoquant. Thus, it refers to input substitution associated with a constant level of output. It is, however, non-negative measure, and the elasticity of substitution of xi for xj is precisely the same as the elasticity of substitution of xj for xi.

Given, these physical quantities, the so-called technical efficiency is defined as the minimal combinations of inputs that can produce the unit of output, or the maximum output that can be produced with any combination of inputs. [7] It is therefore determined by the slope of the isoquant (MRTS).

The Economic Theory of Production (Price Efficiency)

The physical production function provides one of two sets of information required for measuring economic efficiency. The second set of information is the economic magnitudes (i.e. price efficiency), such as price data or any other quantities which serve as economic criteria. Price efficiency indicates the minimum cost for producing a given output at a given prices.[8] Such a minimum cost is presented in the price or isocost line (curve) which is the locus of all input combinations that may be purchased or hired for a given expenditure of funds. [9] Thus, any point on the isocost is, in fact, price efficiency. It is the slope of the isocost which is represented by the input-price ratio,

Hence

$$\text{Price efficiency} = -\frac{\frac{Px_1}{P_y}}{\frac{Px_2}{P_y}} = -\frac{Px_1}{Px_2}$$

where

P_y, px_1 and px_2 are the prices of the output and two inputs respectively.

The slope of the isocost at every point is the negative of input price ratio. If the price of one input is changed or the prices of the two inputs, but at variable proportion are changed, price efficiency and the slope of the isocost will be changed. The slope of the isocost remains constant when the prices of both inputs are changed at fixed proportion.

Input prices could be fixed or variable. In the case of perfect competition or controlled economy, input prices are fixed and given. Isocost is, therefore, a straight line showing constant slope at every point. If input prices vary with input usage, isocost will be curved and it is concave from below, given the supply prices of inputs are rising.

On the assumption that prices are given and fixed, economic efficiency can be defined by combining the criteria of technical efficiency and that of price efficiency.

Given,

$$Y = f(x_1, x_2)$$

The whole cost is therefore,

$$C = p_1 x_1 + p_2 x_2$$

where p_1 and p_2 are the market prices of the two inputs.

Technical efficiency is represented by the slope of isoquant (i.e. MRTS). Hence,

$$\text{MRTS} = - \frac{\frac{\partial y}{\partial x_1}}{\frac{\partial y}{\partial x_2}}$$

Price efficiency is represented by the slope of isocost (i.e. input price ratio). Hence,

$$\text{Input price ratio} = \frac{\frac{P_1}{P_y}}{\frac{P_2}{P_y}}$$

Combining technical efficiency and price efficiency, economic efficiency is defined as a unique point at which the slopes of the isoquant and isocost are equal. In other words economic efficiency is determined at the unique tangent whose slope equals both the MRTS and input-price ratio.(10) Thus,

$$\frac{dx_1}{dx_2} = - \frac{p_2}{p_1}$$

Economic efficiency can also be determined by employing the cost function(11)

$$x_2 = \frac{1}{p_2} C - \frac{p_1}{p_2} x_1$$

By differentiating x2 with respect to x1 economic efficiency is defined as

$$\frac{dx_2}{dx_1} = - \frac{P_1}{P_2}$$

At this point (economic efficiency), cost is minimised (or profit is maximised), where the marginal value product (MVP) of each input factor and its marginal cost are equal, given competitive market. This is the point at which output is optimised. A significant difference between marginal value product and marginal factor cost is taken as evidence of inefficient resource allocation.

Economic efficiency points at the various levels of output are determined along the expansion path, which is the path along which the marginal rate of technical substitution equals the corresponding input price ratio. It is, therefore, a path of economic efficiency in the sense that cost is minimised or profit is maximised at each level of output. Expansion path does not coincide with isocline unless the production function is characterised by fixed proportion. (12)

If a production function contains more than two variables economic efficiency may be determined by means of Langreagean techniques for constrained extrema.

On the assumption that prices are given and fixed, economic efficiency is achieved if output is maximised at a given level of cost (i.e. maximisation approach) or if cost is minimised for a given level of output (i.e. cost minimisation approach). These two approaches, though different, are dealing with the same problem. Hence, the result should be the same.

1. Maximisation Approach

The objective is to maximise output, but subject to a given cost, so that the objective function is;

$$Y = f(x_1, x_2 \ldots\ldots\ldots\ldots x_n)$$

the restrained function is

$$C = \sum_{i=1}^{n} p_i \ x_i$$

Thus Langregean function is

$$L = f(x_1 \ x_2 \ldots\ldots\ldots x_n) - \lambda \left(\sum_{i=1}^{n} P_i x_i - C \right)$$

By taking the partial derivatives of the Langregean function with respect to each input category and to λ and set them equal zero, we have

$$\frac{\partial L}{\partial x_1} = \frac{\partial Y}{\partial x_1} - \lambda P_1 = 0$$

$$\frac{\partial L}{\partial x_2} = \frac{\partial Y}{\partial x_2} - \lambda P_2 = 0$$

$$\frac{\partial L}{\partial x_n} = \frac{\partial Y}{\partial x_n} - \lambda p_n = 0$$

$$\frac{\partial L}{\partial \lambda} = \sum_{i=1}^{n} p_i x_i - C = 0$$

These equations can be solved for the x_i and λ to determine the magnitude of inputs which maximise the output, under the restraint set out above. By substituting the values of x_{1s} into the production function the optimum level of output is determined.

2. Minimisation Approach

Given a stipulated level of output, the objective is to minimise the production cost of this level of output, thus,

The objective function is

$$C = \sum_{i=1}^{n} P_i \ X_i$$

subject to

$$Y = f(x_1, x_2, \ldots\ldots\ldots\ldots\ldots\ldots x_n)$$

And the Langregean function is

$$L = \sum_{i=1}^{n} p_i \; x_i - \lambda \left[f(x_1 \; x_2 \ldots\ldots\ldots x_n) - Y \right]$$

Applying the same approach employed in the maximisation case, the minimum cost for a given level of output is obtained.

Economic efficiency is, here measured under rather restrictive conditions. The above optimisation approach assumes that the same output will be produced by various firms, since they are using equal quantities of all inputs and the optimum level of output is homogeneous for all these firms. This follows from the assumptions under which such approach is based. Each individual firm is concerned with profit maximisation; all firms face the same set of prices (i.e. perfect competition); and different firms have the same degree of utilisation (i.e. none of the inputs is in fixed supply). Indeed, these assumptions are not always realistic. Some firms might be concerned with maximising utility rather than maximising profits. Prices are not necessarily the same for all firms as it is the situation in the case of imperfect markets. Different firms could have different degree of control over their resources.

An alternative test of economic efficiency which allows for variations in objectives, prices and resources control is, therefore, suggested.(13) A unit-output price profit function might be employed to measure economic efficiency and its two components; technical efficiency and price efficiency.

Given,

$$Y = F(x_1, x_2, \ldots\ldots\ldots x_n \; ; z_1, \; z_2, \ldots\ldots\ldots z_m)$$

Where,

Y, x_i, and z_i are the output, variable inputs and fixed inputs respectively.

The profit function is therefore,*

$$\pi = Py \left[F (x_1, \ldots\ldots\ldots x_n ; z_1 \ldots\ldots\ldots z_m) \right] - \sum_{j=1}^{m} px_j \; x_j$$

By dividing the profit function by py , both the profit and the prices of the variable inputs are normalised, then;

$$\frac{\pi}{Py} = \left[F (x_1 \ldots\ldots\ldots x_n ; \quad z_1 \ldots\ldots z_n) \right] - \sum_{j=1}^{m} \frac{px_j}{py} \cdot x_j$$

Or $$U = F (x_1 \ldots\ldots\ldots x_n ; z_1 \ldots\ldots z_n) - \sum_{j=1}^{m} R_j \; x_j$$

Where U is the unit-output price profit (i.e.normalised restricted profit) and Rj is input-output price ratio (i.e. normalised price of input j).

Given, the case of profit maximisation as

$$\frac{\partial F (X, Z)}{\partial x_j} = R$$

By utilising the profit-maximisation conditions and solve its equation for both the optimal quantities of variable inputs and the optimal unit-output price profit as a function of the normalised prices of variable inputs and of the quantities of fixed inputs, we have, respectively,

$$x_j^* = f (R , Z)$$

and

$$U^* = f^* (R_1, \ldots\ldots\ldots, R_m ; \; z_1, \ldots\ldots\ldots, z_n)$$

where * refers to optimal levels.

By a dual transformation relations that connect the profit function and the production function, the actual demand of the variable input and the output supply function can be derived respectively (14)

$$x_j = - \frac{\partial u^* \; (R , z)}{\partial R_j}$$

---

* The fixed costs are omitted becuase they do not affect the optimal combination of the variable inputs.

and

$$y^{*} = u^{*} - \sum_{j=1}^{m} \frac{\partial u^{*}(R,Z)}{\partial R_j} R_j$$

Thus, the actual unit-output price profit is given by

$$u = y - \sum_{j=1}^{m} R_j X_j$$

This implies that the actual unit-output price profit is an increasing function of the level of technical efficiency for a given normalised input prices, and it is decreasing in the normalised prices of variable inputs and increasing in the quantities of fixed inputs.

These three functions consider both fixed inputs and normalised prices of the variable inputs. This could overcome the problem of simultaneous equations bias that might exist in single equation estimation of the production function. (15)

IV - 2: The Production Function in Practice

The characteristics of the physical quantities derived from the production function are varied with the various forms of production function. Two broad classes of production function; fixed and varied proportion, can be applied to the studies of technical efficiency. (16)

A production function is characterised by fixed proportion if each level of output technologically requires a unique combination of inputs, so that all pairs of input ratios are constant for each level of output. If input ratios are fixed for all levels of output (i.e. input-output ratio is independant of the scale of production) a homogeneous production function of degree one will prevail, and input coefficient is, therefore, fixed along the isocline. If input ratios remain constant, but change as output changes, the production function will be homogeneous, but not of degree one, so that returns to scale is not necessarily constant. In this case the input coefficient will vary along the isocline, but at fixed proportion. Iscoline is therefore a line, but not passing through the origin. However, such proportional variation allows the marginal product to be positive and equal to the average product. The marginal and average curves, which are usually concave from above are positively or negatively sloped according as returns to scale are increasing or decreasing respectively.

The variable-proportions production function is that which allows variation in input ratios as well as input-output ratios. Output always responds to a change in any one input, all other inputs held constant. The input coefficient is, therefore, changeable at variable proportion as output expands. The isocline is curved, so that the direction and magnitude of function coefficient depend not only on the ray along which it is measured, but also on the point at which it is measured (i.e. the slope of the isocline at the measured point).

Linear Homogeneous Production Function (L.H.P.F.)

Special attention is, here, given to the homogeneous production function of degree are, simply because it is the most widely function applied in agricultural empirical studies. Furthermore, it is perhaps a simplified case of an accurate empirical approximation of production conditions in agriculture.

A production function is characterised by a linear homogeniety when the sum of output elasticities is equal one. Thus, homogeniety of degree one prevails if a simultaneous proportional increase of all inputs results in an expansion of output by the same proportion (i.e. constant returns to scale). (17)

The marginal product function is homogeneous of degree zero. Thus the marginal product depends only upon the input ratio

If $y = f(X_1, X_2)$

$$\frac{\partial y}{\partial x_1} = f'\left(\frac{x_1}{x_2}\right)$$

And the magnitudes of the marginal product is independant of the scale of input usage.

The average product is also homogeneous of degree zero, and its magnitude depends on the input ratio irrespective of the scale of input usage.

Given

$$AP_1 = \frac{Y}{x_1}$$

Since

$$Y = \frac{\partial Y}{\partial x_1} x_1 + \frac{\partial Y}{\partial x_2} x_2 \qquad \text{(Eulers' theorem)}$$

Or

$$y = f' \left\{ \frac{x_1}{x_2} \right\} x_1 + f' \left\{ \frac{x_1}{x_2} \right\} x_2$$

Then

$$AP_1 = \frac{f' \left\{ \frac{x_1}{x_2} \right\} x_1 + f' \left\{ \frac{x_1}{x_2} \right\} x_2}{x_1}$$

However, the linear and homogeneous production function is usually characterised by diminishing marginal returns (i.e. the second derivative is negative). This property follows from the assumption of constant returns to scale. Accordingly the marginal production function itself must be a non-negative function.

Since both marginal and average product functions are homogeneous of degree zero, their ratio is also homogeneous of degree zero. Hence, the value of the output elasticity depends only upon the input ratio. And as long as the input ratio is fixed at each level of output (by definition) the elasticity of production is constant along the isocline and independant of the scale of production. The isocline is therefore a straight line passing through the origin, showing constant input ratio.

The marginal rate of technical substitution in a homogeneous function of degree one is always constant along the isocline, simply because its function is homogeneous of degree zero. This follows from the assumption of zero homogeniety of the all marginal product functions. It is also a function of the input ratio regardless of the scale of production. Since MRTS is constant along the isocline, one isoquant is sufficient to describe the entire isoquant map.

Perhaps Cobb-Douglas and Constant Elasticity of Substitution functions are the most frequently functions applied to production studies. In this context, both functions are discussed to be weighted against their limitations. Alternative functions are discussed.

The Cobb-Douglas Production Function (C.D.)

The best known and the most widely used in agricultural production studies is the Cobb-Douglas production function. (C.D.), which is linear in logarthims. It is generalised in the form,[18]

$$y = AX_1^{\beta_1} X_2^{\beta_2} \ldots\ldots\ldots\ldots\ldots x_n^{\beta_n}$$

where y is the output and x_is are the inputs.

This function contains two parameters; A the efficiency parameter (a constant term) and b_i the transformation parameter for the level of input x_i (i.e. input intensity parameter).

By differentiating C.D. function with respect to one input x_1 the marginal product function can be obtained,

$$\frac{\partial Y}{\partial x_1} = A\beta_1 X_1^{\beta_1 - 1} x_2^{\beta_2} \ldots\ldots\ldots\ldots x_n^{\beta_n} = \beta_1 \frac{Y}{x_1}$$

The marginal product is therefore, a function of the average product (output-input ratio). If β_1 is positive, the marginal product will always be positive for a positive level of input. Since it depends only on the output-input ratio $\left(\frac{y}{x1}\right)$ which declines as the input x_1 increases and increases as the input x_1 decreases , the marginal product of the input x_1 declines or increases as the level of the input increases or decreases respectively. This property is consistent with the theory of production and, indeed desirable for any production function. However, the behaviour of the marginal product can be seen from the second derivative of the output with respect to an input.

$$\frac{\partial^2 Y}{\partial x_1^2} = \beta_1 \quad (\beta_1 - 1) \quad \frac{Y}{x_1^2}$$

Hence C.D. allows either constant, increasing or decreasing marginal product, but not all of them within the same function. Neither can it allow for both positive and negative marginal product. This might rise some limitation on the application of C.D. function.

By differentiating the marginal product with respect to the average product $\frac{(y)}{(x_i)}$, the elasticity of production can be estimated.

$$\frac{\partial MP}{\partial AP} = \beta_i$$

or

$$\frac{\frac{\partial Y}{Y}}{\frac{\partial x_1}{x_1}} = (\beta_i \quad \frac{Y}{x_1}) \cdot \frac{x_1}{Y} = \beta_1$$

The elasticity of production is directly estimable in terms of the exponent of the respective input . However C.D. function assumes constant elasticity of production over the various levels of inputs. Hence the scale of returns represent the average condition for the sample.

The relation between two inputs in C.D. function rises interesting implications concerning isoquants, MRTS, elasticity of substitution and isoclines.

Such a function implies substitubility between the various input factors, so that any point on a particular isoquant represents a particular combination of the inputs x_1 and x_2 that would produce the same level of the output. Fixing y at some arbitrary level $\hat{y}$, we have,

$$\hat{y} = AX_1^{\beta_1} \; x_2^{\beta_2} \; \ldots\ldots\ldots, x_n^{\beta_n}$$

Solving for x_1 in terms of x_2 we have,

$$x_1 = \left[\frac{\hat{y}}{x_2^{\beta_2} \left(AX_3^{\beta_3} \ldots\ldots, x_n^{\beta_n} \right)} \right]^{\frac{1}{\beta_1}}$$

The isoquant will, then be convex to the origin, since diminishing marginal returns prevails. Diminishing marginal returns require βi for both inputs to be positive and hence satisfy the condition for a convex isoquant.

In order to keep the output on the same isoquant, the rate at which one input can be substituted for the other can be expressed;

Given

$$dy = \frac{\partial Y}{\partial x_1} dx_1 + \frac{\partial Y}{\partial x_2} dx_2 = 0$$

Thus

$$\frac{\partial x_1}{\partial x_2} = -\frac{\beta_2 x_1}{\beta_1 x_2} = -\frac{\beta_2}{\beta_1}\left(\frac{x_1}{x_2}\right)$$

The marginal rate of technical substitution between two variables is a linear function of the ratio in which the two variables are combined. Isoclines are, therefore, straight lines passing through the origin indicating a fixed proportion or mix of the independent variables (i.e. fixed marginal rate of technical substitution) at the various levels of output. The isocline equation is

$$x_1 = \left(\frac{y}{(Ax_2^{\beta_2})}\right)^{\frac{1}{\beta_1}}$$

By differentiating MRTS equation with respect to input ratio, we write,

$$\left(\frac{d\ (MRTS)}{d\ \frac{(x_1)}{(x_2)}}\right) = \frac{\beta_2}{\beta_1}$$

Since the elasticity of substitution (σ) is

$$\left(\frac{MRTS}{\frac{(x_1)}{(x_2)}}\right) \div \left(\frac{d\ (MRTS)}{d\ \frac{(x_1)}{(x_2)}}\right)$$

σ in C.D. function is $\frac{\beta 1}{\beta 2} \cdot \frac{\beta 2}{\beta 1} \cdot \frac{(x_2)}{(x_1)} \cdot \frac{(x_1)}{(x_2)} \equiv 1$

This indicates that a certain percentage change in the marginal products ratios of the two factors (i.e. MRTS) will induce an equiportional change in their utilisation ratio in the opposite direction. However the assumption of unity elasticity of substitution is a fairly restrictive property of C.D. function.

The C.D. production function is, however, widely applied at various levels of aggregation. Apart from its simple computition, it yields statistically significant estimates of the coefficients without imposing excessive demands upon data accuracy. On the other hand some of its properties are perhaps consistent with the theory of production. The properties of positive but declining marginal products and the inverse relation between the marginal rate of technical substitution and factor proportion are perhaps realistic and desirable in economic sense.

Such a function implies substitubility between the various input factors and therefore excludes the possibility of estimating a production function in which factors are complementary. Since complementary exists in the short-run, C.D. function should be used only to define the long run relation between variables. (19)

Each resource in C.D. function serves as a limitional input. No output is forthcoming if any of the independent variables is zero. This is not always valid assumption. On the other hand no maximum output is defined by the function. If capital is disaggregated into relatively large number of variables, the assumption of unity elasticity of substitution and linear isocline of each and every pair of factors might not be realistic. However C.D. function is statistically criticised in the sense that it implies multicollinearity between the inputs, as shown in the next section.

The Constant Elasticity of Substitution Production Function

The Constant Elasticity of Substitution function (CES) was popularised by Arrow, Chenery, Mintus and Solow (ACMS) in their joint article in 1961.[20]

The form originally suggested by ACHS contains two inputs only; labour and capital,

$$y = A \left[\alpha L^{-p} + (1 - \alpha) k^{-p} \right]^{-\frac{1}{p}}$$

Such a function is like C.D. mathematically simple and statistically tractable, but unlike C.D. is it possible to be linearised by taking logarithms. It assumes constant returns to scale, though such a restriction can be relaxed as shown below.

CES function contains three parameters:

A is the efficiency parameter which is constant term corresponds to that of C.D.

α is the distribution parameter. It determines the distribution of output between capital and labour for a given elasticity of substitution and given factor proportion. It is therefore positive, constant and less than one ($o \leq \alpha < 1$

P is the substitution parameter ($-1 < \rho < \infty$). It specifies the elasticity of substitution as shown below.

Marginal product in CES is similar to that in C.D.. By differentiating the original function with respect to one input, we have

$$\frac{\partial Y}{\partial L} = -\frac{1}{P} A \left[\alpha L^{-p} + (1 - \alpha) K^{-p} \right]^{-\frac{1}{P}-1} - P\alpha L^{-p-1}$$

$$= \alpha A^{-p} \left\{ \frac{Y}{L} \right\} (1 + p)$$

Since the parameters α and A are positive, the marginal product will be positive for a positive value of inputs. Furthermore, it is decreasing throughout its entire range. Given the second derivative, the behaviour of marginal products can be observed;

$$\frac{\partial^2 y}{\partial L^2} = (1 + p) \; \alpha \cdot A^{-p} \left\{\frac{Y}{L}\right\}^{p} \cdot \left(\frac{\alpha \frac{\partial y}{\partial L} - y}{L^2}\right)$$

Since α is constant, the slope of the isoquant is constant (i.e. straight line), and the marginal rate of technical substitution is also constant.

$$MRTS = -\frac{dk}{dL} = -\frac{\alpha}{1-\alpha}\left\{\frac{K}{L}\right\}^{p+1}$$

CES in this respect is similar to C.D.

The major difference between CES and C.D. functions is perhaps attributed to the magnitude of substitution. While C.D. function constraints the value of the elasticity of substitution to be unity, CES function allows it, though restricts it to constancy, to have much wider choices of alternative values depending on the value of p, the substitution parameter. This follows immediately from the suggestion that capital - labour proportions do not vary simply as a result of variations in marginal products.

Given,

elasticity of substitution, $\sigma = \left(\frac{d\left\{\frac{k}{L}\right\}}{\frac{k}{L}}\right) \cdot \left(\frac{\frac{dk}{dL}}{d\left\{\frac{dk}{dL}\right\}}\right)$

In CES function

$$MRTS = -\frac{dk}{dL} = -\frac{\alpha}{1-\alpha}\left\{\frac{k}{L}\right\}^{1+p}$$

Dividing by $\frac{k}{L}$ thus

$$\frac{\frac{dk}{dL}}{\frac{k}{L}} = -\frac{\alpha}{1-\alpha}\left\{\frac{k}{L}\right\}^{p}$$

Differentiating MRTS with respect to $\left(\frac{k}{L}\right)$ gives

$$\frac{d\left\{\frac{dk}{dL}\right\}}{d\left\{\frac{k}{L}\right\}} = -(1+p)\;\frac{\alpha}{1-\alpha}\left\{\frac{k}{L}\right\}^{p}$$

Then

$$\sigma = \frac{-\frac{\alpha}{1-\alpha}\left\{\frac{k}{L}\right\}^{p}}{-(1+p)\frac{\alpha}{1-\alpha}\left\{\frac{k}{L}\right\}^{p}}$$

$$= \frac{1}{1+p}$$

It is obvious that elasticity of substitution specifies uniquely the parameter p, and confirms that σ is indeed a constant and equal to $\frac{1}{1+p}$

Hence, it appears that factor shares in CES function is unlike C.D. function varied depending on the value of p.

$$\frac{YL}{YK} = \frac{\alpha}{1-\alpha}\left\{\frac{k}{L}\right\}^{p}$$

If $p = 0$, the factor share $\frac{YL}{YK} = \frac{\alpha}{1-\alpha}$ to be reduced to that in C.D. function with constant returns to scale, and $\sigma = 1$, so that CES will be typically C.D. function.

CES function is, therefore, capable of describing a whole range of isoquants from $p = -1$ to $p = \infty$ including, of course, that isoquant preculiar to C.D. function (i.e. p = 0). It allows factors to be either substitutes or complements and thus unlike C.D. needs not to be restricted to long-run applications.* If $\sigma > 0$ input factors will be substitutes, while they are complementary when $\sigma < 0$. This shows a distinguished feature of CES function.

The original form of CES assumes constant returns to scale (Homogeniety of degree one). This constraint can, however, be removed by adding a special parameter (i.e. returns to scale parameter) as suggested by Tsurumi.[(21)]

* In this case estimation should be based on non-linear regression techniques.

$$Y = A \left[\alpha K^{-P} + (1-\alpha) L^{-P} \right]^{-\frac{V}{p}}$$

In this case the production function is assumed to be homogeneous, but not necessarily of degree one. The returns to scale V is, here, variable though the elasticity of substitution σ remains unchanged at $\frac{1}{1+p}$, e.g. $\frac{dy}{y} = V.\frac{dk}{k}$ will be reduced to the original form.

Still, such a form suggested by Tsurumi is constrained in the sense that it assumes that the returns to scale are independent of the level of output. This might produce inconsistent estimates of the elasticity of substitution.

Soskice, in an attempt to prove such inconsistency suggests a modified CES function in which point returns to scale are functionally related to the level of output. (22)

Given, point of returns to scale are function of output,

$$\frac{\partial y}{\partial k} \cdot \frac{k}{y} + \frac{\partial y}{\partial L} \frac{L}{y} = h(Y)$$

where y, k, and L are the output, capital and labour respectively.

By imposing an arbitrary constant and applying the relevant intergration the form of isoquant is determined as

$$C = \alpha K^{-P} + (1-\alpha) L^{-P}$$

By relating the constant C to the output level y, the modified CES function is, after the appropriate manipulation and intergration is derived.

$$y \left| y - a \right|^{\frac{\beta}{a+\beta}} \left| y - \beta \right|^{\frac{a}{\beta+a}} = A \left[\alpha k^{-p} + (1-\alpha) L^{-p} \right]^{-\frac{V}{p}}$$

Where A is an arbitrary constant, V is the returns to scale parameter and a and β are the roots of quadratic. The term in LHS acts as a deflator or inflator of y.*

It is obvious that such a modification allows the various returns to scale to be related to the level of output. Still the CES function proposed by ACMS is constrained to two inputs. (i.e. labour and capital) If it is expanded to contain more than two variables, the elasticity of substitution between each pair of factors must be considered (i.e. partial elasticity of substitution).

The concept of partial elasticity of substitution was originally introduced by Allen.(23)

Given

$$y = f(x_1, x_2 \ldots\ldots\ldots\ldots x_n)$$

The partial elasticity of substitution σ_{ij} between xi and xj is

$$\sigma_{ij} = \frac{x_1 f_1 + \ldots\ldots\ldots + x_n f_n}{x_i x_j} \quad \frac{F_{ij}}{F}$$

Where

$$F_i = \frac{\partial F}{\partial x_i} \quad \text{and} \quad F_{ij} = \frac{\partial^2 F}{\partial x_i \partial x_j}$$

$$F = \begin{bmatrix} 0, & f_1 & & f_n \\ f & f_{11} & & f_{1n} \\ & & & \\ f_n & f_{n1} & & f_{nn} \end{bmatrix}$$

and F_{ij} is the co-factor of the element f_{ij} in the determinant F.

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* When the level of output at the actual returns to scale is lower than that at the fixed (unchanging) returns to scale V, the term in LHS acts as inflator and vise versa.

The partial elasticity of substitution σ_{ij} is symmetric, so that

$\sigma_{ij} = \sigma_{ji}$ for all $i \neq j$.

Indeed some partial elasticities of substitution may be negative, but the positive ones must be more than the negative partial elasticities to allow the total elasticity to be positive. However, input complementarily might be defined in terms of partial elasticity of substitution, so that substitution is restricted along the isoquant and xi and xj are competitive or complementary according as $\sigma \lesseqgtr 0$, but any one input must be competitive with all other inputs. (24)

However, there have been some attempts of which tried to generalise the two factor CES imposed by ACMS to include n factors and yet retain its properties intact.

Adopting the Allen partial elasticity of substitution Uzawa shows that an extension of the two factor CES function could take the form. (25)

$$y = \left\{ \alpha_1 x_1^{-\beta} + \alpha_2 x_2^{-\beta} \ldots\ldots \alpha_n x_n^{-\beta} \right\}^{-\frac{1}{\beta}}$$

Where $\alpha_1 \ldots \alpha_n > 0$ and constant

And $-1 < \beta < \infty$

This function is homogeneous of degree one, yields diminishing returns to all inputs and exhibits constantly declining marginal rates of technical substitution. One major characteristic of such a function is that the partial elasticity of substitution (i.e. $\sigma_{ij} = \frac{1}{1+\beta}$) are independent of factor prices and are constant and identical for all pairs of two factors of production.

Uzawa rejects such a function as a generalised form of CES, in the sense that elasticities of substitution, though constant, might, in some cases differ with various pairs of inputs.

Instead, he suggests another form which allows the partial elasticities of substitution to be identical for each subset inputs, but not necessary the same for all inputs. (26)

Given

$$y = f(x_1 \; x_2 \ldots\ldots\ldots x_n)$$

The entire set of inputs $(x_1 \ldots\ldots x_n)$ are divided into subsets $(z_1 \ldots\ldots z_s)$. Each group of inputs with identical partial elasticity of substitution is included in one subset.

The suggested form is defined by

$$y = \prod_{s=1}^{S} f \left(z^{(s)}\right)^{P_s}$$

Where

$P_s > 0$

And

$P_1 + P_2 + \ldots\ldots\ldots\ldots + P_s = 1$

And

$$f(z) = \left(\Sigma \alpha_i x_i^{-\beta_s}\right)^{-\frac{1}{\beta_s}}$$

Where $\alpha_i > 0$

and $-1 < \beta_s < \infty$ $\quad \beta_s \neq 0$

Thus

$$y = \left[\alpha_1 x_1^{-\beta_1} + \alpha_2 x_2^{-\beta_1}\right]^{-\frac{P_1}{\beta_1}} \cdot \left[\alpha_3 x_3^{-\beta_2} + \alpha_4 x_4^{-\beta_2}\right]^{-\frac{P_2}{\beta_2}}$$

and so on.

This function is homogeneous of degree one, strictly quasi-concave and possess continuous partial derivatives of third order. The partial elasticity of substitution (i.e. $\sigma_1 = \frac{1}{1 + \beta_1}$) is identical within each subset, but not necessary the same for all subsets. However Uzawa function keeps all the Allen partial elasticities of substitution constant. This is possibleonly if $\sigma = 1$. Thus the present function assumes that the partial elasticities between inputs in different subsets are always equal unity (i.e. $\sigma_1 = \sigma_2 = \sigma_3 = 1$ This assumption might impose restriction on the application of such a function.

Following the same approach, McFadden by introducing two new definitions of the partial elasticity of substitution (i.e. direct and shadow partial elasticity of substitution)* suggests an expanded form of Uzawa function.(27)

The suggested function is a block additive with linear homogeniety characterised by a linear constant direct partial elasticity of substitution. Given a partition $(N_1, \ldots\ldots\ldots\ldots N_S)$ of the set of inputs $(x_1, \ldots\ldots\ldots x_n)$, the fraction takes the form

$$1 = A \sum_{s=1}^{S} \alpha_s \left[\prod_{j \in N_s} \left\{ \frac{x_j^{(s)}}{y} \right\} \right]^{-p} \qquad \text{for} \quad p \neq 0$$

If all subsets contain the same number of elements, m, it reduces to

$$y = A \left[\sum_{s=1}^{S} \alpha \prod (x_j^{(s)})^{-p} \right]^{-\frac{1}{pm}}$$

Where $pm > -1$

Thus

$$y = A \left[(\alpha_1 x_1^{-p} x_2^{-p}) + (\alpha_2 \; {}_3^{-p} \; x_4^{-p}) \right]^{\frac{-1}{pm}} \; {}^{**}$$

* Direct partial elasticity of substitution is defined by applying the elasticity of substitution between each pair of inputs when the levels of the other inputs remain constant. Shadow partial elasticity of substitution helds the same definition, given fixed prices and total cost for the other inputs.

** McFadden also considered the constancy of the shadows partial elasticity of substitution resulting in a more complicated form of CES function.

This function is contineous, yields diminishing returns to all inputs and strictly quosi-concave. The direct partial elasticities of substitution between any pair of factors within a class, σsi is equal one and is some single value σ between any two factors drawn from any two different classes. However, σ is restricted to the range $0 < \sigma \leq \frac{m}{m-1}$. It is obvious, if m = 1, McFadden function is reduced to ACMS production function.

Mukerji shows that constant and identical partial elasticities of substitution has a limited empirical application. She suggests a generalised non-homageneous function which keeps the ratios of Allen partial elasticities of substitution constant, but not necessary the same.(28) The function takes the form;

$$y = A \left(\sum_{r=1}^{m} \alpha_r \; x_r^{-P_r} \right)^{-\frac{1}{P}}$$

Such a function allows P_{rs} to be varied from one input to another, and this allows the partial elasticities of substitution to be not constant. Of course if P_{rs} are all equal the function will be homogeneous and reduced to ACMS function with more than two variables.

Sato, in his useful paper and perhaps the best applicable modified form of the CES production function, argues that the previous attempts were rather restrictive, having limited empirical application. Thus, he introduces an interesting two-level production function, in an attempt to overcome the restrictive nature of the forms suggested by, though closely related, Uzawa and McFadden. (29)

Employing the separable function expressed in an additive form, Sato suggests a generalised form of CES production function which allows two classes of elasticities of substitution to be measured. Both are constant, but not necessary equal one.

The proposed function consists of two levels of which each takes the CES form.

Given

$$y = f(x_1, x_2, \ldots\ldots x_n)$$

Where xi's are the disaggregated inputs that can be partitioned into separate groups.

If a number of the inputs xi's can be aggregated into a single index Zs, we have the lower level of the function

$$Zs = g_s(X^{(s)})$$

Applying CES form, we obtain

$$Zs = \left[\sum_{i \in Ns}^{s} \beta^{(s)} x_1^{(s)\,-P_s} \right]^{-\frac{1}{P_s}}$$

Where $\beta^{(s)} > 0$

And $-1 < P_s = \frac{1 - \sigma_s}{\sigma_s} < \infty$

σs is the intra-class elasticity of substitution which is constant within each subset.

Accordingly the function $y = f(x_1, x_2, \ldots\ldots x_n)$ can be written as $y = f(z)$, this is the upper level of the function which also takes the form of CES, hence

$$y = \left[\sum_{s=1}^{s} \alpha_s Z_s^{-P} \right]^{-\frac{1}{P}}$$

Where $\alpha s > 0$

And $-1 < p = \frac{1 - \sigma}{\sigma} < \infty$

is the inter-class elasticity of substitution which is also constant among input subsets.

The whole function with its two levels can then be written as

$$y = \left[\sum_{s=1}^{s} \alpha_s \left(\sum_{s \in Ns}^{s} \beta_i^{(s)} X_i^{(s)\,-P_s} \right)^{\frac{P}{P_s}} \right]^{-\frac{1}{P}}$$

Such a two level CES production function allows both inter,σ and itra, σ_s class elasticities of substitution to be constant, but does not necessary lead to the constancy of partial elasticities of substitution. This is true since either σ or σ_s are not necessary equal unity.

In order to relax the assumption of linear homogeniety a return to scale parameter V can be added to the function, thus,

$$y = \left[\sum_{s=1}^{S} \alpha_s \left(\sum_{i \in N} \beta_i^{(s)} x_i^{(s)-P_s} \right)^{\frac{P}{P_s}} \right]^{-\frac{V}{P}}$$

Furthermore, the constancy of σ, the inter class elasticity of substitution might be removed if the function is rewritten in the form,

$$y = \left[\sum_{s=1}^{S} \alpha_s \left(\sum_{i \in N} \beta_i^{(s)} (x_i^{(s)})^{-P_s} \right)^{\frac{P_s'}{P_s}} \right]^{-\frac{1}{P}}$$

This function is a general case of non-constant returns which is in fact very close to that suggested by Mukerji if $(x^{(s)})$ consists of only one element Xs.

However, the two-level CES function is indeed a useful approach if the study is interested in knowledge about a set of inputs in aggregated as well as disaggregated forms. A production function which includes a large number of general inputs could be efficient in describing the reality of the production process. The affect of each individual input as well as the whole subset as one variable, on the output can be investigated. Finally, such a function is flexible in the sense that it can be generalised to allow inter-class elasticities of substitution to be varied.

Alternative Functions with variable Elasticity of Substitution

Most of the empirical production studies in agriculture have been based on the assumption of constant or even unity elasticity of substitution. Although C.D. and CES production functions are mathematically simple, statistically and practically manageable and perhaps in many cases empirically valid, they are subject to the limitation that the value of elasticity of substitution is constant and rather unity (in C.D.) This is not always true, the elasticity of substitution could be varying for different pairs of factors. When input ratio varies due to change in factor price ratio, it is possible that elasticity of substitution will vary as the input ratio varies. Thus both C.D. and CES production functions could be considered as special cases of a general form of production function.

Several algebraic forms can be used to represent and estimate the production function with variable elasticity of substitution. Of those only two general forms are, here, introduced and analysed. The variable elasticity of substitution function (VES), and Transcendental Logarithmic Production Function (TLPF) are perhaps the best useful algebraic forms that could be applied if production process is characterised by variable elasticity of substitution.

The Variable Elasticity of Substitution Production Function (VES)

Dropping the restriction of constant elasticity of substitution, an explicit form of a generalised production function which allows for variation in input ratio as well as elasticity of substitution might be derived. [30]

Given

$$y = f\,(L, K)$$

Where y, L and K are the output, labour and capital respectively in a perfect competitive market and f is a linear homogeneous function.

Employing the average production function, we obtain,

$$\frac{y}{L} = f\left\{\frac{L}{L}, \frac{k}{L}\right\}$$

Or $$\frac{y}{L} = f\left\{\frac{k}{L}\right\}$$

Thus, the average product of labour is a function of capital-labour ratio. Such relation was ignored by CES function, assuming that the partial regression coefficient of $\frac{k}{L}$ is unity. This shows that output per worker depends not only on wage rate (i.e. as suggested by ACMS), but also on the capital-labour ratio.

By taking $\frac{y}{L}$, output per worker, as a log-linear function of w, wage rate and $\frac{k}{L}$ capital-labour ratio, we then have

$$\text{Log}\left(\frac{y}{L}\right) = \text{Log } a + b \log w + c \log\left(\frac{k}{L}\right) + e$$

Where

a, b, c are constants.

But wage rate in the competitive market is,

$$w = \frac{y}{L} - \frac{K}{L} \cdot \left(\frac{d\left(\frac{y}{L}\right)}{d\left(\frac{k}{L}\right)}\right)$$

By substituting w into the log-linear function we have

$$\text{Log}\left(\frac{y}{L}\right) = \text{Log } a + b \log\left[\frac{y}{L} - \frac{k}{L}\left(\frac{d\left(\frac{y}{L}\right)}{d\left(\frac{K}{L}\right)}\right)\right] + c \log\left(\frac{k}{L}\right)$$

By integrating this differential equation and applying the required manipulation and substitution the VES function is derived,

$$Y = \left[\beta K^{-\left(\frac{1}{b} - 1\right)} + a^{-\frac{1}{b}} \frac{1 - b}{1 - b - c}\left(\frac{K}{L}\right)^{-\frac{c}{b}} L^{-\left(\frac{1}{b} - 1\right)}\right]^{-\frac{1}{\frac{1}{b} - 1}}$$

By setting $\frac{1}{b} - 1 = p$, $\frac{1-b}{1-b-c} = \phi$, $a^{-\frac{1}{b}} = (1 - \alpha)\ A^{-p}$

and $\beta = \alpha A^{-p}$, we obtain

$$y = A\left[\alpha k^{-p} + (1 - \alpha)\ \Phi \left(\frac{k}{L}\right)^{-c\,(1 + p)} L^{-p}\right]^{-\frac{1}{p}}$$

a production function of the same form of CES function, but containing the capital-labour ratio variable. If c equals zero, VES function will be reduced to CES function, and if c = 0 and b = 1, it is reduced to C.D. function.

The suggested VES function has the same properties of C.D. and CES, except that the elasticity of substitution is variable. The marginal products of L and K are both positive and MRTS decreases as $\frac{k}{L}$ increases for the relevant ranges of k and L. The function is continuously differentiable.

The elasticity of substitution in VES is,

$$\sigma = \frac{b}{1 - c\left(1 + \frac{dk}{dL} \cdot \frac{L}{k}\right)}$$

It is obvious that the elasticity of substitution σ changes as $\frac{k}{L}$ changes, and if c = zero and $\sigma = b = \frac{1}{1+P}$ to be constant independent of $\frac{k}{L}$ ratio; and if c = zero, and $b = 1$ (i.e. p = zero), σ will equal unity.

A new version of VES function of which the elasticity of substitution is restricted to be a linear function of capital-labour ratio has been derived by Sato and Hoffman. (31)

Hence, given

$$\sigma = a + b\left(\frac{K}{L}\right)$$

Where a is the return to scale parameter and b is the capital intensity parameter.

An explicit function of absolute form can be derived.

$$y = AK^{\frac{a}{1+c}} \cdot \left[L + \left(\frac{b}{1+c}\right) K \right]^{\frac{a\ c}{1+c}}$$

The marginal product of this function is also positive and all isoquants are downward sloping.

If the returns to scale are assumed to be onstant (i.e. a = 1) the elasticity of substitution will equal $1 + b\left(\frac{K}{L}\right)$, and the function takes the form;

$$y = AK^{\frac{1}{1+c}} \left[L + \frac{b}{1+c} \right] K^{\frac{c}{1+c}}$$

If b = o, the function is reduced to CES function.

However, the variable elasticity of substitution function is a more general form which includes C.D. and CES as a special case. Such a function allows for a higher range of flexibility that is not feasible in either C.D. or CES functions.

VES function is restricted to only two explanatory variables. It is, however, difficult to generalise them to include more than two variables. Furthermore, the function requires additional information that is not always available.

Transcendental Logarithmic Production Function (TL)

Christensen, Jorgenson and Lau in their thoughtful paper reject the generalisation of constant elasticity of substitution.(32) They argue that constancy of the elasticity of substitution could be realistic assumption only in the case of one output and two inputs, and show-through empirical investigation - that additvity and homogeniety which coincide with constant elasticity of substitution is not suitable assumption if production possibilities with several output and inputs are considered. Instead they introduce a new approach of which production function is quadratic in the logarithm of the quantities of inputs and outputs in order to allow production frontiers to have a high variety of substitution and transformation. They, also, employ a function for price possibility frontier, in an attempt to exploit the duality between prices and quantities in the theory of production.

CJL introduce the production possibility frontier in the form of transcendental logarithmic. Although they represent their approach in the case of two output and two inputs, it can easily be extended to include any number of outputs and inputs.

Given two outputs and two inputs or even one output and three inputs, x_1 x_2 x_3 and x_4, the production possibility frontier F may be presented in the form,

$$F\ (x_1, x_2, x_3, x_4) = 0$$

And the logarithm function of outputs and inputs is

$$\begin{aligned} \text{In}\ (F+1)^{*} = & ao + a_1 \text{ In } x_1 + a_2 \text{ In } x_2 + a_3 \text{In} x_3 + a_4 \text{ In } x_4 \\ & + \text{In } x_1 \left(\tfrac{1}{2}\ \beta_{11} \text{ In } x_1 + \beta_{12} \text{ In } x_2 + \beta_{13} \text{ In } x_3 \right. \\ & \left. + \beta_{14} \text{In } x_4\right) + \text{In } x_2 \left(\tfrac{1}{2}\ \beta_{22} \text{In } x_2 + \beta_{23} \text{ In } x_3 \right. \\ & \left. + \beta_{24} \text{ In } x_4\right) + \text{In } x_3 \left(\tfrac{1}{2}\ \beta_{33} \text{ In } x_3 + \beta_{34} \text{ In } x_4\right) \\ & + \text{In } x_4 \left(\tfrac{1}{2}\ \beta_{44} \text{ In } x_4\right). \end{aligned}$$

Applying the transcendental logarthmic form for the production possibility frontier in the equilibruim case, three ratios can be obtained,

$$\frac{P1}{P2} = -\frac{\Phi X1}{\Phi X2}, \quad \frac{P3}{P2} = -\frac{\Phi X3}{\Phi X2}, \quad \frac{P4}{P2} = -\frac{\Phi X4}{\Phi X2}$$

Where P_1, P_2, P_3 and P_4 are the corresponding prices, and Φx_i can be estimated. For instance Φx_1 is estimated by .

$$\Phi x_1 = a_1 + \beta_{11} \text{ In } x_1 + \beta_{12} \text{ In } x_2 + \beta_{13} \text{ In } x_3 + \beta_{14} \text{ In } x_4$$

Similarly

Φx_2, Φx_3 and Φx_4 are derived.

Given the prevailing prices and the estimated values of Φx_1, Φx_2, Φx_3 and Φx_4, the function can be solved.

Indeed the values of only two ratios are required for complete econometric

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* A Unity is added to the production frontier, since the frontier is equal zero.

model of production. This follows from the relation that;

$$\frac{P1}{P2} + \frac{P3}{P2} - 1 = \frac{P4}{P2}$$

Thus, the third ratio is determined by the accounting identity.

Obtaining the value of the parameters of a two ratios, the parameters of the third ratio is determined. This is obvious from the relations as given;

$$a_1 + a_2 + a_3 + a_4 = 0$$
$$\beta_{11} + \beta_{21} + \beta_{31} + \beta_{41} = 0$$
$$\beta_{12} + \beta_{22} + \beta_{32} + \beta_{42} = 0$$
$$\beta_{13} + \beta_{23} + \beta_{33} + \beta_{43} = 0$$
$$\beta_{14} + \beta_{24} + \beta_{34} + \beta_{44} = 0$$

The same procedure is applied to transcendental logarithumic price possibility frontier, in order to employ the duelity between quantities (i.e. direct estimation) and prices (indirect estimation) in the theory of production.

CJL test their approach, using time series data for the United States private domestic economy for 1929-69. They found that the assumption of constant elasticity of substitution (i.e. additivity and homogeniety) is not always valid, if there are several outputs and inputs. They suggest that their approach could be valid in many cases. Indeed such an approach might be useful in the case of disaggregated agricultural production function.

IV - 3: Practical and Statistical Constraints to the Application of Production Theory

In practice, a production function which specifies the real situation is often confronted by statistical constriants. The conflict between reliable statistical estimates and the specification of the actual production process might impose some limitation to constructing the appropriate form of production function. Multicollinearity and autocorrelation are perhaps the major statistical constraints to unbiased estimates.

Disaggregation and Multicollinearity

Ideally, a true econometric model in production must contain all the relevant explanatory variables in disaggregated form. Disaggregation is necessary if the estimated production elasticities are to be unbiased, since homogeniety within each variable is a necessary condition if the estimated marginal productivities are to be meaningful. Indeed the traditional division of the factors into land, labour and capital might delete the homogeniety requirement and thus reduces the meaningfulness of the estimates. (33)

Although inputs' disaggregation is desirable in economic sense, it might reveal a high intercorrelation among the independent variables (i.e. multicollinearity). Serious multicollinearity usually affects the precision with which individual coefficients can be estimated and thus leads to problems of structural estimation and specification error. Each individual coefficient is estimated by using only that part of the variation in the independent variable that is associated with the dependent variable (i.e. pure variation) ignoring the variation that associated with the other independent variables. If an independent variable is highly correlated with one or more of the other independent variables, there will be little pure variation on which to base an estimate of the effect in its change. Accordingly the residual sum of squares from the regression of this independent variable on the other independent variables will tend to be small and the variance of its coefficient will be large. (34) There would thus be considerable uncertainty attached to the estimate of coefficient. The degree of multicollinearity can, however, be estimated and localized by applying the matrix of coefficient correlation and principle component or factor analysis.

In order to minimise or at least reduce the degree of multicollinearity, the intercorrelation between the independent variables must be isolated. One way is to aggregate factors with perfect or high intercorrelation into one category. Perfect complements and perfect substitutes can be aggregated into a single input. In this case, unbiased estimates of slope coefficient will be obtained, if and only if, the aggregated variables are based on standarised weights. (35) In reality such standarised weights are unknown or at least not accurate enough. Theoretically, aggregation has little to defend it. (36) Aggregating some input factors might overcome the problem of multicollinearity, but at the cost of the meaningfulness of the study. Thus it must be avoided as long as alternative ways can be applied in minimising the degree of multocollinearity.

An alternative solution is to drop one or more of the correlated variables. When two variables are perfectly correlated, one of them can be omitted without introducing biased estimate. This is, however, not the case in reality. In many cases there exist a high intercorrelation between more than two factors. The difficulty is to know which variables are to be omitted. The estimates corresponding to the dropped variables are implicitly set to zero. Thus, biases will be introduced unless the excluded variables have coefficients close to zero. Prior knowledge might be helpful in recognising the least important factors. In the absence of prior knowledge, some statistical tests might be used. The method of confluence analysis(37) or t statistic could be of some use as a guide to decide which variables are to be deleted. However, the omission of one or more variables is not desirable in economic sense, simply because some of the available information that can be used to utilise our knowledge are thrown away.

Fortunately it is possible to minimise the degree of multicollinearity without reducing the meaningfulness of the study, by applying the so-called principle components or factor analysis. Both techniques are,however, members of the wider family of factor analytic methods. The general role is to rearrange the original variables into a new set of factors(i.e. components) each consisting entirely of information which is not contained in the others. These new set of factors (component) are usually smaller than the original variables. They can be rotated in terms of their contribution to the explanation of the behaviour of the dependent variable. It is also possible to identify individual factors as containing specific types of information. Once these factors (components) are obtained, a regression in which the factors are used in place of the original explanatory variables can be run, and then the resulting coefficients can be converted back into estimates of the parameters of the original function. (38) The estimates obtained on converting back to the parameters of the original function will be identical to these from a regression on the original variables, if all the factors are used. However, the difference will be slight, if only the least important factors are excluded.

In some cases, where the correlation between each two explanatory variables is high, but low among all pairs of variables. Input ratio between each two correlated variables can replace the original variables.

Generally speaking, the objective of constructing a production function is to obtain the maximum knowledge with unbiased estimate, about the problem in hand. Hence, it is not wise to solve multicollinearity problem at the cost of the meaningfulness of the study. In some cases, attempts to reduce multicollinearity are not needed, so long as the results can correctly and meaningfully be interpretated, given prior knowledge. In other cases, alternative algebraic forms of production function which reduce distortion of multicollinearity may be used.

Time Series and Autocorrelation

Ordinary least square (OLS) is often used to estimate the regression coefficients of a time series production function. In such a case, OLS could produce unbiased estimates if and only if the observations are not serially correlated (i.e. the correlation between successive items in a time series of observations) and the disturbance of one period is not influenced by the disturbances in the previous periods. This is not always true. Indeed, autocorrelation usually exists among serial observations and the assumption of independence of the disturbance is therefore no longer valid. Thus, one might expect that OLS estimates of the regression coefficients will not be unbiased, nor will they have minimum variances. This is perhaps due to the application of unsatisfactory algebraic form of production function, observation errors, or / and the omission of important explanatory variables.(39) Durbin-Watson test is widely used in testing whether the disturbances are serially correlated. (40) Ideally the test must be based on the disturbance values, but these cannot be observed, so that residuals can be used instead. The test is applied by using the ratio of the total first differences of the residuals to the total squared residuals to test the independence of disturbance assumption which if true would indicate the optomality of OLS, thus,

$$d = \frac{\sum_{t=2}^{t=n} (e_t - e_{t-1})^2}{\sum_{t=1}^{t=n} e_t^2}$$

The value of d can be weighted against the tabulated value to test whether the null hypothesis is rejected or accepted.

Durbin-Watson test assumes that the explanatory variables can be considered to be non-random. Such an assumption is not always valid and thus the value of the test statistic is no longer a reliable indicator of the disturbance behaviour.

Durbin suggests an alternative test based on the asymptotic theory. The test statistic is [41]

$$h = (1 - 0.5d)\sqrt{\frac{n}{(1-n\ Var\hat{\beta})}}$$

Where d is the Durbin-Watson statistic, n is the number of observations, and Var $(\hat{\beta}_1)$ is the estimate of the variance of coefficient of y obtained from a stantard OLS calculation, applied to the original model. Under the null hypothesis of serial independence of the disturbances, the statistic, h, has an asymptotic normal distribution and, following the principle of the original Durbin-Watson test, a one-tailed procedure is used. This test is also not always accurate. For a relatively small number of observations, the behaviour of the test statistic is uncertain, since the probabilities of error are purely nominal. [42]

Two alternative techniques might be used in order to correct the effects of serial correlation. One way is to rearrange the original variables into a new set of variables of which each corrected variable is the first difference of the original variable. Such a method assumes that the disturbance parameter, ρ is equal one. By disturbance parameter is meant the degree of disturbance resulted from serial observations over a certain period of time. It is estimated by regressing the residual in one period against that of the previous period. Residuals are used as alternative to the unobservable disturbances. Hence the estimated value of ρ, the disturbance parameter is rather approximation of the true value. [43] Thus,

$$\hat{\rho} = \frac{\sum_{t=2}^{n} e_t\ e_{t-1}}{\sum_{t=2}^{n} e_{t-1}^2}$$

$\hat{\rho}$ is usually less than one. Thus the first differences of the original variables technique might not be good enough to correct the serial correlation, since it assumes that the value of ρ is equal one. Indeed it might induce high disturbances and even higher than that in the original model.

A more reliable technique of which the generalised least square (GLS) is used to estimate the regression coefficients of the transformed value of the original variables. Transformation technique is also based on the first differences of the original variables, but after taking the actual (approximate estimation) value of the disturbance parameter ρ into consideration. The value of each original variable multiplied by the estimated ρ in one period is subtracted from the value of this variable in the following period in order to obtain the transformed variable. These new transformed variables are regressed to estimate unbiased coefficients. (44) Such a technique relies on the actual value of ρ while the former technique assumes that ρ is equal one. The estimate of the coefficients in the original model is based on the assumption that ρ is equal zero.

The only problem with the application of first differences of the original variables is the reduction of observations by one. Thus, another observation should be added to the corrected model. This can be done by giving ρ a new value (i.e. $\rho = \sqrt{(1 - \rho^2)}$) to be applied to the first observation.

It seems that the choice of the appropriate algebraic form of production function might create some conflict between the realistic application of the theory, the statistical methods in hand, and the available information in practice. Indeed the advantageous of using simple and manageable form could be at the cost of accurate estimates of the parameters. Nevertheless, empirical investigations in many cases show that the simple functional forms (i.e. C.D. and CES Production Functions) are useful tools in the analysis of economic development. However, given the available data one should utilise his mathematical and statistical knowledge in deriving the best approximate theoretical form of production function that fit the actual situation.

CHAPTER V

Review of Empirical Investigations of Production behaviour in Egyptian Agriculture

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Review of Empirical Investigations of production behaviour in Egyptian Agriculture

Quite a few quantitative investigations of production behaviour in Egyptian agriculture have been made. All the studies have used the popular form of Cobb-Douglas function almost automatically and perhaps without justification. A brief review of these quantitative investigations emphasising their major deficiencies is presented in this chapter.

Perhaps the study made by El-Imam in 1965, [(1)] is the major leading contribution to the field of production in Egyptian agriculture. The objective of this empirical investigation was to estimate the net contribution of each relevant factor to agricultural production. A macro-model was applied to a time series data during the period 1913-55. The values of gross output of the major field crops * were combined to be regressed against the relevant input factors (i.e. aggregated production function). Index numbers referred to base equal to the average of the years 1950-54 were used as a measure of the estimated variables.

Land is measured in Feddan/year unit rather than Feddan unit (land measure unit in Egypt). Feddan/year refers to the exploitation area which is obtained by weighing the cropped area to the length of the production period of each crop. Land fertility differentials are neglected,

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* The crops included in the function are cotton, wheat, millet, maize, rice, beans, barley, lentils, helba, onions and sugar cane.

since crop allocation is assumed to be constant over the period under study. This is rather restrictive assumption, particularly over such a long period and it would induce some deviation from the true value.

The total number of workers actually living directly upon agricultural activity is used in measuring labour input. This concept is based on the phenomenon that an increase in the number of those who are directly living upon agriculture would induce a reduction in both average and marginal productivity. The estimate of labour coefficient is therefore derived from data on the available labour force (supply side) rather than the actual employment (demand side). This approach could be misleading if the rate of unemployment is changeable over time. This is however, not a serious problem since open unemployment is negligable in agriculture.

Capital is disaggregated into fixed and working capital. With respect to fixed capital, mechanisation is omitted, simply because it has not been seriously applied in Egyptian agriculture over the period under study. However, if there had been any changes in machinary use, they can be embodied in a trend variable. The major part of agricultural capital during the period under study has been invested in irrigation. Thus investment in irrigation is included, but indirectly, in the production function. In order to have homogeneous units, the amount of water annually leased at the Aswan Dam is used in measuring investment in irrigation. Indeed, a more accurate estimate would be obtained if it is measured according to the deviations from the optimum water requirements.

As far as working capital is concerned, chemical fertilisers is the only variable included in the production function. Each type of fertilisers had been transformed into its equivalent of phosphate and nitrate to be aggregated into one variable. Due to the lack of information the supply side was used in estimating chemical fertilizer coefficient, and natural manure has not been included in the function. Seeds and insecticides have also been excluded from the function assuming proportional relation between output and these two inputs. This is perhaps true, but only if crop composition remains constant.

Applying a power function of the Cobb-Douglas type to data, for the period 1913-55, El-Iman has estimated an aggregative function for Egyptian agriculture; (2)

$$\text{Log } Y = 1.3066 + \underset{(0.337)}{0.2} \text{ Log } X_1 + \underset{(0.123)}{0.297} \text{ Log } X_2$$

$$+ \underset{(0.014)}{0.0316} \text{ Log } X_3 + \underset{(0.0565)}{0.0367} \text{ log } X_4 + \underset{(0.000756)}{0.00089}\, t$$

$$R^2 = 0.851$$

Where

y is the gross value of output

X_1 is Feddan/Year

X2 is labour force

X3 is the amount of water

X4 is chemical fertiliser

t is the time trend

Such poor fit of the variables with high value of R^2 might be attributed to either multicollinearity, series correlation, or both. The author has not employed statistical test for both multicollinearity (i.e. correlation matrix or factor analysis) and auto correlation (i.e. Durben-Watson test or auto-correlation coefficient). It is therefore not feasible to identify the exact reason behind such poor fit of variables. However, one might expect that chemical fertilser and time variable are highly correlated, since the former is increasing overtime.

Dropping both chemical fertiliser and time (insignificant coefficients), the function takes;(3)

$$\text{Log } Y = 1.3814 + \underset{(0.329)}{0.196} \log X_1 + \underset{(0.080)}{0.313} \log X_2 + \underset{(0.0135)}{0.0324} \text{ Log } X_3$$

$$R^2 = 0.849$$

This function exhibits diminishing returns to scale. Still land coefficient is insignificant. Indeed one might suggest that the effect of land on production is underestimated. Agricultural land in Egypt is quite limited, so that an increase in the cultivated area is expected to have a considerable influence on production.

However, there are some doubts about the accuracy of the function estimated by El-Imam. This is perhaps due to the lack of some information which forced the author to use unreliable data and to put rather restrictive assumptions. Data on the supply side of labour and fertiliser are used as an alternative measure of the actual amount used. Factors of some importance such as weather, insecticides and natural manure are omitted from the function. Crop-composition is assumed to be constant and therefore land fertility differentials and seed affects are neglected. The different types of fertilisers are added together on the assumption that they are hormogeneous. Capital other than that invested in irrigation has not been taken into consideration.

Following the same approach but confinning the investigation to cotton crop during the period 1913-60, Kheir-El-Din has estimated the cotton production function, in an attempt to investigate the nature of cotton production phenomenon in Egypt and to find out its relation with both technical progress and disguised unemployment. (4)

A production function of Cobb-Douglas form was also derived, in order to estimate the correlation between cotton production and few inputs; area, labour, nitrate and phosphate;(5)

$$\text{Log } Y = -0.446 + \underset{(0.0726)}{0.7209} \log As + \underset{(0.2095)}{0.3953} \text{ Log } L$$

$$+ \underset{(0.0569)}{0.0413} \log F_n - \underset{(0.0569)}{0.0009} \log F_p \qquad R^2 = 0.93$$

Where Y, As and L are the output, land and labour respectively, and Fn and Fp are nitrate and phosphate respectively.

Cotton area, As is measured in weighted index. It is not obvious which weights are used, but one might guess that cotton area is weighted according to land fertility, and perhaps is based on land taxation and with respect to the various types of cotton. Labour L, is measured in man/day index. Chemical fertilizer is disaggragated into nitrate Fn and phosphate Fp. Natural manure is neglected due to the lack of information during the period under study. Both nitrate and phosphate figures are based on the supply side rather than the actual use of them. Indeed, the supplied amount of fertiliser is usually larger than the true amount used, hence both nitrate and phosphate coefficients might deviate from the true value. On the other hand, the omission of natural manure might induce biased estimate of fertiliser. An increase in the use of chemical fertiliser might be accompanied by a reduction in the use of natural manure. If this is true as likely to be the case over time, the effect of chemical fertilizer would be smaller than its true value. However, an index of the average of the previous and current years' supply of each type of chemical fertiliser is used to estimate the relevant coefficient.

Apart from the area coefficient which is significant at the 1% level, all the coefficients are insignificant. Dropping phosphate which is of negligible coefficient from the function, a new function with only three input factors was obtained. (6)

$$\log \hat{Y} = -0.4554 + \underset{(0.0717)}{0.7215} \log As + \underset{(0.1879)}{0.3988} \log L + \underset{(0.0402)}{0.0394} \log F_n \qquad R^2 = 0.93$$

The coefficients of area and labour are different from zero at the 1% and 5% significant levels respectively, but nitrate coefficient is still insignificant. Fisher test shows that R^2 is significant at 1% level.

The author relies on this suggested function for further analysis and accepts the assumption of constant returns to scale in cotton production over the period under study.

Fixed capital was omitted from the function on the basis that mechanisation has not seriously taken place in Egyptian agriculture over the period under investigation. However, a trend variable can be introduced in the function in order to express the use of more machinery together with the improvement in production technique and the use of more animals. Indeed, the time variable was also excluded from the function. The author found that the time trend has a slight affect on the output (y is independent of t).(7)

With respect to the working capital, seeds and insecticides were excluded due to the lack of information and phosphate was omitted because it was found that its estimate is insignificant. It is, however, assumed that seeds and insecticides are proportional to the volume of production, and phosphate is of negligable affect on production.

Relying on the estimates obtained from this function, Kheir-El-Din concludes that constant returns to scale has been prevailed over the period 1913-60. Land is the most important factor, so that changes in cotton production can largely be attributed to cotton area fluctuations. This is, infact, sensible result and relevant to production logic in Egyptian agriculture. Labour increases smoothly over time during the period 1913-33, then remains nearly constand after 1933. Nitrate is of limited importance, though increases over time. As mentioned above the nitrate coefficient could be biased.

However, land and labour have the highest contribution to cotton production. This conclusion is confirmed by regressing cotton production against cotton area and labour only. The estimated function is as follows(8)

$$\text{Log } \hat{y} = -0.9949 + \underset{(0.0515)}{0.7704} \text{ Log As} + \underset{(0.0773)}{0.567} \text{ Log L} \qquad R^2 = 0.9$$

It is obvious that both land and labour are significant at 1% level. R^2 is still significant at 1% level, though it is slightly reduced. However this assumed form is supported by statistical materials. Such a function shows that returns to scale is rather increasing. The author admits that this is unusual in agriculture, but she accepts the result in the sense that restriction in cotton area may allow marginal productivity to increase. In fact both inputs' coefficients and therefore function coefficient are overestimated due to the exclusion of some other factors particularly nitrate.

Kheir-El-Din argues that although there is no significant relation between time and production, we cannot say that there has been no technical change in Egyptian agriculture. Technical change may be embodied in some inputs such as fertilisers. Data suggest that changes took place in the case of chemical fertiliser. The effect of changes in kinds of nitrate has been included into the production function, but the effect of the increase in the proportion of nitrate to total fertilizers (nitrate plus natural manure) has not been taken into consideration. *

The study also shows that labour marginal productivity in cotton as well as in the whole field crops is positive, but substantially less than the yearly wage rate (table V-1)

TABLE : V-1

Average wage rate and marginal productivity of Labour (1937-60)

Years	Average wage rate in agriculture per year at current prices (L.E.)	Labour Marginal productivity in agriculture per year at current prices (L.E.)	
		in field crops	in cotton
1937	8.87	4.65	2.76
1947	30.25	13.45	7.78
1960	37.40	21.50	14.25

Source: H..Kheir-El-Din, "The cotton production function in the U.A.R. and its relation to technical progress and to disguised unemployment; opcit P.15

The author concludes that the marginal product in agriculture is of the same order of magnitudes as wage rate, so that there is no absolute labour surplus in Egyptian agriculture.

* Manure was excluded from the function.

In general the present study by deriving a disaggregated function rather than aggregated function is perhaps more useful in the economic sense. Besides, unlike the aggregated function, it reduces the range of errors. The estimate of land coefficient is unlike the previous study, relevant to the production logic in Egyptian agriculture, though one might expect that the estimate of all input coefficients are slightly overestimated due to the exclusion of some relevant inputs. Thus returns to scale would be decreasing rather than constant as suggested by the author.

Still, the production functions estimated by El-Imam and Kheir-El-Din are not accurate enough to express the actual situation in Egyptian agriculture. This is perhaps due to the lack of information. Both studies relied on time series data obtained from the official statistical agencies. Such data is usually available in aggregated form and not reliable enough to the purpose under investigation.

In order to minimise or at least to reduce the data error, Risk and Afar (1970) [9] have tried to estimate disaggregated production functions for the major crops in Egypt using cross sectional data collected by a group of researchers from five Governates., Kafr-el-Shiek, Gharbia, Kalubia, Beni-Suef and Menia. [10] A cluster random sampling technique was employed in collecting the required data on four crops; cotton, rice, maize and wheat in the five selected Governates. A separate production function for each crop within each Governate was estimated.

The authors applied the crude and traditional division of the factors into land, labour and capital. Land is measured in Feddon units (area measure in Egypt), while both family and hired labour are included in one variable to be represented by man /day, capital is measured in money terms.

Both fixed and working capital are valued to be included in one variable. Fixed capital includes depreciation, maintenance and fuel of the used machines, the current cost of used animals and all other fixed investment. Seeds, fertiliser and insecticides are valued to be added up to the valu e of fixed capital. Output is measured in either quantity or value. (11)

Applying the C.D. function in its generalised form the input coefficients for each crop in each Governate are estimated as shown in table V - 2.

Given

$$y = f(x_1, x_2, x_3)$$

where y is the output

x_1 is Feddan unit (area)

x_2 is man / Day

x_3 is the value of capital

The function takes the form

$$y = AX_1^{b1} X_2^{b2} X_3^{b3}$$

The objective of the study is to test whether the use of resources is efficient and then to identify the possibility of increasing agricultural output through reallocation of resources. Assuming allocation efficiency in terms of profit maximisation, the authors have estimated marginal products of the relevant factors for each individual crop in all Governates and then test for equality between the estimated value of marginal products and opportunity costs of the geometric mean farm. The ratios of the value of marginal product to the opportunity cost of the inputs are used as an indicator of economic efficiency. If the ratio is significantly different from one, resource allocation would be rather inefficient.

Market prices for the inputs and outputs in 1966 are used in

TABLE V - 2

The Estimate of The Production Functions (C.D.) for the Major Crops in the Various Regions in 1966

Area	A	b_1	b_2	b_3	Returns to Scale	R^2	R
Cotton							
Kafr-El-Sheik	4.9737	0.818* (0.1989)	- 0.619 (0.1568)	0.285 (0.1447)	0.8846	0.8318*	0.9121
Gharbia	4.8917	0.7193* (0.0795)	0.1878* (0.0646)	0.1269* (0.0742)	1.034	0.960*	0.9798
Kalubia	5.2234	0.5981* (0.1546)	0.3272* (0.1449)	0.1683 (0.0865)	1.0936	0.9661*	0.9829
Beni-Suef	4.5901	0.7673* (0.1146)	0.0348 (0.0941)	0.152 (0.0888)	0.9173	0.9139*	0.9560
Menia	4.2558	0.248 (0.1619)	-0.1168 (0.1861)	0.8531* (0.0818)	0.9903	0.9190*	0.9679
Rice							
Kafr-El-Sheik	1.6194	0.6514* (0.0805)	0.0429 (0.0422)	0.3046* (0.0935)	0.9989	0.9559*	0.9777
Gharbia	1.0868	0.9241* (0.2096)	0.2267 (0.1735)	0.0148 (0.1558)	1.1656	0.9133*	0.9557
Kalubia	0.5484	0.8022* (0.2695)	0.1633 (0.2047)	-0.026 (0.1722)	0.9395	0.9176	0.9579
Maize							
Kafr-El-Sheik	2.4084	0.0027 (0.928)	0.5233* (0.1289)	0.5461* (0.1249)	1.0721	0.8292*	0.9106
Gharbia	2.4163	0.7667* (0.057)	0.0588 (0.0528)	0.195* (0.0658)	0.945	0.959*	0.9793
Kalubia	2.2758	0.0733 (0.149)	0.0951 (0.1309)	0.9386* (0.1368)	1.107	0.8248*	0.9082
Beni-Suef	2.2829	0.9401* (0.0958)	0.0745 (0.0775)	-0.0601 (0.0841)	0.9545	0.88261*	0.9395
Menia	2.3009	0.9184* (0.1303)	-1.0827* (0.0984)	1.1322* (0.0987)	0.9679	0.9595*	0.9795
Wheat							
Kafr-El-Sheik	2.1957	0.1578 (0.0637)	0.1237 (0.0789)	0.6758* (0.0941)	0.9573	0.8908*	0.9439
Gharbia	1.8129	0.8028* (0.076)	0.0455 (0.0637)	0.2413* (0.0923)	1.0897	0.9347*	0.9668
Kalubia	1.5807	0.7158* (0.1885)	-0.2005* (0.0955)	0.4196* (0.1519)	0.9349	0.8709*	0.9332
Beni-Suef	1.7070	0.6966* (0.1284)	0.1655 (0.1137)	0.2472 (0.1167)	1.1093	0.9053*	0.9515
Menia	1.9783	0.6596* (0.113)	-0.0651* (0.0056)	0.4125* (0.1135)	1.007	0.9518*	0.9515

* Significant at 1% or 5% level.

Source : M. M. RISK and M. A. AFAR, "Production Functions for the Major Field Crops in Egypt", INP, Memo No. 116, Cairo, 1970, p.127, 128, 132, 134, 138, 141, 145, and 147.

estimating the values of marginal products and opportunity costs. (12) The estimated values of marginal products and the ratio of the value of marginal products to the opportunity costs are shown in tables V - 3 and V - 4 respectively.

General observations on the input coefficients, the values of marginal products and opportunity costs estimated by Risk and Afar, are here summarised.(13) Land coefficients are generally high except for maize production in Kafre-El-Shiek and Kalubia which are surprisingly low, and cotton production in Menia. This shows that agricultural land is generally fertile, but limited relative to other inputs. Given the ratios of the values of land marginal product to the opportunity cost $\left(\frac{VMP}{MC}\right)$, this result is confirmed. A part from maize production in Kafr-El-Shiek and Kalubia and cotton production in Menia, the ratios are significally higher than unity indicating that land is under used. Thus one might suggest that more land to be put under cultivation is needed if agricultural production is to be increased. Indeed the increase in production would be less than one might expect, since the fertility of the new land is usually lower than that of the existing land. The significant difference between the values of marginal products of land whether among the various crops within one Governate or for the same crop in the various Governates, indicate that land is inefficiently allocated between its different uses. In practice there is little to be done in order to correct land misallocation. Land use is, in fact, restricted according to soil structure, availability of water, and imposed crop rotation. Still substitution between crops such as maize and rice in some regions could induce considerable increase in production.

Labour coefficients for nearly all crops in the various Governates are very low, and in some cases are negative. Apart from cotton production in Kafr-El-Shiek labour is overused and one might safely assume that

TABLE V - 3

The Values of Marginal Products of the Relevant inputs with respect to the major crops in the various regions

Governate / Crop	Kafr-El-Sheik	Gharbia	Kalubia	Beni Suef	Menia
		LAND			
Cotton	56.445	60.974	89.604	75.588	21.619
Rice	39.842	46.053	64.377	-	-
Maize	0.103	30.862	2.753	37.768	50.377
Wheat	4.804	27.810	26.321	22.28	29.307
		LABOUR			
Cotton	- 0.053	0.219	0.701	0.031	- 0.077
Rice	0.003	0.181	0.233	-	-
Maize	0.059	0.050	0.132	0.046	- 0.064
Wheat	0.098	0.039	-1.234	0.133	- 0.984
		CAPITAL			
Cotton	0.272	0.318	0.416	0.524	4.243
Rice	0.672	0.025	-0.154	-	-
Maize	0.985	0.250	0.758	-0.242	3.944
Wheat	0.949	0.344	1.204	0.506	1.161

Source : M. M. RISK and M. A. AFAR, "Production Functions for the Major Field Crops in Egypt", Institute of National Planning, Memo No. 116, Cairo, 1970, p. 161, 167, 171, and 175.

TABLE V - 4

The Ratios of the Values of Marginal Products of the Relevant Inputs

Crop \ Governate	Kafr-El-Sheik	Gharbia	Kalubia	Beni-Suef	Menia
		LAND			
Cotton	4.269	3.159	3.091	3.260	1.014
Rice	4.931	7.295	4.140	-	-
Maize	0.014	5.521	0.260	5.029	6.336
Wheat	0.545	2.060	2.020	1.525	2.190
		LABOUR			
Cotton	-0.192	0.855	2.336	0.155	-0.550
Rice	0.010	0.760	0.776	-	-
Maize	0.214	0.234	0.44	0.23	-0.456
Wheat	0.356	0.162	-4.113	0.565	-7.028
		CAPITAL			
Cotton	0.259	0.302	0.396	0.499	4.040
Rice	0.640	0.024	-0.147	-	-
Maize	0.938	0.238	0.722	-0.230	3.756
Wheat	0.904	0.328	1.147	0.482	1.106

Source : : M. M. RISK, and M. A. AFAR, "Production Functions for the Major Field Crops in Egypt", op. cit. p.161, 167, 171, and 175.

Egyptian agriculture is characterised by high labour intensity. The ratios of the value of labour marginal products to opportunity costs are significantly less than unity and in some cases they are negative. Reallocation of labour between the different crops or among the various regions might not induce serious increase in production, since labour marginal products do not differ significantly from one crop to another or from one region to another, perhaps Kalubia is the only region on which production could be increased if labour is reallocated.

Capital intensity varies from one region to another. It is generally high in Gharbia and Beni-Suef and highly low in Menia. Reallocation of capital between the various crops in these Governates is, therefore, not useful policy since production will not significantly be increased. In Kafr-El-Shiek and Kalubia, capital intensity differs from one crop to another. In both regions capital use is concentrated on cotton and rice productions at the cost of maize and wheat productions. Reallocation of capital in favour of the two latter crops would increase agricultural production. However it appears that the values of marginal products of capital in all regions except Menia are lower than the opportunity cost ($\left\{\frac{VHP}{MC}\right\}$ ratios are less than one). The authors conclude that a reduction in capital use would increase its marginal productivity. This is indeed misleading conclusion, simply because the authors include all capital inputs in one variable without differentiating between animals and machines, and between chemical fertilisers and natural manure, and neglecting the variations in the quality of different capital inputs. The low productivity of capital could be attributed to the over-use of animals; it might be resulted from inefficient mix of fertilisers, or due to the use of traditional varieties of seeds and insecticides. Unless capital is disaggregated into the relevant inputs the analysis will not be feasible and then a wrong policy might be approached.

As far as substitution between labour and capital is concerned, one should distinguish between two groups. In Governates such as Menia and Kafr-El-Shiek, a considerable increase in production is forthcoming if capital replaces labour. In the other Governates the rate of increase in production varies from one crop to another. Generally speaking wheat production might be increased signficantly if labour is substituted by capital. This is not the case with rice production. Again this conclusion is not necessary valid, since the marginal rate of substitution between labour and capital, differ according to the structure of capital. While fertiliser cannot be substituted for labour, machines could be perfect substitutes for labour. Indeed the inclusion of all capital inputs in one variable is rather a restrictive approach. The aggregation of capital inputs which are usually correlated would degard the homogeneity assumption and substantially reduce the meaningfulness of the estimates. Furthermore, it would be more meaningful, if the authors had tried to examine the substitution between labour and capital for a given unit of land. Such investigation is useful in approaching a short-run policy. So long as land is fixed in the short-run an increase in agricultural productivity might be obtained through the reallocation of labour and capital.

The study also shows that returns to scale in almost all cases are either constant or decreasing. Increasing returns to scale prevails in one case (i.e. rice production in Gharbia.). Relying on these observations, the authors wrongly argue that small farms are relevant to Egyptian agriculture. (14) This is true, if and only if, the input ratio is similar for the various sizes of farms. This is an unlikely assumption. Indeed the input ratio would differ with the various sizes of farms. Knowledge on the relation between productivity and farm size can only be obtained if the estimates are considered separately for each farm size or if the farm size is included in the function as an independant variable. However, the authors, elsewhere argue against small farms;

"higher returns could be obtained if the farmer holds a larger area." (15)
In this context the analysis is not consistent.

The major contribution of the study made by Risk and Afar, is the attempt to investigate economic efficiency for each crop separately at the micro level. Apart from some few biased estimates, the obtained results are feasible and consistent with the production logic in Egyptian agriculture. Still some factors which might have significant implications on the behaviour of agricultural production are ignored. All capital inputs are assumed to be homogeneous. The impact of both farm size and pattern of ownership on agricultural production has not been considered.

In an attempt to overcome the deficiencies of the previous investigations, the present study, using both time series and cross sectional data collected directly from agricultural organisations' records, farmers and co-operatives, applies a disaggregated production function to test resources allocation efficiency among the various classes of farm size and forms of tenure. Maximisation technique for constrained extrema is applied to estimate the optimum level of output under the present economic structure for the various farm classes.

CHAPTER VI

An Estimate of Time Series Production Function "Technical Efficiency 1"

CHAPTER VI

An Estimate of Time Series Production Function "Technical Efficiency 1"

Both time series data for the period 1960-76, and cross sectional observations in 1975 are used separately in testing resource allocation efficiency within the agricultural sector. The three major crops; cotton, rice and wheat are considered in the time series study. They contribute some 60 per cent of the value of field crops, of which more than 80 per cent of the farmers are involved. Cotton and rice are cash crops, supplying the economy with more than 50 per cent of the foreign exchange earnings. Wheat is an import crop and absorbs some 25 per cent of the foreign exchange earnings. (1) Cross sectional observations are confined to cotton, but with respect to the different farm size classes and various forms of tenure.

The study covers the total area allocated to the crops under investigation, but at the micro-level. The area is divided into regions, and data whether time series or cross section were collected for each region separately. Area classification is specified with respect to geographical situation, land quality, weather factor, local agricultural policy and output quality. The whole area is therefore divided into five regions; North & West Delta, Middle Delta, East Delta, Middle Egypt and Upper Egypt. *

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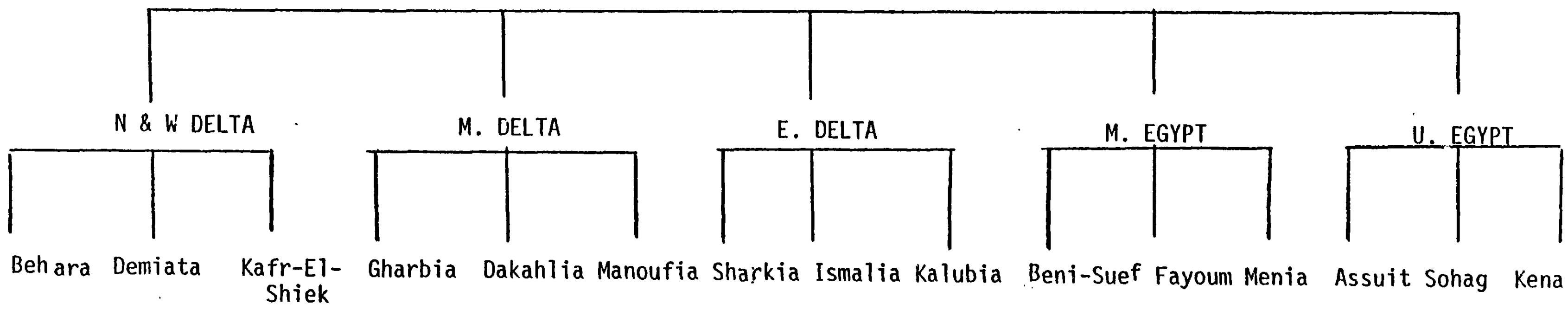
* Chart VI - 1

CHAPTER VI - 1

CLASSIFIED REGIONS



Assuming allocative efficiency in terms of profit maximisation, the general approach is to estimate marginal products from a disaggregated production function fitted to each set of data and then test for equality between the estimated values of marginal products (VMP) and marginal costs (MC). A significant difference between VMP and MC is taken as evidence of inefficient resource allocation. Langregean techniques for constrained extrema are applied in determing the optimum level of output. (2) The procedure applied in selecting the relevant form of production function is to try various algebraic forms which are believed to be consistant with production logic in Egyptian agriculture, and select the one which provides the "best fit".

Three major specifications are considered in selecting input variables. First, the omitted variables are those of least importance or those of relatively constant nature. Secondly,some account is taken of the quality differentials within each input, either by disaggregating the input with various qualities into more than one variable or by using weighted measures. Thirdly, aggregating over inputs is avoided as far as data will allow. The land variable is omitted from the function by considering the correlation between the output and relevant inputs for a given unit of land (Feddan). * Land is fixed and immobile in the short-run, and there is perhaps little to be done to correct land misallocation. Indeed land is restricted according to soil structure, availability of water and crop rotation. However, knowledge of the marginal product of the existing land might not be useful in projecting future policy concerning land reclamation, since the productivity of new land would differ from that of the existing land.

The present chapter is devoted to testing technical efficiency using time series data. In Chapter VII, cross sectional production functions for the various classes of farms are estimated and tested. Economic efficienty is investigated in a final chapter

* Feddan = 1.04 acre

An Estimate of Time Series Production Function

Time series data used in estimating the underlying production functions were collected during January - April 1977, from various bodies and through some reports as well as personal contact with the officials. The data were collected separately for the three crops under investigation to cover the period 1960-75 for cotton and rice and the period 1960-76 for wheat. In the case of cotton, only the years 1962-75 are considered due to the exceptional unfavourable biological factors that prevailed in 1961. Data before 1960 are niether reliable nor sufficient for the purpose under investigation.

VI - 1 Choice and Specification of variables

Given knowledge of the mechanics of production process in Egyptian agriculture, all the possible relevant inputs are included in the production function to be statistically tested.

Output (Y):

Output per Feddan is measured in local physical units: Kentare (cotton) Ardab (wheat), and Duriba (rice).* Output quality for wheat and rice are rather homogeneous among regions and over the whole period, but not for cotton. Three types of cotton; long staple (above $1\frac{3}{8}$"), long medium staple (>$1\frac{1}{4}$" - $1\frac{3}{8}$"), and medium staple (>$1\frac{1}{8}$" - $1\frac{1}{4}$") are produced in Egypt. Since 1960, only one type is produced in North & West Delta (long staple) and in Middle Egypt and Upper Egypt (medium Staple). In Middle Delta and East Delta, both long and long medium staples are cultivated, but at constant proportion over the whole period.(3) Output quality differentials are therefore not significant.

Labour (X_1)

Due to lack of information, no distinction between family and hired

* Kentare = 157.5 l.g. Ardab = 150 k.g. Duriba = 940 k.g.

labour is made. Labour data were converted into standard man-units assuming two children of 10 - 15 age or females as equivalent to one man unit. This assumption is justified, since male adults wage rate is twice of wage rate paid either to child or woman. (4) Moreover, a recent study made by Ministry of man-power suggests that child or woman productivity is nearly one-half of male adult productivity. (5) Man-units were, in turn, converted into man/ hours to accomodate variations in the daily working hours. During the slack seasons, the working hours are six a day, whilst they are eight in the peak seasons (i.e.harvesting and plant protection). (6)

Machines (X_2)

Machines are measured in money terms at fixed cost (1966 = 100). Apart from few large farmers who use a variety of machines, machines are partly used in land preparation, irrigation, threshing and plant protection. (7) Threshing is confined to rice and wheat, and plant protection is not used on wheat. The operating cost per hour at fixed prices for each type of machines is computed by applying the following formula;

$$C = \frac{D + T + G + F + O + M + W + A}{H}$$

where
C is cost per hour

D is the annual depreciation.

$$D = \frac{FV + I - SV}{EL}$$

where
FV is the fixed value of machine at 1966 prices.

I is the intrest 4%

SV is the scrap value

EL is the expected life in years.

T is the annual tax and insurance

G is the annual cost of building for housing the machine

F & O are the annual cost of Fuel and Oil respectively.

M is the annual repairs and maintenance

W is operator wage per year

A is administrative expenses per year

H is the annual working hours.

The aggregate cost of machines power is obtained by multiplying the cost per hour of each type of machine by the corresponding working hours during the production period, to be added together.

Animals (X_3)

Animals used in agricultural activities (i.e. land preparation and irrigation) are measured in horse-power / hour. Animal / hour units were converted into standard units of horse-power / hour assuming that Cow or Buffalo is equivalent to 0.45 horse-power and Bullock or Ox is equivalent to 0.75 horse-power. (8)

Chemical Fertilisers

Two types of fertilisers;Nitrogenous(X4) and Phosphate(X5) are applied to cotton and rice cultivation, while only nitrogenous fertilisers is used on wheat. Since the proportion of plant nutrient is not homogeneous, chemical fertilisers in kilogrammes of gross weight were converted into standard units of plant nutrient. Due to the absence of information on the amount actually used of chemical fertiliser, estimates were based on sales figures.

Manure (X_6)

Manure is measured in physical units of cubic metre.

Insecticides

Insecticides used in the present period (X_7) and that used in the previous year ($_{71}$) are included, but separately in the production function. Lagged insecticides is included to test its impact on crop yield of the following year. Insecticides are measured in fixed cost at 1966 prices which is based on the price index of industrial materials. (9)

The Level of Irrigation Water (X_8)

Irrigation water is available in amounts generally in excess of demand at the time of growing wheat. (10) The irrigation water variable is omitted from wheat function, because water supply is controlled and regulated at the required level over the period understudy.

In the absence of storage, irrigation water would not suffice for the requirements of summer crops. (i.e. cotton and rice). The level of water would then fluctuate from one year to another depending on the improvement of storage reservoirs. In Delta, perennial irrigation which regulates both the timing of irrigation and the quantities of water * has been prevailed over the period understudy. In Middle and Upper Egypt perennial system was not dominant though expanding overtime.(11) The irrigation water variable is therefore included only in the cotton function of both Middle Egypt and Upper Egypt and measured in cubic metres.

High Yielding variety seeds (HV)

The quantity of seeds applied to a given unit of land with respect to each individual crop is more or less constant over time. Variation would be in the quality of seeds used. High yielding variety seeds are therefore measured as a proportion of the total amount of seeds used except in the case of cotton where quality was homogeneous.

Weather Index (W)

Variations in weather are measured as deviations from the mean for the period under study. Technically, two meteorological factors;

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* perennial irrigation involves an elaborate system of storage reservoirs to supplement the natural flow of the Nile during the annual low-water period to maintain the flow into the canals.

temperature and humidity would affect the crop yield , while rainfall is of negligible importance. All the area under cultivation in Egypt is fully irrigated. However, three steps are processed. [12] First, monthly observations on temperature and humidity over the production period were collected for the whole period from weather stations. Separate linear functions are fitted for temperature and humidity by regressing the average value over the production period against the monthly value to obtain weights for monthly observations.

Thus,

$$\hat{P}_t = a_1 P_{t1} + a_2 P_{t2} + \dots\dots\dots\dots + a_n P_{tn}$$

$$\hat{H}_t = b_1 h_{t1} + b_2 h_{t2} + \dots\dots\dots\dots + b_n h_{tn}$$

where,

P and H are the fitted values of the average temperature and humidity respectively in year t. P_{ti} and h_{ti} $(i=1,2,\dots\dots n)$ are the monthly values of temperature and humidity respectively.

Crop yield is then regressed against the fitted value of both temperature, P_t and humidity H_t . Time is inserted in the function as an integer-valued variable allowing for technological advance. Both linear and quadratic functions are fitted. Linear regression, in all cases, gave better fit. Hence,

$$\hat{y} = \alpha_o + \alpha_1 P_t + \alpha_2 H_t + \alpha_3 T$$

$$\hat{y} = \beta_o + \beta_1 P_t + \beta_2 P_t^2 + \beta_3 H_t + \beta_4 H_t^2 + \beta_5 P_t H_t + \beta_6 T + \beta_7 T^2$$

The linear function was therefore selected. Time was found to be insignificant with a small coeffieient. It is omitted from the function.

The weather index is obtained by applying the following formula, [13]

$$W = \frac{\alpha_1 P_t + \alpha_2 H_t}{\alpha_1 \bar{P}_t + \alpha_2 \bar{H}_t}$$

Where, $\bar{P}_t$ and $\bar{H}_t$ are the mean values of temperature and humidity over the whole of the period under consideration.

Time (T)

Time is included in the function to express the changes over time that have not been embodied in the other included variables. It might express changes in technical progress, land fertility, farm size etc.

The data summary and related statistics on the included variables are given in tables VI - 1,2,3. Some general comments can be derived:

1. The average size of holding in all regions is declining over time. This is perhaps due to the redistribution of agricultural land in favour of small farmers (i.e. Land Reforms of 1952, 65 & 69).(14) The impact of size of holding has not considered though it might be significant, because the available data are not classified into holding size.

2. Apart from cotton yield in Upper Egypt, variations in cotton and rice yields are not significant. The relatively high variations in cotton yield in Upper Egypt is perhaps due to the sudden increase or dramatic reduction in production resulted from exceptional few good or bad years.(15) Wheat yield is increasing particularly over the last few years (1970-76). This might be attributed to the introduction of high-yielding seeds. This is unlike rice for which high yielding varieties were introduced in 1950s. Since 1960 there was no real improvement in seed quality.

3. Labour employed in all the three crops has declined slightly over the whole period. While machine use has considerably increased, animal use moved in the opposite direction.

4. There is a tendency for chemical fertiliser, insecticides, and manure to move together over time. Chemical fertiliser, and insecticdes have gradually been increasing, while manure was decreasing.

5. The variation in the broad pattern of variables' behaviour over the whole period is not significant either among regions or between the underlying crops.

TABLE VI - 1
Geometric mean and coefficient of variation of the level of inputs used and output produced in Cotton cultivation 1962 - 75

Source : See Table VI - 3

	Average Size	Y " "	X_1 Man/hour	X_2 Cost at fixed prices	X_3 Horse-power/hour	X_4 Pl.Nutriant K.g.	X_5 Pl. Nutriant K.g.	X_6 Cubic Met.	X_7 Cost at fixed prices	X_{71} Cost at fixed prices	X_8 Cubic Met.	W Deviation
N.&W. Delta												
MEAN	4.924	4.612	547.235	1.264	55.538	34.250	9.461	7.785	8.297	7.830	-	1.00
Stand. Deviation	1.862	0.417	66.705	0.972	32.053	9.343	2.107	1.460	2.931	1.938	-	0.659
Coefficient of variation	0.378	0.090	0.122	0.769	0.577	0.273	0.223	0.187	0.353	0.247	-	0.659
Trend	-	-	-	+	-	+	+	-	+	+		
M. Delta												
MEAN	2.601	5.521	570.567	2.385	53.126	39.341	9.571	4.816	8.803	7.798	-	1.00
Stand. Deviation	0.778	0.563	69.984	1.812	28.828	12.206	1.715	1.616	3.371	1.908	-	0.382
Coefficient of variation	0.299	0.102	0.123	0.760	0.543	0. 310	0.179	0.336	0.383	0.239	-	0.382
Trend	-	+	-	*	-	+	+	-	+	+		
E. Delta												
MEAN	2.841	5.632	598.338	1.964	53.589	38.229	8.466	7.889	8.211	7.317	-	1.00
Stand. Deviation	0.978	0.788	57.903	1.512	28.272	10.976	1.753	0.879	3.297	2.030	-	0.022
Coefficient of variation	0.344	0.140	0.097	0.770	0.528	0.287	0.207	0.111	0.402	0.277	-	0.022
Trend	-	+	-	+	-	+	+	-	+	+		
M. Egypt												
MEAN	2.824	5.374	519.892	1.877	30.586	42.223	7.333	8.745	5.563	5.002	3.751	1.00
Stand. Deviation	0.751	0.480	32.651	0.488	15.671	11.191	2.202	3.345	2.265	1.924	0.047	0.702
Coefficient of variation	0.266	0.089	0.063	0.260	0.512	0.266	0.300	0.383	0.407	0.385	0.012	0.702
Trend	-	+	-	+	-	+	+	-	+	+		
M. Egypt												
MEAN	2.452	5.349	541.655	8.301	37.302	46.478	6.641	0.700	6.000	4.857	5.325	1.00
Stand. Deviation	0.500	0.908	36.308	1.286	12.930	9.061	1.677	1.135	3.879	2.877	0.350	0.737
Coefficient of variation	0.204	0.170	0.067	0.155	0.347	0.195	0.252	1.622	0.646	0.592	0.066	0.737
Trend	-	+	-	+	-	+	+	-	+	+		

TABLE VI - 2

Geometric means and coefficient of variation of the level of inputs used and output produced in wheat cultivation

	Y "ARDAB"	X_1 Man/Hour	X_2 Cost at fixed prices	X_3 Horse-power/ hour	X_4 Plant Nutriant	H.V. Propor-tion	X_6 Cubic Metres	π Devia tion
N & W Delta								
MEAN	6.657	153.445	1.331	65.123	33.458	0.046	2.875	1.00
St. Deviation	1.300	28.563	1.706	30.163	9.565	0.104	1.157	0.025
Cost of variation	0.195	0.186	1.282	0.463	0.286	2.255	0.402	0.025
Trend	+	-	+	-	+	+	-	
M. DELTA								
MEAN	8.470	153.716	1.981	68.546	40.021	0.045	2.382	1.00
St. Deviation	1.271	29.709	2.292	41.740	18.423	0.104	1.867	0.061
Cost of variation	0.150	0.194	1.157	0.609	0.460	2.322	0.784	0.061
Trend	+	-	+	-	+	+	-	
E. DELTA								
MEAN	8.304	163.562	2.289	55.803	36.224	0.062	5.034	1.00
St. Deviation	1.462	17.659	2.905	35.275	15.702	0.138	4.042	0.053
Cost of variation	0.176	0.108	1.269	0.632	0.433	2.222	0.803	0.053
Trend	+	-	+	-	+	+	-	
M. EGYPT								
MEAN	8.386	160.944	1.421	49.747	38.688	0.040	6.787	1.00
St. Deviation	0.824	18.570	1.518	29.622	11.205	0.088	2.677	0.038
Cost of variation	0.10	0.115	1.069	0.595	0.290	2.230	0.394	0.038
Trend	+	-	+	-	+	+	-	
U. EGYPT								
MEAN	7.908	184.767	3.850	62.056	44.618	0.02	-	1.00
St. Deviation	0.873	15.675	1.928	31.285	8.482	0.068	-	0.021
Cost of variation	0.110	0.085	0.501	0.504	0.190	3.422	-	0.021
Trend	+	-	+	-	+	+		

Source : See Table VI - 3

TABLE VI - 3

Geometric Mean and Coefficient of variation of the level of input used and output produced in Rice cultivation (1960 - 75

	Y "Dariba"	X_1 Man/hour	X_2 Cost at fixed price	X_3 Horse-power/hour	X_4 Plant Nutriant K.g.	X_5 Plant Nutriant K.g.	H.V. Proportion	X_6 Cubic Metres	X_7 Cost at fixed prices	X_7 Cost at fixed prices	W Deviation
N & W Delta											
MEAN	2.347	335.045	1.129	90.020	27.778	7.427	0.875	6.293	0.057	0.040	1.00
Stand. Deviation	0.130	38.264	0.345	49.515	7.043	1.828	0.109	2.375	0.127	0.114	0.047
Coef. of variation	0.055	0.114	0.305	0.550	0.254	0.246	0.126	0.377	2.244	2.874	0.047
Trend	+	-	+	-	+	+		-	+	+	
M. DELTA											
MEAN	2.262	317.938	1.693	88.085	30.594	7.639	0.869	4.773	0.086	0.044	1.00
Stand. Deviation	0.135	52.599	0.592	49.129	7.525	1.565	0.092	2.907	0.204	0.133	0.541
Coef. of variation	0.06	0.165	0.350	0.558	0.246	0.205	0.106	0.609	2.372	3.008	0.541
Trend											
E. Delta											
MEAN	2.266	366.542	0.947	91.669	28.755	6.313	0.953	3.489	0.038	0.020	1.00
Stand. Deviation	0.120	36.579	0.175	46.100	9.816	1.973	0.056	1.708	1.103	0.081	0.236
Coef. of variation	0.053	0.10	0.185	0.502	0.341	0.312	0.059	0.490	2.741	4.00	0.236
Trend											

Sources :

1. Ministry of Agriculture, Department of Agricultural Economics and Statistics (from records)
2. Ministry of Manpower, Department of Agricultural labour.
3. Ministry of Agriculture, Department of Agricultural Mechanisation, "unpublished report".
4. Personal contact with the Director of Department of Agricultural Mechanisation.
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VI - 2 Specification and Estimation of the Model

A disaggregated production function is fitted for each crop within each region by regressing crop yield against the above specified variables. Both linear and Cobb-Douglas functions are estimated. No other forms have been attempted because of the small size of sample. Non-linear forms, other than Cobb-Douglas, would reduce the degrees of freedom unduly. In most cases, a linear function produced better fit in terms of the adjusted coefficient of multiple determination $\bar{R}^2$, F ratio, and the significance of the estimated coefficients. The assumption of linear correlation between output and inputs seems to be an empirical approximation of production conditions over the period under study. This is perhaps true in such short period during which no radical changes in technology took place. The changes in inputs used are not great enough to change output non-lineary. Indeed, using the average of the whole region might be attributed to such linear relation. However, a linear function would not permit the marginal product to change.

The fitted functions for the underlying crops are as follows:-

Cotton function

14 samples (1962 - 75)

$$y = ao + a_1 x_1 + a_2 x_2 + a_3 x_3 + a_4 x_4 + a_5 x_5$$
$$+ a_6 x_6 + a_7 x_7 + a_{71} x_{71} + a_w W + a_t T$$

*Irrigation water is added in the function for Middle Egypt and Upper Egypt.

Wheat Function

17 samples (1960 - 76)

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* Manure (x6) is excluded from Upper Egypt function.

$$y = b_0 + b_1 x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_6x_6 + b_{hv} HV + b_w W + b_t T.$$

Rice function

16 samples (1960 - 75)

$$y = c_0 + c_1x_1 + c_2x_2 + c_3x_3 + c_4x_4 + c_5x_5 + c_6x_6 + c_7x_7 + c_{71}x_{71} + c_{hv} HV + c_w w + c_t T.$$

The marginal product in a linear function is directly estimable in terms of the coefficient of respective input (i.e. first deriative). The estimated coefficients and related statistics for the underlying functions are shown in Appendix B. Some features emerge:

1. Although the adjusted coefficient of multiple determination $\bar{R}^2$ in ten out of thirteen functions is fairly high with significant F ratio, only 27 out of 125 input coefficients are significant at less than or equal to 10 per cent level of significance. 54 coefficients have negative sign of which only 14 are significant. Apart from irrigation water (X8), weather (W) and time (T), the negative sign is not consistent with the assumption of economic rationality. Such good fit with large number of insignificant coefficients may be attributed to the existence of high degree of multicollinearity among the independent variables. Correlation matrix (Appendix C) shows that, in all cases, high inter-correlation exists between machines, X_2, animals X_3, Nitrate X_4, and Time T, and in some cases other variables such as labour X_1 (i.e. rice function in N & W Delta and E. Delta), manure X_6 (i.e. wheat function in N & W Delta and E. Delta), and weather index W (i.e. cotton and wheat functions in M. Delta, and rice function in E. Delta) are highly correlated with the above variables. Such high degree of multicollinearity would introduce wrong estimates of intercept and slope coefficients. (16)

2. Out of thirteen fitted functions, in only four the random variable is not serially correlated, as Durbin-Watson test suggests. Indeed Durbin-Watson test is not always appropriate particularly if lagged

variable is included in the function [17] as the case of cotton and rice. The auto-correlation coefficients for the fitted functions are therefore estimated by regressing the residual of one year against the previous year. [18] It appears that negative serial correlation exists in all nine functions. Thus the assumption of independence of the disturbance would not be valid, and the regression coefficients might not be unbiased, nor have they minimum variances.

It seems that the underlying fitted functions are disturbed by the existence of both multicollinearity and auto-correlation. Unless these two statistical problems are solved, one would have no confidence on the estimated functions for further analysis. [19]

Multicollinearity

Although input disaggregation is desirable in the economic sense it usually reveals high inter-correlation among the independant variables, particularly in time series estimates where variables tend to move together over time. Statistically, multicollinearity can be minimised either by aggregating correlated variables, using factor analysis, or by dropping one or more of the correlated variables. Unless the statistical solution does not conflict with the economic meaning of the study, removing multicollinearity is not desirable. Aggregation over the correlated variables is rejected because it reduces the meaningfulness of the estimate and interrupt the interpretation of results. Factor analysis technique is also excluded because it destorts the actual nature of relationship between input variables, by absorbing all the correlated variables into one factor.

The approach adopted is to omit one or more of the correlated variables. This is done in a stepwise fashion. It is true that this approach is not always successful, and might introduce specification error in the model as well as reduce the meaningfulness of the estimates.

In order to avoid mis-specification error, the omitted variables are confined to those with small (close to zero) and insignificant coefficients. Unless the fit of the functions is improved, the omitted variable is retained. The procedure is carried on until the best fit is reached. Important variables even with insignificant coefficients have not been dropped. Thus no important information is missed, and one can safely assume that the marginal product of the omitted variable is approaching zero. In many cases, it was found that labour, animal and nitrogenous fertilisers, and in some cases manure, are not important variables in marginal terms. By removing one or more of these variables, the fit of the function is improved.

The new fitted functions suggest (Tables VI - 4, 5 & 6)

1. The adjusted coefficient of multiple determination $\bar{R}^2$ is improved in all individual functions except two : cotton function in N & W Delta and wheat function in E. Delta, for which $\bar{R}^2$ is slightly reduced from 0.96 to 0.94 and from 0.91 to 0.90 respectively. The F ratio of all equations is now highly significant at the 1 per cent level, implying that all the specified independent variables are important for explaining the variation in the dependent variable. Thus, one would expect the estimated input coefficients to be significant.

2. Out of 69 input coefficients, only 11 are insignificant against 98 out of 125 before applying the underlying procedure. 27 input coefficients have negative sign.

3. Apart from minor changes in the numerical values of the estimated coefficients the general behavious of the fitted functions has not radically been changed after the correction procedure.

TABLE VI - 4

The New Estimated Coefficients and Related Statistics in Wheat Cultivation
(Linear production function)

	N & W Delta	M. Delta	E. Delta	M. Egypt	U. Egypt
Constant	- 4.526	2.607	- 8.244	13.697	22.309
t. stat	(- 0.363)	(0.794)	(- 1.709)	(2.558)	(4.974)
X_1	- 0.0115		0.024**	0.0217*	
t.stat	(- 1.201)		(2.088)	(3.267)	
X_2	0.528*	0.368*	0.212***	0.331**	0.164**
t. stat	(3.763	(3.716)	(1.829)	(2.073)	(2.377)
X_3					
X_4			- 0.0046	-0.153*	0.0664*
t. stat			(- 0.147)	(-3.072)	(3.625)
X_6				0.0929 ***	
t. stat				(1.838)	
H.V.	1.697**	1.134**	2.951	5.903*	5.160*
t. stat	(2.677)	(2.707)	(1.514)	(3.361)	(3.009)
W	12.025	5.148**	12.090**	- 7.084	- 17.872*
t. stat	(1.028)	(2.486)	(2.773)	(-1.535)	(-3.979)
T				0.321*	
t. stat				(3.594)	
$\bar{R}^2$	0.754	0.826	0.887	0.844	0.81
F. stat	13.255*	26.297	26.1773*	13.343*	18.045*
D.W.	2.175	1.5046	1.3618	2.947	1.7231
Aut Coef.	- 0.1496	0.2263	0.29	- 0.490	0.0985

* Significant at the 1% level
** Significant at the 5% level
*** Significiant at the 10% level

TABLE VI - 5

The new estimated coefficients and related statistics in cotton cultivation

(Linear Production Function)

	N & W Delta	M. Delta	E. Delta	M. Egypt	U. Egypt
Constant	5.262	10.361	17.193	35.986	- 26.716
T. stat	(11.352)	(20.806)	(3.796)	(4.07)	(- 3.895)
X_1	0.0048*	- 0.0028*		-0.0084*	
T. stat	(5.346)	(-4.439)		(-4.717)	
X_2	0.429*	0.195*	0.878*	0.702*	1.322*
T. stat	4.149	(7.068)	(5.748)	(4.401)	(5.967)
X_3				-0.494*	0.133*
T. stat				(-4.288)	(4.455)
X_4	- 0.0958*		- 0.0814*		- 0.0616
T. stat	(- 8.864)		(- 3.450)		(-1.661)
X_5		- 0.239*	- 0.133***	0.0489	0.257
T. stat		(- 9.193)	(- 1.951)	(1.083)	(1.868)
X_6	- 0.0485	- 0.128*		0.217*	- 0.204***
T. stat	(- 1.489)		(- 4.331)	(4.722)	(- 2.248)
X_7				- 0.0573	- 0.323*
T. stat				(- 1.641)	(4.491)
X_{71}	- 0.184*	- 0.098*			
T. stat	(- 8.150)	(- 3.855)			
X_8				- 9.539*	2.378**
T. stat				(- 4.665)	(2.575)
W	- 0.321*		- 9.061**	7.828	0.894*
T. stat	(5.954)		(2.008)	(1.894)	(4.686)
T	0.223*				
T. stat	(5.271)				
$\bar{R}^2$	0.94	0.927	0.86	0.87	0.93
F. stat	31.23*	33.870*	20.647*	11.537*	23.201*
D.W.	2.509	2.854	1.954	3.528	2.394
Aut. Coef.	- 0.367	- 0.437	- 0.036	- 0.817	- 0.222

* Significant at the 1% level
** Significificant at the 5% level
***Significant at the 10% level

TABLE VI - 6

The new estimated coefficients and related statistics in rice cultivation

(Linear production function)

	N & W Delta	M. Delta	E. Delta
Constant	2. 055 (19.927)	- 0.0256 (- 0.0497)	0.892 (5.231)
X_1		- 0.0011*** (- 2.379)	
X_2	0.0788* (10.297)	0.435** (2.937)	0.679* (4.236)
X_3		- 0.0023*** (- 2.633)	
X_4	- 0.018* (- 5.859)		
X_5		0.0627* (3.645)	
X_6			
X_7			0.300** (2.637)
X_{71}		0.510* (3.619)	
H.V.	0.248*** (2.488	1.069* (3.607)	0.976* (3.950)
W		1.353*** (2.348)	
T	- 0.0189** (- 2.989)	- 0.0789* (- 3.543)	-0.025* (-5.242)
$\bar{R}^2$	0.957	0.912	0.912
F. stat	67.5096*	20.526*	39.98*
D.W	2.947	3.2949	2.0025
Aut. coef.	-0.6542	- 0.6736	0.0025

Figures between brackets refer to t statistics

* Significant at the 1% level.

** Significant at the 5% level.

*** Significant at the 10% level.

4. The degree of multicollinearity is greatly reduced, though it still exists in some few cases.* Any further attempt to reduce the degree of multicollinearity would not be feasible, and might destort the estimates.

Autocorrelation

The correction of the incidence of serial correlation depends entirely on the source of auto-correlation. It might result from mis-specification of the mathematical form, omission of one or more important explanatory variables, or mis-specification of the true random term U. These three main sources of autocorrelation are tested. Serial correlation with respect to non-linear function (appendix B) is as high as in linear function. Fitting a linear function is therefore not the cause of auto-correlation.

Auto-correlation might be influenced by the omission of unidentified variables such as farm size, form of tenure or land fertility. Also purely random factors such as abnormal weather or biological conditions could be the cause of serial correlation.

However the estimated auto-correlation coefficients (tables VI - 4, 5 & 6) show that negative serial correlation is the dominant feature. More than one factor could be the reason for such negative auto-correlation. Continuous reduction of the size of holding or deterioration in land fertility might have a negative affect on production. Negative serial correlation could also be attributed to low yield caused by unfavourable biological conditions.

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* See appendix D.

Serial correlation is corrected by transforming the original data into a new set of data which is a product of the original observations of one period minus the product of autocorrelation coefficient $\hat{\rho}$ times the value of the variables in the previous period.

$$Y - \hat{\rho}Y_{t-1} = (1 - a_o) + (x_1 - \hat{\rho}x_{1t-1}) + \ldots\ldots + (x_n - \hat{\rho}x_{nt-1})$$

The new residualls are also tested for auto-correlation. If they fail to pass Durbin-Watson test, the procedure is repeated for second, third differences and so on until serial correlation is minimised. The final structure of the fitted functions is reported in tables VI 7, 8 & 9.

It appears that serial correlation in all functions except four is nearly eliminated. Apart from the cotton function in Middle Delta, serial correlation is not serious in the other three functions (i.e. $\hat{\rho}$ is less than -0.5 and the Durbin-Watson test is less than or equal to 2.5). Only three input coefficients are now insignificant (i.e. X_6 in the cotton function, and X_1 and W in the wheat function). Except two functions, the adjusted coefficient of multiple determination $\bar{R}^2$ is improved.

TABLE VI - 7

The Final estimate of the production function (Cotton)

1962 - 75 (14 samples)

Independent variables	N & W Delta	M. Delta	E. Delta	M. Egypt	U. Egypt
Constant "C"	5.262 (11.352)*	27.054 (12.722)*	17.193 (3.796)*	101.475 (18.50)*	-16.948 (4.411)*
X_1	0.0048 (5.346)*	-0.0029 (-2.762)**	- -	- 0.0094 (-20.649)*	-
X_2	0.429 (4.149)*	0.199 (4.29)*	0.878 (5.748)*	0.760 (9.459)+	0.994 (6.288)*
X_3	-	-	-	- 0.0583 (- 7.949)*	0.102 (4.691)*
X_4	-0.0958 (-8.864)*	-	-0.0814 (-3.450)*	-	-
X_5	-	-0.268 (-6.447)*	-0.133 (-1.951)***	0.0568 (2.738)	-
X_6	-0.0485 (-1.489)	-0.149 (-2.910)**	-	0.247 (9.114)*	-0.252 (-2.274)**
X_7	-	-	-	- 0.0694 (- 5.517)*	-0.154 (-2.189)**
X_{71}	-0.184 (-8.150)*	-0.0844 (4.214)*	-	-	-
X_8				- 9.940 (-11.237)*	1.344 (2.140)**
W	-0.321 (5.954)	-	- 9.061 (2.008)***	10.885 (3.583)*	-
T	0.223 (-5.271)	-	-	-	0.599 (4.683)*
$\bar{R}^2$	0.94	0.99	0.86	0.996	0.92
F. stat	31.23*	156.867*	20.647*	389.981*	23.294*
D.W.	2.509	2.222	1.954	2.928	1.945
Aut. Coef.	-0.367	-0.29	- 0.036	-0.62	- 0.06

* Significant at the 1% level
** Significant at the 5% level
*** Significant at the 10% level

Figures between brackets refer to t statistics

TABLE VI - 8

The Final estimate of the production function (Wheat)

1960 - 76 (17 samples)

Independent Variables	N & W Delta	M. Delta	E. Delta	M. Egypt	U. Egypt
Constant "C"	- 9.775 (-0.686)	2.811 (1.185)	- 1.887 (- 0.769)	101.325 (11.754)*	22.309 (4.974)*
X_1	- 0.0115 (- 1.281)	-	- 0.0203 (2.431)**	0.024 (8.893)*	-
X_2	0.508 (3.863)*	0.389 (3.611)*	0.217 (2.770)**	0.577 (6.263)*	0.164 (2.377)**
X_3	-	-	-		-
X_4	-	-	-	- 0.199 (-11.961)*	0.0664 (3.625)*
$\bar{H}\bar{V}$	2.398 (2.945)**	0.571 (2.360)**	2.450 (2.035)***	9.415 (16.594)*	5.160 (3.009)**
X_6	-	-	-		-
W	16.088 (1.383)	4.129 (2.281)**	8.011 (2.068)***	-21.091 (- 8.735)*	-17.872 (3.979)*
T	-	-	-	0.212 (6.47)*	-
$\bar{R}^2$	0.81	0.74	0.68	0.99	0.81
F. stat	17.211*	15.237*	7.850	325.725*	18.045*
D. W.	2.084	1.941	1.944	2.640	1.723
Aut. Coef.	- 0.088	-0.018	0.007	- 0.44	- 0.098

* Significant at the 1% level
** Significant at the 5% level
*** Significiant at the 10% level

Figures between brackets refer to t statistics

TABLE VI - 9

The Final Estimate of the production function (Rice)

1960 - 75 (16 samples)

Independent variables	N & W Delta	M. Delta	E. Delta
Constant "C"	8.804 (19.677)*	1.024 (1.261)	0.892 (5.231)*
X_1	-	0.00105 (-2.929)**	-
X_2	0.766 (7.974)*	0.409 (3.826)*	0.679 (4.236)*
X_3	-	-0.0025 (-4.829)*	-
X_4	-0.020 (-15.675)*	-	-
X_5	0.0412 (8.585)*	0.0474 (2.505)**	-
HV	0.313 (8.507)*	0.873 (4.718)*	0.976 (3.950)*
X_6	-	-	-
X_7	-	-	0.300 (2.637)**
X_{71}	-	0.521 (6.613)*	-
W	-	1.223 (3.700)*	-
T	-0.015 (-1.955)***	-0.0787 (4.738)*	-0.025 (-5.242)*
$\bar{R}^2$	0.997	0.98	0.912
F. stat	856.358*	110.629*	39.98*
D. W.	2.002	2.651	2.0025
Aut. Coef.	-0.02	-0.392	0.0025

* Significant at the 1% level
** Significant at the 5% level
*** Significant at the 10% level

Figures between brackets refer to t statistics

VI - 3 Interpretation of Results

Some general characteristics emerge from the estimated marginal products.

1. Apart from few cases, the estimated marginal products of labour X_1, animal X_3, chemical fertilisers X_4 and X_5, and manure X_6 are very small and in some cases they are negative. Further use of these inputs would then have little impact on production. Such an intensive use of inputs might be attributed to the relatively low cost of the underlying inputs. Family labour is available in surplus during the slack seasons and it is more or less costless to the farmers. Animals are usually kept to produce cheap milk and meat, hence no further cost will be paid if they were used in agricultural activities. Manure is produced locally at no extra cost. Chemical fertiliser is subsidised and purchased on credit. Since the estimated marginal product for any of these inputs does not vary significantly between regions and crops, there would be little increase in production if it is reallocated among the various regions or crops.

2. It seems that insecticides applied to cotton and rice crops during the period understudy have a limited impact on crop yield. One interpretation is possible. Insecticides have been systematically and continuously used either efficiently or inefficiently over the whole period. Experimental studies made in this field show that insecticides are of particular importance to cotton crop.[20] However, in some few cases such as cotton in Upper Egypt and North West Delta and rice in East Delta, crop yield and insecticides are negatively but significantly correlated. In the case of rice in Middle Delta crop yield is positively affected by the variations in insecticides used.

3. The amount of water available for cotton cultivation in Upper Egypt is a significant factor, implying the necessity of improving irrigation

system. Unlike Upper Egypt, the increase in the amount of water has negative affect on cotton yield in Middle Egypt. Water is available in excess with an inefficient drainage system.

4. The use of machines and high yield variety seeds makes a considerable contribution to production. The yields of all the underlying crops in all regions would therefore be improved if resources are reallocated in favour of machines and high yield variety seeds. Furthermore, there will be significant productive use for machines if they reallocated either among crops or among regions. Marginal product of machines used in wheat crop is generally low compared with the other crops. Cotton production could be increased if machines reallocated from Middle Delta and North & West Delta to the other regions, while reallocating machines in favour of Middle Egypt and North and West Delta would improve wheat production. The marginal products of machines allocated to rice crops do not vary greatly from one region to another. On the other hand high yield variety seeds are an extremely important factor with respect to wheat yield, perhaps due to the recent introduction of Mexican varieties. The contribution of high yield variety seeds to rice yield, though significant is less than to wheat yield. It is relatively low in North and West Delta.

5. The weather affects the wheat crop even with small variations, while cotton and rice yields were influenced by weather variations only where they were large. The latter case applies to cotton function in North and West Delta, East Delta and Middle Egypt, and rice function in Middle Delta.

6. The general behaviour of the individual fitted functions is more or less homogeneous implying similar pattern of resource allocation either among regions or between crops.

However, the accuracy of the estimated functions is limited by the availability and reliability of data. While family labour is usually estimated as the members of family available over the production period, hired labour is estimated as input actually used. Biased estimate might be introduced if the proportion of family labour to the total labour varies from one year to another. Data on manure and animals used are roughly estimated. Chemical fertilizers data are based on the value of sales rather than input actually used. Instead of using them, some farmers might re-sell their quota to get çash. Unless input purchased and that used are proportionaly related over the whole period, the estimated coefficients of chemical fertilizer would be deviated from the true value. Insecticides are used in various types and qualities varied from one year to another destorting homogeniety condition. Some factors which could be important such as farm size and pattern of ownership are neglected.

Cross sectional data collected directly from the farmers are therefore used to overcome the above deficiencies, and to test resource allocation efficiency among farms of different sizes and tenures.

CHAPTER VII

An Estimate of

Cross Sectional Production Function

"Technical Efficiency 2"

CHAPTER VII

An Estimate of Cross Sectional Production Function

"Technical Efficiency 2"

VII - 1: Objectives, Classifications and Data Collection

Cross sectional data collected from field studies conducted in Egypt for crop year 1975, are used to test allocative efficiency hypothesis. The investigation is confined to cotton production, cotton being the major single crop. The specific objectives are:

1. To test the hypothesis that there are significant differences between different farm size classes.

2. To test the hypothesis that there are no significant differences among various tenure forms within each farm size class.

3. To investigate economic efficiency among the various stages of cultivation on farms of different sizes and tenures.

4. To examine the impact of time spent on cultivation on agriculthral production.

5. To estimate the productivity gap through the application of optimisation techniques in order to indentify the relevant farm class to Egyptian agriculture.

The present chapter is devoted to describing the method of collection and characteristics of the collected data. Variables and model specifications, results and related statistics are also presented. In Chapter VIII, resource allocation efficiency on the different classes of farm size and tenures are tested. Implication of the findings for agriculthural policy is examined.

Classes of Farm Size

Three classes of farm size; small (less than 5 Feddans), medium (5 - <20 Feddans) and large farms (20 or more Feddans) are considered in the present study. The maximum ownership as well as maximum holding of land is now 50 Feddan per person and 100 Feddan per family. Data on the number of farmers and size of holding within each class of farm size are summarised in table VII-1. The following features emerge:

1. In all regions except North and West Delta, 60 per cent or more of cotton area is controlled by small farmers who represent some 90 per cent of the total farmers.

2. Large farmers have little influence on cotton production. Only 8 per cent or less of the cotton area is held by large farmers.

3. The average farm size of the whole area is some two Feddans, against 1.5, 8 and 30 Feddans in small, medium and large farms respectively.

4. Average farm size in North & West Delta is slightly higher than the other regions. Small farmers in this region controll only 51.5 per cent of all the total area against 63 per cent in the whole area.

5. In general, variations among the different regions are not significant.

TABLE VII-1

Cotton Area, Number of Farms, and average Farm Size in each region classified to Farm Size in 1975

Farm Size	Small Farms					Medium Farms					Large Farms					Total				
	Area		No. of Farms		Ave. Size	Area		No. of Farms		Ave. Size	Area		No. of Farms		Ave. Size	Area		No. of Farms		Ave. Size
Region	Feddan	%	No.	%		Feddan	%	No.	%		Feddan	%	No.	%		Feddan	%	No.	%	
North and West Delta	158931	51.5	84096	82.5	1.89	125739	40.8	16980	16.7	7.41	23844	7.7	853	0.8	27.9	308514	100	101929	100	3.03
Middle Delta	279890	69.3	203039	94.5	1.38	98585	24.4	11246	5.2	8.77	25591	6.3	653	0.3	39.2	404066	100	214938	100	1.88
E. Delta	111329	66.4	83487	93.7	1.33	42978	25.6	5050	5.7	8.51	13279	8.0	521	0.6	25.5	167586	100	89058	100	1.88
M. Egypt	168243	59.4	123256	90.1	1.36	98551	34.8	12954	9.5	7.61	16426	5.8	592	0.4	27.7	283220	100	136802	100	2.07
U. Egypt	133026	73.1	93634	95.2	1.42	44679	24.6	4623	4.7	9.66	4137	2.3	134	0.1	30.9	181842	100	98391	100	1.85
Total	851419	63.3	587512	91.6	1.45	410532	30.5	50853	7.9	8.07	83277	6.2	2753	0.5	30.2	1345228	100	641118	100	2.10

Sources : Ministry of Agriculture, Department of Agricultural Holdings "Records", 1976

In order to identify the impact of farm size on resource allocation efficiency, and to test the hypothesis that there is significant differences in efficiency between farm size classes, a separate production function for each farm size within each region is fitted, allowing both intercept and slope coefficients to vary between different classes of farm size.

Forms of Tenure

Tenure form might also be associated with resource allocation efficiency. The underlying hypothesis is tested by fitting a separate production function for each form of tenure within each class of farm size. The two major tenure forms; owners and tenants are identified only for small and medium farms. The collected samples on large tenants were very small and in inadequate size for regression analysis. However, the proportion of large tenants is greatly reduced due to the restriction on tenancy holding imposed by Land Reform Law. (1) Unfortunately data on tenure forms are not available.

Farm Sample

The procedure implies random sampling of the population under study. Unless a large sample is collected, random sampling might introduce considerable bias into the sample if there are large variations among the population under investigation. In order to reduce such variations, four specifications are considered.

1. The whole area is divided into five regions; North & West Delta, Middle Delta, E. Delta, Middle Egypt and Upper Egypt to allow for variations in land quality, weather factor, and output quality.

2. Each region is subdivided into three strata classified according to farm size. The aggregate number of farms for each class of farm size within each region is considered as total population.

3. Fifteen farms were randomly drawn from each form of tenure, i.e. owners and tenants within both small and medium farms in all regions.

4. Variations in output quality (i.e. length of the staple) are eliminated by considering one type of staple in each region. Observations in North and West Delta and Middle Delta are confined to long staple. Medium staple is the only cultivated type of cotton in Middle Egypt and Upper Egypt while long medium staple is the prevailing type in East Delta.

In order to ensure that the sample is sufficiently representative of the population at large, and sampling error is minimised, the unbiased estimate method is applied in determining the optimum size of sample. (2)

Setting the coefficient of variation ($V\bar{x}$) equal to the average error that one is willing to tolerate (A), we have

$$V\bar{x} = A$$

but

$$A = \frac{D}{t_{\alpha,\infty}}$$

where D is the maximum error that one wants to be certain not to exceed, and $t_{\alpha\infty}$ is the confidence limits.

Hence

$$V\bar{x} = \frac{D}{t_{\alpha\infty}}$$

Given

$$V\bar{x}^{2} = \frac{N - n}{N}\left(\frac{V^{2}}{n}\right)$$

where

N is the total number of listing units

n is the sample size

V^2 is the relative variance in population.

Thus

$$\left(\frac{D}{t_{\alpha,\infty}}\right)^2 = \frac{N - n}{N}\left(\frac{V^2}{n}\right)$$

or

$$n = \frac{t^2_{\alpha,\infty} NV^2}{ND^2 + t^2_{\alpha,\infty} V^2}$$

The relative difference between the estimated mean from the sample and the true mean is restricted to a maximum error of 5 & 8 per cent for small and medium farms, and large farms respectively. Such small range of error is unlikely to introduce biased estimate. The coefficient of variation in the population is not precisely known. Fortunately a rough estimate would be sufficient to give satisfactory results. If the estimate is approximately normally distributed, a coefficient of variation no greater than10 or 15 per cent might be sufficiently reliable in obtaining an adequate size of sample. [3] It is, however, initially assumed that the coefficient of variation in small and medium farms is 10 per cent and in large farms is 12 per cent. A higher range of variation is permitted for large farms, because differences in inputs used and policies applied among large farmers are expected to be greater than small and medium farmers. The underlying assumption is tested and adjusted according to the computed coefficient of variation from the collected observations. The optimum size of sample within each stratum in all regions are shown in table V11 - 2.

Ideally the collected observations should be scattered over the region under investigation. In practice a scattered sample is not feasible and rather impossible due to cost and time constraints. Random cluster sampling is therefore used in the present study. Two clusters (i.e. villages) were arbitrary but randomly selected. With respect to

TABLE VII-2

Optimum Size of Sample within each Strata in the various regions

Farm Size / Region	Small Farms		Medium Farms		Large Farms		Total Farms	
	Population	Sample	Population	Sample	Population	Sample	Population	Sample
N & W Delta	84096	36	16980	36	853	20	101929	92
M Delta	203039	36	11246	36	653	20	214938	92
E Delta	83487	36	5050	36	521	19	89058	91
M Egypt	123256	36	12954	36	592	20	136802	92
U Egypt	93634	36	4623	36	134	18	98391	90
Total Area	587512	180	50853	180	2753	97	641118	457

large farms more than two clusters were selected because large farms are scattered over clusters. Observations were proportionaly collected from the selected clusters, assuming that variations among and within clusters are approximately homogeneous. Cluster sampling would not sufficiently represent the population at large if variations among clusters are higher than variations within the selected cluster (s). (4) Cluster sampling method was, however tested by drawing randomly some 5 - 7 clusters from each region. The coefficient of variation for crop yield and some inputs of which data are available among the drawn clusters is calulated to be weighted against that within the selected cluster. In all cases it was found that variations among clusters do not significantly differ from that within the selected cluster(s).

Data Collection

Most farmers do not keep records for their activities. One, therefore, had to rely on their memories. Fortunately, they have good memories and can be accurate enough if they want to. Farmers are usually sceptical about providing information particularly to government officials. Unless they are convinced that the survey will not do any harm to them and rather would help them in improving production, they will not respond. One interesting character of the Egyptian farmers is that they respect, trust and follow their village leader (i.e. the eldest or village mayor). This characterestic was the key factor to our survey. The village leader was visited before making any contact with farmers, and convincing him of the purpose of the survey. In most cases village leaders were understanding people and gave full co-operation. Farmers were, therefore, instructed to respond to the survey and in many cases they were called to the leaders' house to be interviewed under his supervision. Large farmers who keep records of their activities were helpful and many of them made constructive comments by which the design of the questionaire was improved.

However, a survey procedure of the personal interview type was carried on in collecting the required data. The questionaire was designed to be consistant with production order.* Cotton production period was divided into six operations, land preparation, irrigation, sowing, fertilisation, plant protection and harvesting. The various inputs used and time spent in each operation were recorded. Some other information on crop yield, experience, education, form of tenure, size of holding etc. were also reported.

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* Appendix E

VII - 2 Choice and Specification of Variables

All variables included in the function are measured as inputs actually used per unit of land over the production period, Land is assumed to be fixed and therefore excluded from the function. Except machines used in small and medium farms, the output and all the variables included in cross sectional function are measured as shown in time series estimates (Chapter VI). X_1 refers to the quantity of labour measured in hours, X_3 refers to animals in terms of horse power/hour, X_4 and X_5 refer to Nitrate and phosphate in K.g. of plant nutrient respecti vely, and X_6 refers to manure in cubic meter. Machines used in small and medium farms, X_2 are confined to land preparation and irrigation. Machine/hours for each type were converted into standard units of horsepower/hour and aggregated. Large farmers who do not use either animals or manure, apply variety of machines for which measurement in physical standard units is not feasible. The same formula as was used in time series estimate is applied instead. All fixed cost such as building and assets other than machines are included in one variable identified as improvement X_7. Only services cost related to the production period is included in improvement variable. Improvement cost at 1975 prices is divided by the expected life in years to be weighted to 10 months, the cotton production period. Improvement is considered only with respect to large farms, because it hardly exists in small and medium farms. Insecticides, irrigation water and seeds are not included in the function because they are constant over each sample. Both plant protection and irrigation and drainage system are completely governed by Ministry of Agriculture and Ministry of Irrigation respectively. They are equally available to all farmers within each area. A summary of the data on the underlying variables is shown in table Vll - 3.

TABLE VII-3

DATA SUMMARY

G. MEAN and Coefficient of Variation

N. W. DELTA

Class	Small Farms		Medium Farms		Large Farms	
No. in Sample	42		37		24	
No. of Clusters	2		2		4	
Variables	G. MEAN	Coeff. of Variation	G. MEAN	Coeff. of Variation	G. MEAN	Coeff. of Variation
Average Size	1.70	0.110	7.20	0.140	26.1	0.206
Crop yield Y	4.660	0.063	5.532	0.014	5.277	0.05
Man hour X_1	513.510	0.003	499.391	0.009	428.813	0.004
Machine X_2	29.013	0.104	153.199	0.030	14.695	0.061
Animal hour X_3	48.472	0.018	28.906	0.027	-	-
Nitrog. X_4	37.422	0.017	42.259	0.016	60.261	0.014
Phosphate X_5	10.066	0.037	11.368	0.036	11.140	0.035
Manure X_6	10.680	0.111	7.209	0.108	-	-
Improvement X_7	-	-	-	-	3.723	0.132

TABLE VII-3 (Cont'd)

M. DELTA

Class		Small Farms		Medium Farms		Large Farms	
No. in Sample		49		40		24	
No. of Clusters		2		2		4	
Variables		G. MEAN	Coeff. of Variation	G. MEAN	Coeff. of Variation	G. MEAN	Coeff. of Variation
Average Size		1.37	0.09	7.70	0.125	38.7	0.210
Crop yield	Y	4.710	0.034	5.540	0.008	5.716	0.030
Man hour	X_1	492.444	0.001	463.469	0.001	433.517	0.003
Machine	X_2	106.635	0.020	272.848	0.020	14.273	0.048
Animal hour	X_3	35.257	0.010	9.379	0.058	-	-
Nitrog.	X_4	46.995	0.012	55.914	0.011	67.343	0.015
Phosphate	X_5	9.676	0.063	11.876	0.062	14.917	0.066
Manure	X_6	3.695	0.820	4.246	0.363	-	-
Improvement	X_7	-	-	-	-	4.156	0.044

TABLE VII-3 (Cont'd)

E. DELTA

Class	Small Farms		Medium Farms		Large Farms	
No. in Sample	40		37		22	
No. of Clusters	2		2		3	
Variables	G. MEAN	Coeff. of Variation	G. MEAN	Coeff. of Variation	G. MEAN	Coeff. of Variation
Average Size	1.47	0.085	8.57	0.139	27.2	0.231
Crop yield Y	4.716	0.018	5.419	0.004	5.707	0.036
Man hour X_1	498.020	0.004	472.128	0.001	437.541	0.003
Machine X_2	65.834	0.021	221.214	0.012	12.547	0.061
Animal hour X_3	30.863	0.006	14.632	0.043	-	-
Nitrog. X_4	44.274	0.010	53.942	0.009	63.146	0.014
Phosphate X_5	9.238	0.046	11.472	0.041	15.537	0.052
Manure X_6	7.135	0.084	5.591	0.081	-	-
Improvement X_7	-	-	-	-	3.536	0.068

TABLE VII-3 (Cont'd)

M. EGYPT

Class	Small Farms		Medium Farms		Large Farms	
No. in Sample	43		40		24	
No. of Clusters	2		2		4	
Variables	G. MEAN	Coeff. of Variation	G. MEAN	Coeff. of Variation	G. MEAN	Coeff. of Variation
Average Size	1.52	0.101	7.73	0.121	29.1	0.211
Crop yield Y	4.886	0.034	5.382	0.050	5.574	0.015
Man hour X_1	513.598	0.001	468.694	0.001	454.887	0.020
Machine X_2	89.025	0.021	276.848	0.008	12.915	0.037
Animal hour X_3	34.289	0.007	13.096	0.040	-	-
Nitrog. X_4	47.339	0.013	56.537	0.012	68.290	0.012
Phosphate X_5	8.976	0.052	10.500	0.050	18.763	0.029
Manure X_6	6.078	0.096	4.595	0.116	-	-
Improvement X_7	-	-	-	-	3.881	0.032

TABLE VII-3 (Cont'd)

U. EGYPT

Class	Small Farms		Medium Farms		Large Farms	
No. in Sample	43		40		24	
No. of Clusters	2		2		4	
Variables	G. MEAN	Coeff. of Variation	G. MEAN	Coeff. of Variation	G. MEAN	Coeff. of Variation
Average Size	1.41	0.075	9.2	0.153	35.1	0.301
Crop yield Y	4.642	0.011	5.686	0.004	5.976	0.015
Man hour X_1	487.393	0.001	464.170	0.001	421.749	0.024
Machine X_2	202.178	0.023	296.845	0.002	21.132	0.030
Animal hour X_3	22.999	0.025	12.642	0.011	-	-
Nitrog. X_4	53.672	0.016	61.447	0.013	73.417	0.011
Phosphate X_5	7.997	0.062	9.905	0.050	18.025	0.026
Manure X_6	1.196	3.058	-	-	-	-
Improvement X_7	-	-	-	-	4.651	0.053

Source : Collected samples within each region "Questionnaire Survey"

Test and Characteristics of Data

Except for manure, the coefficient of variation appears to be smaller than assumed, implying that variations within each class of farms are not great. Analysis of variance test suggests the existence of significant farm size class effects on both crop yield and inputs used (Table V11 - 4). This would appear to justify the necessity of farm size classification. Analysis of variance (5) applied to forms of tenure within both small and medium farms indicates that there is no significant evidence to reject the hypothesis that different tenure forms have no effects on crop yield and input used, (table V11 - 5). However, differences between regions for one class of farm size are considerably less than that between farm size classes within one region. It seems that the major difference between regions is attributed to the variability in the degree of mechanisation. It is relatively high in Middle Delta, Middle Egypt and particularly in Upper Egypt.*

Relative technical efficiency among different classes and between various regions is initially tested by employing a measure of the average product (table V11 - 6) The following characteristics are derived:

1. Agriculthural productivity in terms of crop yield is positively correlated with farm size, but no tenure form could be considered more productive than any other.

2. Variations in average product of all underlying inputs variables, between owners and tenants within each farm size class are insignificant.

3. In general average product for all variables among all farm size classes within each region differs considerably and more than variations

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* Table V11 - 3

TABLE VII-4

Analysis of variance test for significant differences among classes of farm size

Variables	N & W Delta		M Delta		E Delta		M Egypt		U Egypt	
	F[a]	df[b]	F	df	F	df	F	df	F	df
Crop yield	53.6*	2,100	155.3*	2,110	119.5*	2,96	57.3*	2,104	158.5*	2,104
Labour	138.5*	2,100	266.7*	2,110	229.9*	2,96	205.6*	2,104	955.7*	2,104
Machines	346.0*	2,100	291.2*	2,110	162.9*	2,96	416.3*	2,104	481.5*	2,104
Nitrate	993.4*	2,100	261.9*	2,110	287.9*	2,96	339.1*	2,104	124.91*	2,104
Phosphate	13.67*	2,100	40.2*	2,110	84.7*	2,96	438.8*	2,104	484.4*	2,104

a - F = $\frac{\text{mean square between classes}}{\text{mean square within classes}}$

b - df = degree of freedom

* Significant of the 1% level

TABLE VII-5

Analysis of variance test for significant differences among forms of tenure

Variables	N & W Delta		M Delta		E Delta		M Egypt		U Egypt	
	F1*	F2**	F1	F2	F1	F2	F1	F2	F1	F2
Crop yield	1.271	0.95	2.00	1.01	1.52	0.95	2.510	0.82	2.323	0.97
Labour	0.814	0.45	0.920	0.34	0.85	0.42	0.80	0.27	0.712	0.29
Machine	0.521	0.76	0.420	0.77	0.42	0.76	0.92	0.92	0.342	0.77
Animal	0.310	0.53	0.410	0.72	0.201	0.72	0.54	0.75	0.233	0.68
Nitrate	1.72	0.88	0.97	0.83	1.54	0.75	0.68	0.62	1.92	0.77
Phosphate	1.53	0.65	1.71	0.71	1.62	0.62	0.75	0.73	1.71	0.66
Manure	0.72	1.02	0.63	0.82	0.62	0.92	0.79	0.82	0.59	-

* F1 for small farms

** F2 for medium farms

TABLE VII-6

Average Product of the Underlying Inputs from the Sample Classified to Farm Size and Form of Tenure in all Regions

	Small Farms			Medium Farms			Large Farms
	All Farms	Owners	Tenants	All Farms	Owners	Tenants	
N & W Delta							
X_1	0.009	0.009	0.009	0.011	0.011	0.011	0.012
X_2	0.161	0.156	0.167	0.036	0.036	0.037	0.359
X_3	0.096	0.098	0.093	0.191	0.193	0.189	-
X_4	0.125	0.125	0.124	0.131	0.130	0.131	0.088
X_5	0.463	0.465	0.466	0.487	0.486	0.484	0.474
X_6	0.436	0.441	0.430	0.767	0.768	0.751	-
X_7	-	-	-	-	-	-	1.417
M Delta							
X_1	0.01	0.009	0.01	0.012	0.012	0.012	0.013
X_2	0.044	0.043	0.045	0.020	0.020	0.020	0.400
X_3	0.134	0.132	0.135	0.591	0.591	0.588	-
X_4	0.100	0.099	0.101	0.099	0.099	0.098	0.085
X_5	0.487	0.482	0.483	0.466	0.469	0.460	0.383
X_6	1.275	1.814	1.120	1.305	1.551	1.139	-
X_7	-	-	-	-	-	-	1.375

TABLE VII-6 (Cont'd)

	Small Farms			Medium Farms			Large Farms
	All Farms	Owners	Tenants	All Farms	Owners	Tenants	
E.Delta							
X_1	0.0095	0.01	0.009	0.011	0.011	0.011	0.013
X_2	0.072	0.071	0.072	0.024	0.024	0.024	0.455
X_3	0.153	0.153	0.152	0.370	0.370	0.373	-
X_4	0.107	0.107	0.107	0.100	0.102	0.100	0.090
X_5	0.511	0.510	0.511	0.472	0.492	0.473	0.367
X_6	0.661	0.664	0.654	0.969	0.973	0.962	-
X_7	-	-	-	-	-	-	1.614
M Egypt							
X_1	0.0095	0.009	0.01	0.0115	0.011	0.0115	0.012
X_2	0.066	0.055	0.054	0.019	0.02	0.019	0.432
X_3	0.142	0.140	0.145	0.411	0.393	0.427	-
X_4	0.103	0.103	0.103	0.095	0.097	0.094	0.082
X_5	0.544	0.548	0.540	0.513	0.533	0.499	0.297
X_6	0.804	0.792	0.820	1.172	1.154	1.196	-
X_7	-	-	-	-	-	-	1.436

TABLE VII-6 (Cont'd)

	Small Farms			Medium Farms			Large Farms
	All Farms	Owners	Tenants	All Farms	Owners	Tenants	
U Egypt							
X_1	0.0095	0.0095	0.01	0.012	0.012	0.012	0.014
X_2	0.023	0.023	0.023	0.019	0.019	0.019	0.283
X_3	0.202	0.200	0.203	0.500	0.447	0.453	-
X_4	0.086	0.088	0.085	0.093	0.093	0.092	0.081
X_5	0.580	0.599	0.563	0.574	0.585	0.562	0.332
X_6	3.881	4.403	3.529	-	-	-	-
X_7	-	-	-	-	-	-	1.285

among regions for a given class of farm size.

4. Average product of labour is, as one would expect, positively correlated with farm size and not very different between regions for a given farm size class.

5. Average product of machines is generally high in North & West Delta and low in Upper Egypt; and higher in small farms than medium farms. Comparison with large farms is not feasible because machines are measured in different units. Animals average product performs similary, to machines average product, but in opposite direction.

6. Variations in the average product of both types of chemical fertiliser are not significant either among regions or between farm classes. Nitrogeneous fertiliser average product is generally less than that for phosphate.

Average product information might be useful in identifying the general behaviour of input variables, but not in testing resource allocation efficiency. The latter is investigated in terms of marginal product and profit maximization.

Vll - 3 Specification and Estimation of the Model

The approach adopted is to derive the marginal products from the estimated production function for testing allocative efficiency of farms in terms of profit maximisation. The underlying approach is based on two crude assumptions. (6) All resources are variable and fully used in the production process irrespective of their supply level and all farms face the same prices.* In reality some of the inputs might be fixed in the short-run. Land is strictly fixed and immobile. Family labour could be fixed if family members are available for farm work and there is no alternative employment or no desire to take up other work. Multi-period capital such as machines and animals might also be fixed if they are not used to full capacity. If this is true and there exist differences in fixed factor endownments among farmers, the production function approach which is defined as the actual quantity of each resource which has gone into the production process irrespective of its supply level, (7) might not reflect the reality. Two farms using equal quantities of input variables may produce different quantities of output, therefore attaining different levels of efficiency,either because they have different endowments of fixed factors, or they have different degrees of control over the resources they use.

The relevance of the production approach is tested with respect to the production logic of the case under study and the specification of the included inputs. Family labour in Egyptian agriculture is in relative surplus and might be fixed factor in small farms during the slack seasons, where employment opportunities elsewhere are limited. (8) Although

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* The relevance of the homogeneous price assumption is tested in Chapter Vlll in which economic efficiency is examined.

machines and animals are fixed factors as assets owned by farmers, their services during the production period might not be fixed, since they can be hired out. Indeed machines in Egyptian agriculture are scarce and farmers compete to use them.[9] Animals are kept not only for agricultural activities, but also, perhaps mainly, to produce cheap food. Farmers would not sell their animals if they do not need them in agriculthural activities. Family labour, machines and animals might be in fixed supply to the farm, but not to individual crop, since they are measured as inputs actually used in production regardless of their availability. Furthermore, farm classification into groups would reduce the variation in the degree of control over the used resources among farmers.

Four mathematical forms of production function are tested against the numerical observations. A linear function is fitted and compared with non-linear function in the form of Cobb-Douglas, constant Elasticity of Substitution and Transcendental logarithmic with variable elasticity of substitution.

Linear function

$$y = A + b_1 x_1 + \ldots\ldots + b_n x_n$$

Cobb-Douglas function (C.D.)

$$\text{Log } y = \text{Log } A + b_1 \text{ Log } x_1 + \quad + b_n \text{ Log } X_n$$

Constant Elasticity of Substitution (CES)

$$y = A \left[b_1 x_1^{-\rho} + \ldots\ldots + b_n x_n^{-\rho} \right]^{-\frac{1}{\rho}}$$

Transcendental Logarithmic Function (TL) [10]

$$\begin{aligned} \text{In } (F + 1) = {} & A_0 + a_1 \text{ Iny} + a_2 \text{ In} X_1 + \quad + a_n \text{In} X_n \\ & + \text{Iny } (\tfrac{1}{2} b_{11} \text{Iny} + b_{12} \text{Inx}_1 \quad + b_{1n} \text{In} X_n) \\ & + \text{In} X_1 (\tfrac{1}{2} b_{22} \text{Inx}_1 + b_{23} X_2 \ldots\ldots + b_{2n} \text{In} X_n) \\ & \text{In } X_n (\tfrac{1}{2} b_{nn} \text{ In} X_n) \end{aligned}$$

The characteristics, limitation and derivation of the above forms of production functions are shown and analysed in Chapter lV-2.

The estimation and derivation of TL for a large number of variables is complicated and the iterative method used worked with only a few cases for which the fit was bad. The fit of linear function was in most cases good, but with high standard errors for most input coefficients. The CES function is tested against the C.D. function. The latter gave a better fit in terms of sum of square residuals. However, the derived marginal product of the underlying variables from both forms of function were close, apart from the intercept. The substitution parameter in the CES function was very small, implying that the elasticity of substitution is approaching unity. The CES function is therefore reduced to C.D. function. If the function is true, one would assume that unit elasticity of substitution is an empirical approximation of reality.

The Cobb-Douglas function is therefore selected to estimate the elasticity of production corresponding to the underlying variables of which marginal products are derived. Due to the existence of some differences in terms of the employed inputs and the nature of their relationship, between small and medium farms, and large farms, the model specification is considered separately for each group.

Model specification for small and medium farms

Two alternative, though complementary techniques are employed for measuring efficiency and relative efficiency of resource allocation of the two farm size classes and with respect to the different tenure forms.

Model 1: Single Equation

A function of C.D. form is fitted by regressing crop yield against man/hour (X_1), machines horse power/hour (X_2) animals horse-power/hour (X_3), Nitrate (X_4), phosphate (X_5) and manure (X_6). Thus:

$$Y_i = \prod_{j=1}^{t} x_{ij}^{\beta j} u_i \qquad i = 1, \quad ,n;$$

The function is applied separately to both small and medium farms in each region. A regression is also fitted to the separate subsamples of owners and tenants within each farm size class. The production coefficients and related statistics are shown in Appendix F. Although the adjusted coeffieient of determination $\bar{R}^2$ in all regressions is high with a significant F ratio, the standard error of the estimated coefficients of machine horse power/hour (X_2) and animal horse power/hour (X_3) is high inducing insignificant estimate. The correlation matrix (Appendix G) suggests that X_2 and X_3 in all functions are highly correlated. This was to be expected because machines and animals are close substitutes. They move together and perhaps proportionally, but in opposite direction. Statistically, multicollinearity could be solved either by dropping one of the intercorrelated variables or by aggregating them into one variable. Neither method is entirely reliable. Dropping one variable is an acceptable approach if and only if, the coefficients' true value is equal/or at least close to zero, which is not necessary the case. Aggregation over the correlated inputs would radically reduce our knowledge of the nature of relationship between them and the output,[11] destorting the meaningfulness of the estimate. Besides, adding them together would introduce biased estimate if the technical efficiency of horse power of machine and animal are not homogeneous.

An attempt is made to replace the two correlated variables. (X_2 and X_3) by their ratio (i.e. RF = X2/X3) to be included in the function as a single variable. Using the machine-animal ratio would remove multicollinearity among the two inputs without destorting the homogeniety condition. Both individual variables are still, though indirectly, identified. No important knowledge would, therefore, be missed and the nature of relationship between each input and output can be derived. The function is now;

$$y = Ax_1^{\beta 1} RF^{a} X4^{\beta 4} X5^{\beta 5} X6^{\beta 6}$$

where RF = X2/X3

The estimated coefficients and related statistics are shown in table V11 - 7.

This function is true if:

$$RF^{a} \equiv X_2^{\beta 2} X3^{\beta_3}$$

or $$X2^{a - \beta_2} \equiv X3^{a + \beta_3}$$

Unfortunately, the true value of β_2 and β_3 are unknown. Their estimated values from the original function are biased due to the existence of multicollinearity. Alternatively the function is tested by (1) investigating the behaviour of the correlation matrix after replacing machines and animals by their ratio, and (2) comparing the estimated coefficients of the variables other than X_2 and X_3 from the original function with their values after placing RF in the function. It appears that the structure of correlation matrix (Appendix H) has not been changed, implying no significant changes in the correlation among inputs and between each input and output. Apart from a few insignificant coefficients, there have been no radical change in the value of the estimated coefficients after placing RF in the function.

The estimated coefficient of machine-animal ratio (RF) is interpretated as the change in output relative to substituting animals by machines. Since X_2 and X_3 are substitutes, an increase in one of them will be accompanied by a reduction in the other. Hence RF will be increased if animals are substituted by machines. If the estimated coefficient of RF is positive there would be positive correlation between the output and substituting animals by machines, implying that the marginal product of machines is higher than that of animals. Further increase in the output would therefore be forthcoming if animals are replaced by machines. If the estimated coefficient of RF is Zero, both inputs would have the same marginal product, and there will be no increase in crop yield if animals are substituted by machines. However, the estimated coefficients of RF in all fitted functions are positive and highly significant. They are particularly high in small farms, showing that the marginal product of machines is considerably higher than that of animals.(table VII - 7)

In most cases the intercept (constant term) was found to be small and insignificant. It is therefore excluded from the function, thus improving the significance of the estimated coefficients. The constant term represents differences in endowments of fixed factors as well as the impact of non-measurable inputs such as management. A small intercept would therefore imply little variation in the amount of fixed factors and in the degree of control upon inputs among farmers within each set of data. This supports our previous argument concerning the absence of variation in both fixed factors and managerial efficiency* among each group of farmers.

The adjusted coefficient of determination $\bar{R}^2$ in all estimated functions is high and F ratio is significant at the 1 per cent level. In small farm functions, only thirteen out of 75 input coefficients are insignificant at less than 10 per cent level. Only two coefficients

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* Managerial efficiency is considered with respect to large farms as shown below.

TABLE VII-7

Estimated Coefficients and related statistics Classified to regions and forms of tenure in both Small and Medium Farms

	Small Farms			Medium Farms		
	All Farms	Owners	Tenants	All Farms	Owners	Tenants
N & W Delta						
X_1	0.160* (4.192)	0.149** (2.939)	0.132** (2.686)	0.219* (50.667)	0.220* (38.340)	0.209* (19.431)
RF	0.119* (16.346)	0.122* (10.607)	0.127* (6.087)	0.015* (13.784)	0.014* (9.428)	0.018* (6.320)
X_4	0.129*** (1.765)	0.140 (1.364)	0.134** (2.205)	0.052* (5.136)	0.051* (4.081)	0.074** (2.803)
X_5	0.024** (1.897)	0.031 (1.474)	0.015 (0.494)	0.017** (2.749)	0.016** (2.255)	0.008 (0.477)
X_6	0.033* (3.832)	0.039* (3.591)	0.015 (0.534)	0.044* 35.948	0.046* (30.756)	0.043* (16.156)
$\bar{R}^2$	0.93	0.95	0.92	0.94	0.94	0.95
F. Stat	120.905*	96.958*	49.562*	487.88*	274.08*	120.131*
M Delta						
X_1	0.194* (22.021)	0.203* (20.658)	0.203* (16.229)	0.189* (43.703)	0.192* (19.617)	0.186* (53.116)
RF	0.088* (9.170)	0.077* (8.404)	0.074* (4.791)	0.039* (6.870)	0.040* (4.027)	0.049* (8.697)
X_4	0.039** (2.670)	0.025 (1.523)	0.029 (1.413)	0.080* (7.599)	0.073* (3.196)	0.072* (8.610)
X_5	0.0225* (4.202)	0.029* (5.486)	0.0255* (3.798)	0.033* (24.250)	0.034* (12.140)	0.038* (27.188)
X_6	0.035* (45.476)	0.035* (57.676)	0.034* (17.248)	0.011* 23.453)	0.011* (16.168)	0.015* (8.944)
$\bar{R}^2$	0.94	0.96	0.96	0.94	0.95	0.93
F. Stat	390.090*	181.183*	147.685*	418.860*	169.994*	85.366*

TABLE VII-7 (Cont'd)

	Small Farms			Medium Farms		
	All Farms	Owners	Tenants	All Farms	Owners	Tenants
E Delta						
X_1	0.118* (8.298)	0.160* (8.963)	0.096* (3.404)	0.220* (18.569)	0.219* (15.824)	0.202* (4.769)
RF	0.265* (33.350)	0.240* (22.979)	0.275* (18.040)	0.016** (1.983)	0.013*** (1.916)	0.015*** (1.961)
X_4	0.139* (6.216)	0.072** (2.528)	0.179* (4.339)	0.053* (3.019)	0.056** (2.755)	0.071 (1.212)
X_5	0.034* (5.69)	0.046* (6.763)	0.025 (1.770)	0.031* (10.245)	0.030* (8.254)	0.033* (3.820)
X_6	0.008 (1.782)***	0.000 (0.003)	0.007 (0.613)	0.010* (2.607)	0.009*** (2.07)	0.023 (1.505)
$\bar{R}^2$	0.93	0.95	0.94	0.93	0.95	0.88
F. Stat	338.483*	70.70*	57.24*	153.111*	100.164*	27.318*
M Egypt						
X_1	0.114* (5.085)	0.166* (5.054)	- 0.016 (-0.278)	0.222* (22.844)	0.228* (23.531)	0.220* (7.293)
RF	0.400* (20.353)	0.418* (18.197)	0.297* (7.493)	0.043* (7.689)	0.044* (7.984)	0.044** (2.394)
X_4	0.008 (0.141)	- 0.030 (-0.444)	0.322** (2.797)	0.024 (1.209)	0.015 (0.727)	0.026 (0.379)
X_5	0.107* (9.074)	0.104* (7.066)	0.055** (2.491)	0.019* (4.821)	0.019* (4.515)	0.021 (1.752)
X_6	0.020* (4.765)	0.021* (4.339)	0.022** (2.695)	0.029* (21.354)	0.029* (23.330)	0.03* (4.775)
$\bar{R}^2$	0.95	0.93	0.91	0.95	0.96	0.92
F. Stat	270.7*	76.39*	68.032*	650.830*	275.21*	90.095*

TABLE VII-7 (Cont'd)

	Small Farms			Medium Farms		
	All Farms	Owners	Tenants	All Farms	Owners	Tenants
U Egypt						
X_1	0.122* (45.803)	0.122* (58.041)	0.122* (26.114)	0.202* (46.020)	0.207* (28.260)	0.202* (38.222)
RF	0.163* (28.437)	0.166* (38.772)	0.178* (15.111)	0.061* (14.563)	0.033* (4.115)	0.062* (9.180)
X_4	0.074* (8.735)	0.076* (12.389)	0.056* (3.338)	0.064* (13.966)	0.081* (12.625)	0.062* (6.969)
X_5	0.061* (11.109)	0.057* (15.157)	0.084* (6.159)	0.019* (11.970)	0.011* (4.583)	0.020* (5.964)
X_6	0.007* (9.434)	0.008** (15.144)	0.004** (2.629)	-	-	-
$\bar{R}^2$	0.94	0.96	0.90	0.94	0.94	0.95
F. Stat	278.411*	707.673*	59.468*	124.755*	83.031*	104.219*

* Significant at the 1% level

** Significant at the 5% level

*** Significant at the 10% level

Figures between brackets refer to t. statistics have improper (negative) sign, but both are insignificant. With respect to medium farms, out of 72 input coefficients, 7 are insignificant. None of them have a negative sign. It seems that most of the insignificant estimated coefficients belong to nitrate and phosphate and in some cases manure. This is perhaps due to the existence of high intercorrelation among these variables in such cases. No attempt is made to aggregate them in one variable, since knowledge on each input is needed for further analysis.

Model 2: Two-Stage Equations

The single equation model is based on the assumption that input units are homogeneous over the whole production period. In reality this assumption may not hold. Machines used in different operations are not homogeneous, and by adding them together bias in the estimates might be introduced. Animal use, though in the same units, could have different impact on production depending on the type of work they do. A two-stage model is therefore applied to test resource allocation efficiency within as well as among stages of cultivation. The whole production period is split into sub-periods corresponding to the various operations. A separate production function for each operation is fitted by regressing time actually spent in each operation against the relevant inputs to test their relative efficiency within each stage of production. Crop yield is therefore regressed against the time actually spent in each operation to investigate relative efficiency of the various operations. Combining the two stages, the indirect impact of each input within each operation on output is identified.

Stage 1:

As far as cotton cultivation in Egypt is concerned, six operations; land preparation, irrigation, sowing, fertilisation, plant protection and harvesting are usually carried on. Variations in sowing and harvesting between farmers over each sample are very small, plant protection is, as mentioned above, completely controlled by govenment and stabilised over the whole area. These three operations are therefore excluded from the model. Investigation is confined to land preparation, irrigation and fertilisation. Both linear and non-linear regressions were fitted. In all cases the linear function gave better fit, showing that the relative change in time spent due to changes in any input is proportional.

The three fitted functions are as follows:

1. Land preparation:

$$Z_1 = a_1 + a_{11} x_{11} + a_{21} x_{21} + a_{31} x_{31}$$

2. Irrigation:

$$Z_2 = a_2 + a_{12} x_{12} + a_{22} x_{22} + a_{32} x_{32}$$

3. Fertilisation:

$$Z_3 = a_3 + a_{13} x_{13} + a_4 x_4 + a_5 x_5 + a_6 x_6$$

where,

z_1 z_2 and z_3 are the time actually spent (in hours) in land preparation irrigation and fertilisation respectively.

x_{11}, x_{12} and x_{13} are labour actually used (in man/hour) in land preparation, irrigation and fertilisation respectively.

x_{21} and x_{22} are machine/hour weighted to horse power used in land preparation and irrigation respectively.

x_{31} and x_{32} are animals/hour weighted to horse power used in land preparation and irrigation respectively.

x_4; x_5, and x_6 are nitrate (in k.g of plant nutrient), phosphate (in k.g of plant nutrient) and manure (in cubic metre) respectively.

In all cases, most of the estimated input coefficients were insignificant due to the existance of very high multicollinearity among the underlying variables. In land preparation and irrigation, labour animals and machines are perfect substitutes (exact multicollinearity), while labour is highly correlated with all other variables in fertilisation. Machines and animals are therefore replaced by their ratios, RF_1 and RF_2 in land preparation and irrigation functions respectively. Labour is omitted from the three functions, since it is perfect complementary with other variables.

The fitted functions are now as follows;

1. Land preparation

$$z_1 = a_1 + b_1 RF_1$$

where $RF_1 = \frac{x21}{x31}$

2. Irrigation

$$z_2 = a_2 + b_2 RF_2$$

where $RF_2 = \frac{x22}{x32}$

3. Fertilisation

$$z_3 = a_3 + b_4 x_4 + b_5 x_5 + b_6 x_b$$

The estimated coefficients (marginal-products) and related statistics are shown in Appendix J. The adjusted coefficient of determination $\bar{R}^2$ is very high with significant F ratio at the 1 per cent level in all functions. All the estimated coefficients are highly significant. This was however expected, since time spent depends largely on the type of inputs used.

In the functions corresponding to both land preparation and irrigation, machine-animal ratio (RF_1 and RF_2 respectively) is negatively correlated with time spent implying that time spent in these two operations would be significantly reduced if machines replace animals. The estimated coefficients of RF_1 and RF_2 are particularly high in small farms functions. Nitrate and phosphate, and manure are positively correlated with time spent.

Stage 11:

A Cobb-Douglas function is fitted by regressing crop yield against the time actually spent in each operation. The function is fitted for each form of tenure as well as all farms within both small and medium farms.

$$y = AZ_1^{\alpha_1} Z_2^{\alpha_2} Z_3^{\alpha_3}$$

where

y is the crop yield in Kentare and Z_1, Z_2 and Z_3 are the time spent in hours in land preparation, irrigation, and fertilisation respectively. The estimated coefficients and their related statistics are shown in table V11 - 8. In all functions, the adjusted coefficient of determination $\bar{R}^2$ is high and significant indicating that the variations in crop yield attribute largely to variations in the time spent in the underlying operations. Out of 87 estimated coefficients, only 7 are insignificant, and the explanatory variables are not highly correlated. In all functions except one, the estimated coefficients of Z_1 and Z_2 have negative sign, while the estimated coefficient of Z_3 is positively correlated with crop yield. An increase in crop yield will be forthcoming if the time spent in land preparation and irrigation is reduced or /and the time spent in fertilisation is increased.

A final attempt is made to identify the impact of each single variable in the whole model on crop yield by employing an overall single function in Cobb-Douglas form;

TABLE VII-8

Estimated Coefficients and related Statistics among Operations

(Stage II)

	Small Farms			Medium Farms		
	All Farms	Owners	Tenants	All Farms	Owners	Tenants
N & W Delta						
Constant	13.504	12.122	17.496	6.076	6.292	6.077
		(33.117)	(21.385)	(20.918)	(9.496)	(23.913)
Z_1				- 0.05**	- 0.061	- 0.041**
				(- 2.564)	(- 1.430)	(- 2.461)
Z_2	- 0.404*	- 0.387*	- 0.486*	- 0.102*	- 0.102*	- 0.108*
	(- 19.495)	(- 14.629)	(- 7.448)	(- 8.606)	(- 3.788)	(- 9.989)
Z_3	0.125*	0.150*	0.132**	0.186*	0.185*	0.187*
	(6.282)	(5.229)	(2.301)	(12.723)	(5.105)	(15.051)
$\bar{R}^2$	0.92	0.94	0.88	0.86	0.75	0.95
F. Stat	244.315*	111.779*	51.220*	73.984*	15.599*	114.688*
M Delta						
Constant	5.946*	6.185*	5.322*	5.371*	5.810*	4.866*
	(17.389)	(20.105)	(11.605)	(5.115)	(5.330)	(4.679)
Z_1	- 0.062*	- 0.60*	- 0.059*	- 0.055*	- 0.067**	- 0.050*
	(- 8.226)	(- 8.281)	(- 5.438)	(- 4.245)	(- 2.854)	(- 4.474)
Z_2	- 0.288*	- 0.220*	- 0.202*	- 0.073*	- 0.084*	- 0.057*
	(- 14.454)	- 17.848	(- 9.961)	(- 8.035)	(- 4.942)	(- 7.996)
Z_3	0.130***	0.132**	0.133**	0.159*	0.148*	0.178*
	(1.657)	(2.68)	(2.174)	(20.412)	(8.494)	(31.996)
$\bar{R}^2$	0.92	0.97	0.93	0.95	0.95	0.97
F. Stat	83.118*	119.169*	63.894*	277.271*	93.801*	194.270*

TABLE VII-8 (Cont'd)

	Small Farms			Medium Farms		
	All Farms	Owners	Tenants	All Farms	Owners	Tenants
E Delta						
Constant	8.438	8.463	8.469	4.871	4.596	4.972
	(58.439)	(29.998)	(40.099)	(4.595)	(4.252)	(4.096)
Z_1	- 1.543*	- 1.523*	- 1.582*	- 0.054*	- 0.039	- 0.070***
	(- 16.666)	(- 9.189)	(- 10.058)	(- 3.172)	(- 1.704)	(- 2.149)
Z_2	- 0.751*	- 0.777	- 0.731*	0.017**	0.018***	0.012***
	(- 11.561)	(- 6.438)*	(- 7.087)	(2.660)	(2.170)	(1.878)
Z_3	0.016	0.009	0.013	0.082*	0.090*	0.097
	(0.743)	(0.247)	(0.389)	(4.843)	(4.152)	(2.54)**
$\bar{R}^2$	0.94	0.96	0.95	0.94	0.96	0.91
F. Stat	448.521*	211.330*	332.617*	176.605*	107.158*	47.049*
M Egypt						
Constant	10.056	10.311	8.900	4.246	3.983	4.840
	(38.626)	(44.761)	(12.437)	(4.083)	(3.768)	(4.513)
Z_1	- 1.500*	- 1.312*	- 1.312*	- 0.053	- 0.054	- 0.055
	(- 14.917)	(- 11.869)	(- 5.848)	(- 1.112)	(- 1.135)	(- 1.082)
Z_2	- 1.246*	- 1.429*	- 1.127*	- 0.033*	- 0.025**	- 0.038*
	(- 18.457)	(- 16.836)	(- 10.74)	(- 5.870)	(- 2.294)	(- 4.27)
Z_3	0.135*	0.104*	0.234*	0.134*	0.146*	0.106*
	(5.511)	(4.745)	(3.936)	(14.605)	(10.415)	(6.664)
$\bar{R}^2$	0.95	0.94	0.96	0.93	0.93	0.93
F. Stat	200.663*	157.581*	127.061*	163.849*	60.915*	61.348*

TABLE VII-8 (Cont'd)

	Small Farms			Medium Farms		
	All Farms	Owners	Tenants	All Farms	Owners	Tenants
U Egypt						
Constant	12.378 (10.298)	12.390 (9.702)	13.930 (12.990)	6.393 (6.318)	6.337 (6.213)	6.023 (5.775)
Z_1	- 0.222* (- 4.048)	- 0.219* (- 3.047)	- 0.527*** (- 1.827)	- 0.09* (- 14.756)	- 0.09* (- 9.211)	- 0.05*** (- 2.148)
Z_2	- 0.209* (- 20.905)	- 0.212* (- 13.424)	- 0.250* (- 5.865)	- 0.005* (- 21.482)	- 0.004* (- 9.951)	- 0.004* (- 5.435)
Z_3	0.162* (34.023)	0.162* (24.576)	0.147* (9.572)	0.10* (43.694)	0.10* (23.621)	0.10* (31.034)
$\bar{R}^2$	0.97	0.97	0.95	0.98	0.97	0.96
F. Stat	840.270*	92.656*	57.141*	487.93*	248.644*	116.397*

Figures between brackets refer to t. statistics

* Significant at the 1% level

** Significant at the 5% level

*** Significant at the 10% level

$$y = ax_1^{\beta_1} RF_1^{\beta_{r1}} RF_2^{\beta_{r2}} X_4^{\beta_4} X_5^{\beta_5} X_6^{\beta_6}$$

In many cases, the estimate is destorted by the existance of high multicollinearity, particularly between RF_1 and RF_2. In some cases of which intercorrelation between explantory variables is not high, the general behaviour of the estimated coefficients is very similar to that explained by the two-stage model.

Model Specification of large farms

A single equation of Cobb-Douglas form is fitted to estimate the impact of labour, machines, nitrate, phosphate and improvement on crop yield;

$$y = A X_1^{\beta_1} X_2^{\beta_2} X_4^{\beta_4} X_5^{\beta_5} X_7^{\beta_7}$$

The function is estimated irrespective of the pattern of ownership because of the absence of an adequate size of sample of each tenure form. Due to the complixity of production process in large farms, the two stage model has not been employed. The estimated coefficients and related statistics are shown in Appendix I. Only 11 out of 25 input coefficients are significant at 10 per cent level or less. The adjusted coefficient of determination $\bar{R}^2$ is low relative to that corresponding to the estimated function for small and medium farms in the same region. Some important factors such as management efficiency might be neglected. Unlike small and medium farms, management and labour are separated in large scale production. Variations in managerial ability among large farmers are likely to be large because they apply their own policy regardless of government policy. This is not the case of small and medium farmers who are generally poor and constrained with lack of capital, relying heavily on government loan. They are therefore forced to apply government policy. An attempt is here made to quantify the difference in management efficiency to test the hypothesis under investigation.

In most studies management has not been included because no entirely satisfactory objective theoretical or empirical measure has yet been found. Nevertheless, some attempts were made in quantifying the productive contribution of management. An uncomplicated approach is to utilise residuals between fitted and actual observed levels of production as basis for an objective management rating. (12) Residuals may not be related to management, but to other excluded factors such as soil structure and public policy. One of the best known procedures is to weight management ability with profit within homogeneous samples. A management index is therefore obtained by rating profit of each observation to the average profit over the whole sample. This approach is consistant with the economic rationality assumption. In practice, it is extremely difficult to obtain homogeneous sample and to ensure that higher profit is entirely attributable to management efficiency. Some other included factors such as capital, improvement or some new inputs might contribute to profit efficiency.

It seems that the objective measures of management are constrained with practical application. Alternatively subjective indices can be useful in quantifying management efficiency. A logical measure of management efficiency is to partition the farm observations into a number of groups on the basis of a relevant criterion and employ the analysis of covariance of production function to test the value of intercept.(13) Knowledge of farming practices and techniques, deviation from the recommended practices or an education index might be used as a representative of management efficiency. (14) Apart from their subjective nature, they might measure management potentiality rather than actual management input over the production period. Still some subjective indices could be useful, if reliable knowledge on the mechanics of production process of the case under study is available.

It is however sensible to assume that knowledge of farming practices and techniques depend largely on the degree of education and the years of experience. Crop yield is therefore regressed against the level of education (ED) and the years of experience (EX). Both linear and quadratic functions are tested against non-linear function of C.D. Form. In all cases linear regression gave better fit. Both factors are linearly correlated with crop yield. The function is;

$$y = a + a_1 (ED) + a_2 (EX)$$

Dummy variables are introduced to measure the level of education which is ranked as 1 for non-educated farmer , 2 for primary educated farmers, 3 for secondary educated farmer and 4 for high educated farmers. Experience is measured in years; the period of which the family holds the land. The estimated functions in the various regions are shown in Appendix K. The adjusted coefficient of determination $\bar{R}^2$ ranges from 0.3 to 0.4 implying that some 30 or 40 per cent of the variations in crop yield are attributed to these two factors. Only two out of 10 input coefficients are insignificant.

An index of management efficiency is obtained by relating the actual level of education and experience for each individual farm weighted to the estimated coefficients,to the average over the whole sample;

$$I = \frac{a_1 (ED) + a_2 (EX)}{a_1 (\overline{ED}) + a_2 (\overline{EX})}$$

The coefficient of variation of management index is estimated to be found as 0.114, 0.109, 0.139, 0.150 and 0.147 for N & W Delta, M.Delta, E. Delta, M.Egypt and U.Egypt respectively. It is indeed higher than coefficient of varation of all the other variables, indicating significant variations in management ability among large farmers.

The function is re-fitted to include management index along with the other variables.* In all functions the fit is improved depending on the importance of management efficiency. Out of 30 input coefficients, only 7 are insignificant. One important reason for high standard error of the estimated coefficients of nitrate X_4, and phosphate x_5 may be the high intercorrelation between these two variables.** It seems that large farmers identify the technical combination between the two types of chemical fertilisers. This might be attributed to relative efficiency of management. The two types of fertiliser are converted into money terms to be aggregated in one variable CF, to replace X_4 and X_5.(Appendix L) All the estimated coefficients except one are now significant. Since knowledge on each type of chemical fertiliser are needed for further analysis, the estimated functions in table V11 - 9 are used in testing economic efficiency.

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* See Table VII - 9

** See Correlation Matrix (Appendix M)

TABLE VII-9

Estimated Coefficients and Related Statistics in Large Farms after including Management Index

All Regions

	N & W Delta	M Delta	E Delta	M Egypt	U Egypt
Constant	0.004	0.086 (0.228)	0.041	0.281 (0.216)	0.101 (0.065)
X_1	0.822** (2.478)	0.382 (1.523)	0.531** (2.229	0.347* (8.160)	0.458* (6.879)
X_2	0.380* (4.668)	0.285* (6.558)	0.406* (14.97)	0.211* (42.59)	0.258* (24.07)
X_4	0.191 (1.408)	0.210** (2.381)	0.114*** (1.899)	0.054 (1.272)	0.083* (3.454)
X_5	0.052 (1.413)	0.018 (0.262)	0.0295 (0.611)	0.054*** (2.106)	0.017 (0.452)
X_7	0.155* (3.407)	0.131* (3.091)	0.091*** (1.913)	0.037* (3.328)	0.078* (8.359)
I_m	0.261* (4.174)	0.057*** (1.805)	0.122* (5.127)	0.059* (17.566)	0.079* (16.827)
$\bar{R}^2$	0.88	0.87	0.95	0.96	0.94
F. Stat	27.834*	26.79*	88.956*	149.361*	117.019*

Figures between brackets refer to t. statistics

* Significant at the 1% level

** Significant at the 5% level

*** Significant at the 10% level

CHAPTER VIII

ECONOMIC EFFICIENCY AMONG FARM CLASSES

CHAPTER VIII

Economic Efficiency Among Farm Classes

Relative efficiency among farms of different tenure forms, farm size classes and regions is tested in terms of input marginal product and profit maximisation. The marginal product of the underlying inputs is derived from the estimated function coefficients at geometric mean to be valued at the prevailing output price and weighted against marginal cost. A significant difference between the value of marginal product (VMP) and marginal cost (MC) is taken as evidence of inefficient resource allocation. The same procedure is applied to the two-stage model to test resource allocation efficiency within and among the various stages of cultivation.

VIII - 1: Price Data and Inputs Cost

The selection of price data depends on both the objective of the study and the conditions under which the case under investigation operates. Since the objective of the present study is to test economic efficiency from the farmers point of view, prices actually paid by the farmers would be the appropriate measure. In this respect two practical problems might be faced. First, indirect or no payment is made for some inputs. Alternatively the opportunity cost principle is applied in imputing the cost of such inputs. The opportunity cost of any given input is defined as the cost of "best" alternative use for this input.(1) The cost of best alternative use for an input is the actual payment to similar inputs doing the same job.[(2)] The opportunity cost of family labour and manure is the actual payment to hired labour and purchased manure respectively. The best payment for machines and animals is the cost of service flow over the production period plus the prevailing interest. Secondly, prices might not be fixed for all farmers. Different farmers could pay different prices for the same input due to the absence of perfect competition. Intra-farm price variations in the case under investigation is unlikely to be significant because:

(1) Inputs are priced at the average price of the selected cluster(s) in each region.

(2) Weighted prices are used for each farm class.

(3) The prices of chemical fertilisers and machines are controlled and fixed.

(4) The market for labour, animals and manure is almost perfect.[(3)]

Labour Cost (wage per hour)

Both family and hired labour are priced at market wage rate. The wage rate is almost fixed for all farms in the same class in a certain season, but varies among seasons. It is therefore weighted to the size of seasonal employment within each farm size class. Large farmers are faced with higher wage rate than small and medium farmers because the proportion of labour employed in the peak seasons for which wage rate is relatively high, is greater on large farms.

Machines and Animals Cost (cost per horse power)

Machines and animals are multiperiod inputs and only the cost of service flows over the production period is relevant for computing the actual cost. The service flows cost of tractor, plough and irrigation machine are calculated separately by employing equation *1 in Chapter VI to be weighted to the actual working hours for each machine.

* p.181

Animal power consists of drought animals and farm tools pulled by them. The cost of animal power per hour is computed by aggregating the cost for drought animal and that for farm tool, to be converted into horse power cost and weighted to the actual working hours of each type. The operating cost of the animals used in Egyptian agriculture is computed by employing the following formula;

(a) In the case of Bullock (Ox)

$$C_a = \frac{D + I + B + R + F + W + A - P}{H}$$

(b) In the case of Cow and Buffalo

$$C_a = \frac{D + I + B + R + F + W + A - M - P}{H}$$

where,

D is the annual despreciation

$$D = \frac{CV + T - SV}{EL}$$

CV is the current (market) price of animal

T is the interest (6 per cent compound)

SV is the scrapped value (40 per cent of the current value)

EL is the expected life in years (10 years)

I is the annual insurance (2 per cent of CV)

B is the annual cost of Building.

$$B = \frac{S.SC}{Y}$$

where,

S is the required square metre

SC the cost per squared metre

Y the expected life.

R is the medical care (2 per cent of CV)

F is the annual cost of food

W is the annual wages paid to animals' keeper

A is the annual administrative expences

M is the annual revenue of selling the milk produced by the animal

P is the annual revenue of selling the manure produced by the animal

H is the annual working hours of the animal

The operating cost of farm tools pulled by drought animals* is estimated by applying the following formula:

$$CT = \frac{D + RM}{H}$$

where

CT is the cost per hour

D is the annual depreciation

RM is the annual repairs and maintenance

H is the annual working hours

The marginal product of machines / animal ratio (RF) was derived and interpretated as the change in output due to substituting animals by machines (Chapter VII). The marginal cost of RF is therefore the difference between machines cost and animals cost at their rate of substitution;

$$dc_r = dc_2 - dc_3$$

where,

dc_r is the marginal cost of RF

dc_2 is the marginal cost of machine units needed to replace one unit of animals.

* Plough (Mihrath) and levelling scoop (Kassabia) are used in land preparation, and Sakia is used in irrigation. Sakia consists of a vertical water wheel with pots on its rim attached by an axis to another vertical wheel with wooden cogs on its rim that mesh with the cogs on a horizontal wheel which is turned by drought animal.

dc_3 is the marginal cost of one unit of animals.

Hence,

$$dc_2 = dx_2 \cdot p_2$$

and

$$dc_3 = dx_3 \cdot p_3 \quad \text{(i.e. } dx_3 = 1)$$

or

$$dc_r = (dx_2 \cdot p_2) - (dx_3 \cdot p_3) = (dx_2 \cdot p_2) - p_3$$

where

p_2 and p_3 are the actual prices per unit (horse power) of machine and animal respectively.

dx_2 is the number of units of machines required to replace one unit of animals (unknown)

dx_3 is the change in animals used by one unit.

and

$$-\frac{dx_2}{dx_3} = K$$

where K is the marginal rate of substitution between x2 and x3

or

$$-dx_2 = K\, dx_3$$

thus

$$dc_r = (kdx_3 \cdot p_2) - (dx_3 \cdot p_3) = dx_3\,(kp_2 - p_3)$$

Given the value of K the marginal cost of RF is obtained. The value of K is estimated by regressing x2 against x3. Linear regression gives better fit, so that;

$$x_2 = a - kx_3$$

By differentiating x2 with respect to x3 the value of K is determined,

$$- \frac{\partial x_2}{\partial x_3} = K \,^{*}$$

The procedure is applied to each operation (land preparation and irrigation) separately to be weighted to the number of units actually employed within each operation.

Chemical Fertiliser Cost ("price per k.g.of plant Nutrient")

Chemical fertiliser prices are rigidly controlled and nationally fixed by the government. This uniformly fixed price is applied only to the prescribed quota. If the farmer decides to buy extra amount over his quota, he must pay higher price (unsubsidised price). This case applies to Nitrate used by large farmers who use it at amounts larger than the recommended dose. Nitrate price paid by large farmers is therefore estimated by weighting both controlled price and market price to the amount used of fertiliser. Price data on chemical fertiliser which is available in gross weight are converted into standard price of plant nutrient.

Manure Cost (price per cubic meter)

While many farmers use their own production of manure, there is some farmers who may purchase it. Opportunity cost concept is therefore applied in pricing manure. However, manure price is determined in a free market according to supply and demand forces. It is very similar among regions.

Output Price (price per Kentare)

Domestic market prices for cotton do not exist in Egypt. They are controlled and fixed by the government. Farmers are obliged to sell their

* The estimated rate of substitution between machines and animals with respect to each farm size in all regions is shown in Table VIII - 1.

whole production to co-operative at a pre-determined price. Variations in cotton prices among regions are due to differences in output quality.

Output and input prices with respect to each class of farm size in all regions are reported in Table VIII - 2. Detailed information and calculations are shown in appendix N.

TABLE VIII - 1

The number of machines horse-power needed to substitute one horse power of animal within each operation

	Small Farms		Medium Farms	
	Land Preparation	Irrigation	Land Preparation	Irrigation
N&W Delta	-	9.97	9.675	9.530
M. Delta	9.804	9.537	9.769	9.597
E. Delta	9.741	9.615	9.742	9.654
M. Egypt	9.730	8.591	9.728	8.589
U. Egypt	9.799	8.528	9.776	8.544

TABLE VIII - 2

Output and Input prices for each class of farm size classified to the different regions

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		Output Y	Man/Hour X1	Mach/Hour X2	Anim/Hour X3	Mach/Anim ratio RF	Nitrogen X4	Phosphate X5	Manure X6	Improv X7
N&W Delta	S. Farms	27.828	0.056	0.029	0.182	0.25	0.132	0.106	0.50	--
	M. Farms	27.828	0.056	0.038	0.200	0.166	0.132	0.106	0.50	--
	L. Farms	27.828	0.064	1.06	--	--	0.139	0.106	--	1.06
M. Delta	S. Farms	26.621	0.058	0.040	0.206	0.180	0.132	0.106	0.50	--
	M. Farms	26.621	0.058	0.042	0.197	0.134	0.132	0.106	0.50	--
	L. Farms	26.621	0.064	1.06	--	--	0.149	0.106	--	1.06
E. Delta	S. Farms	23.947	0.059	0.033	0.207	0.114	0.132	0.106	0.50	--
	M. Farms	23.947	0.059	0.034	0.203	0.128	0.132	0.106	0.50	--
	L. Farms	23.947	0.066	1.06	--	--	0.154	0.106	--	1.06
M.Egypt	S. Farms	24.941	0.057	0.033	0.206	0.119	0.132	0.106	0.45	--
	M. Farms	24.941	0.057	0.033	0.197	0.103	0.132	0.106	0.45	--
	L. Farms	24.941	0.063	1.06	--	--	0.145	0.106	--	1.06
U.Egypt	S. Farms	21.843	0.054	0.030	0.196	0.095	0.132	0.106	0.45	--
	M. Farms	21.843	0.054	0.032	0.192	0.095	0.132	0.106	0.45	--
	L. Farms	21.843	0.062	1.06	--	--	0.144	0.106	--	1.06

Sources:

(1) Ministry of Agriculture, Dept. of Agricult. Economics and Statistics Op.Cit.

(2) Ministry of Agriculture, Dept. of Agricultural Mechanisation, Op.Cit.

(3) Ministry of Agriculture, Institute of Animal.

(4) ACCB, Dept. of Accountancy.

(5) The underlying Survey.

VIII - 2: Resource allocation efficiency among forms of tenure

Input marginal products are derived for owners and tenants within both small and medium farms in all regions to be valued at output price and weighted against marginal cost (Tables VIII-3 and 4). Apart from a few insignificant input coefficients, the differences in input marginal products between owners and tenants are not significant. The degree of variation in VMP/MC ratio among the various inputs is nearly similar between the two tenure forms implying indifferent economic behaviour of farmers of different tenure forms. This is perhaps consistant with the reality of production process in Egyptian agriculture. Tenants are well protected by the law. They have permanent contracts at fixed rent. All farmers whether tenants or owners are compulsory members of the co-operatives, having access to credit. Government policy, in which input distribution and prices are controlled, is applied,similary to all farmers either owners or tenants. Capital availability is very similar for both tenants and owners within a particular farm size.(4) Hence, changes in the present pattern of ownership are unlikely to have a significant impact on productive efficiency.

TABLE VIII - 3

Derived Input Marginal Products, their Values, Marginal Cost and the Ratio between them in Small Farms Classified to Tenure Forms in all Regions

	OWNERS				TENANTS			
	MP	VMP	MC	VMP/MC	MP	VMP	MC	VMP/MC
N&W Delta								
X1	0.00135	0.038	0.056	0.679	0.0012	0.033	0.056	0.589
RF	0.934	25.991	0.25	103.964	1.061	29.525	0.25	118.102
X4	0.017	0.473	0.132	3.583	0.017	0.473	0.132	3.583
X5	0.014	0.390	0.106	3.679	0.007	0.195	0.106	1.838
X6	0.017	0.473	0.50	0.946	0.006	0.167	0.50	0.334
M. Delta								
X1	0.0019	0.051	0.058	0.879	0.002	0.053	0.058	0.913
RF	0.117	3.115	0.180	17.306	0.116	3.088	0.180	17.156
X4	0.0025	0.067	0.132	0.508	0.003	0.080	0.132	0.606
X5	0.014	0.373	0.106	3.519	0.012	0.319	0.106	3.009
X6	0.064	1.704	0.50	3.408	0.038	1.016	0.50	2.032
E. Delta								
X1	0.0015	0.036	0.059	0.610	0.0009	0.022	0.059	0.373
RF	0.528	12.064	0.114	105.824	0.609	14.584	0.114	127.930
X4	0.008	0.192	0.132	1.455	0.019	0.455	0.132	3.447
X5	0.023	0.551	0.106	5.198	0.013	0.311	0.106	2.934
X6	0.000	0.000	0.50	0.000	0.005	0.120	0.50	0.24
M. Egypt								
X1	0.0016	0.04	0.057	0.702	-0.0002	-0.005	0.057	-0.088
RF	0.798	19.903	0.119	167.252	0.553	13.792	0.119	115.899
X4	-0.003	-0.075	0.132	-0.568	0.033	0.823	0.132	6.235
X5	0.057	1.422	0.106	13.415	0.030	0.748	0.106	7.057
X6	0.017	0.424	0.45	0.942	0.018	0.449	0.45	0.998
U. Egypt								
X1	0.0012	0.026	0.054	0.481	0.0012	0.026	0.054	0.481
RF	0.088	1.992	0.095	20.232	0.084	2,053	0.095	21.610
X4	0.007	0.153	0.132	1.159	0.005	0.109	0.132	0.826
X5	0.034	0.743	0.106	7.009	0.047	1.027	0.106	9.689
X6	0.035	0.764	0.45	1.698	0.014	0.306	0.45	0.68

Sources: Tables VII - 7 and VIII - 2

TABLE VIII - 4

Derived Input Marginal Products, their Values, Marginal Cost and the Ratio between them in Medium Farms Classified to Tenure Forms in all Regions

	OWNERS				TENANTS			
	MP	VMP	MC	VMP/MC	MP	VMP	MC	VMP/MC
N&W Delta								
X1	0.0024	0.068	0.056	1.214	0.0023	0.064	0.056	1.143
RF	0.014	0.390	0.166	2.349	0.019	0.529	0.166	3.187
X4	0.007	0.195	0.132	1.477	0.01	0.278	0.132	2.106
X5	0.008	0.223	0.106	2.104	0.004	0.111	0.106	1.047
X6	0.035	0.974	0.50	1.948	0.032	0.890	0.50	1.78
M. Delta								
X1	0.0023	0.061	0.058	1.052	0.0022	0.059	0.058	1.017
RF	0.008	0.213	0.134	1.590	0.009	0.240	0.134	1.788
X4	0.007	0.186	0.132	1.409	0.007	0.186	0.132	1.409
X5	0.016	0.426	0.106	4.019	0.017	0.4525	0.106	4.269
X6	0.017	0.453	0.50	0.906	0.017	0.453	0.50	0.906
E. Delta								
X1	0.0025	0.060	0.059	1.017	0.0023	0.055	0.059	0.932
RF	0.0046	0.110	0.128	0.861	0.0053	0.127	0,128	0.991
X4	0.0057	0.136	0.132	1.034	0.007	0.168	0.132	1.270
X5	0.015	0.359	0.106	3.389	0.0156	0.374	0.106	3.524
X6	0.009	0.216	0.50	0.432	0.022	0.530	0.50	1.06
M. Egypt								
X1	0.0026	0.065	0.057	1.140	0.0025	0.062	0.057	1.088
RE	0.012	0.299	0.103	2.903	0.011	0.274	0.103	2.660
X4	0.0015	0.037	0.132	0.280	0.0024	0.060	0.132	0.455
X5	0.010	0.249	0.106	2.349	0.010	0.249	0.106	2.349
X6	0.033	0.823	0.45	1.829	0.036	0.898	0.50	1.796
U. Egypt								
X1	0.0025	0.055	0.054	1.019	0.0025	0.055	0.054	1.019
RF	0.008	0.175	0.095	1.842	0.015	0.328	0.095	3.453
X4	0.007	0.153	0.132	1.159	0.0058	0.127	0.132	0.962
X5	0.006	0.135	0.106	1.274	0.012	0.262	0.106	2.472

Sources: Tables VII - 7 and VIII - 2

VIII - 3: Resource allocation efficiency among classes of farm size

Derived marginal products, their values, marginal cost and the ratios between them within each farm size class in all regions are shown in Tables VIII - 5 & 6. The following features emerge:

(1) The marginal product of labour is positively correlated with farm size, showing high labour intensity in small farms. Furthermore, in all regions without exception, the value of marginal product of labour employed in small farms, though not zero, is less than the wage rate. Although large farmers are faced with a higher wage rate, it is considerably less than the labour marginal product. It seems that surplus labour exists only on small farms. This is relevant to Mohieldin's investigation on agricultural under-employment in Egypt, which shows a considerable surplus of man labour on small farms, while in the same regions and at the same time large farms can suffer from shortage of female and child labour.[5] Most of the work on small farms is done by family members for whom no direct payment is involved. During the slack seasons, labour is generally available in relative surplus and job opportunities outside family farms are perhaps limited. Mechanisation is more intensive in the slack seasons, reducing the ability of capitalist landlords to absorb labour. The underlying estimates also show that differences in labour marginal product either in small or medium farms are not significant among regions. This is not the case in large farms, because labour productivity would depend on the variaties of machines used and perhaps on the type of activity in which they are used.

(2) Unlike labour, machine intensity is a positive function of farm size. The positive marginal product of RF implies that the marginal product of machines is higher than the marginal product of animals. In all cases the cost of substituting animals by machines is less than the value of marginal

TABLE VIII - 5

Derived Input Marginal Products,their Values, Marginal Cost and the Ratio between them Classified to Small and Medium Farms

	SMALL FARMS				MEDIUM FARMS			
	MP	VMP	MC	VMP/MC	MP	VMP	MC	VMP/MC
N & W Delta								
X1	0.00145	0.040	0.056	0.714	0.0024	0.067	0.056	1.196
RF	0.9258	25.763	0.25	103.052	0.016	0.445	0.166	2.681
X4	0.0161	0.448	0.132	3.394	0.007	0.195	0.132	1.477
X5	0.0112	0.312	0.106	2.943	0.008	0.223	0.106	2.104
X6	0.0144	0.401	0.50	0.802	0.034	0.946	0.50	1.892
M. Delta								
X1	0.0019	0.051	0.058	0.879	0.0023	0.061	0.058	1.052
RF	0.136	3.620	0.180	20.111	0.007	0.186	0.134	1.388
X4	0.004	0.106	0.132	0.803	0.008	0.213	0.132	1.613
X5	0.011	0.293	0.106	2.764	0.015	0.399	0.106	3.764
X6	0.045	1.198	0.50	2.396	0.014	0.373	0.50	0.746
E. Delta								
X1	0.001	0.024	0.059	0.407	0.0025	0.060	0.059	1.017
RF	0.586	14.033	0.114	123.096	0.0057	0.136	0.128	1.063
X4	0.015	0.359	0.132	2.720	0.005	0.120	0.132	0.909
X5	0.017	0.407	0.106	3.840	0.0146	0.350	0.106	3.302
X6	0.005	0.120	0.50	0.240	0.01	0.239	0.50	0.478
M. Egypt								
X1	0.0014	0.035	0.057	0.614	0.0025	0.064	0.057	1.123
RF	0.753	18.781	0.119	157.824	0.011	0.273	0.103	2.650
X4	0.0008	0.02	0.132	0.152	0.0023	0.057	0.132	0.432
X5	0.058	1.447	0.106	13.651	0.01	0.249	0.106	2.349
X6	0.016	0.399	0.45	0.887	0.034	0.848	0.45	1.884
U. Egypt								
X1	0.0012	0.026	0.054	0.481	0.0025	0.055	0.054	1.019
RF	0.086	1.878	0.095	19.768	0.015	0.328	0.095	3.453
X4	0.006	0.131	0.132	0.992	0.006	0.131	0.132	0.992
X5	0.035	0.764	0.106	7.207	0.019	0.415	0.106	3.915
X6	0.027	0.590	0.45	1.311	-	-	-	-

Sources:Tables VII - 7 and VIII - 2

TABLE VIII - 6

Derived Input Marginal Products, their Values, Marginal Cost and the Ratios between them in Large Farms

INPUTS	MP	VMP	MC	VMP/MC
New Delta				
X1	0.0095	0.264	0.064	4.125
X2	0.128	3.562	1.06	3.360
X4	0.0157	0.437	0.139	3.144
X5	0.0231	0.643	0.106	6.066
X7	0.206	5.732	1.06	5.408
Im	1.298			
M. Delta				
X1	0.005	0.133	0.064	2.078
X2	0.114	3.833	1.06	3.616
X4	0.0178	0.474	0.149	3.181
X5	0.007	0.186	0.106	1.755
X7	0.180	4.792	1.06	4.521
Im	0.330			
E. Delta				
X1	0.007	0.167	0.066	2.530
X2	0.182	4.358	1.06	4.111
X4	0.010	0.239	0.154	1.555
X5	0.011	0.263	0.106	2.485
X7	0.145	3.472	1.06	3.275
Im	0.694			
M. Egypt				
X1	0.0042	0.105	0.063	1.667
X2	0.091	2.270	1.06	2.141
X4	0.0044	0.110	0.145	0.759
X5	0.0042	0.105	0.106	0.991
X7	0.053	1.322	1.06	1.247
Im	0.336			
U. Egypt				
X1	0.0064	0.140	0.062	2.258
X2	0.072	1.573	1.06	1.484
X4	0.0067	0.146	0.144	1.014
X5	0.0056	0.122	0.106	1.154
X7	0.0995	2.173	1.06	2.05
Im				

Sources: Table VII - 9 and VIII - 2

product of RF, but considerably lower in small farms. Further profit would be forthcoming if machine replaced animals.

Productive efficiency may not be the same for the two types of machines used in small and medium farms. Unless it is identified for each type of machines, misleading conclusion might be reached. The two-stage model is employed to test investment allocation efficiency between tractor and irrigation machines.*

Given;

$$Z_1 = a_1 + \beta_1 \; RF_1$$

$$Z_2 = a_2 + \beta_2 \; RF_2$$

where;

Z_1 and Z_2 are the time actually spent on land preparation and irrigation respectively.

and

$$Y = Az_1^{\alpha_1} z_2^{\alpha_2} z_3^{\alpha_3}$$

where

y is the crop yield .

By differentiating RF_1 and RF_2 with respect to z_1 and z_2 respectively, we have,

$$\frac{\partial z_1}{\partial RF_1} = \beta_1$$

and

$$\frac{\partial z_2}{\partial RF_2} = \beta_2$$

By differentiating z_1 and z_2 with respect to y, we have,

$$\frac{\partial Y}{\partial z_1} = \alpha_1 \frac{y}{z_1}$$

$$\frac{\partial Y}{\partial z_2} = \alpha_2 \frac{y}{z_2}$$

* See Chapter VII - 3.

But,

$$\frac{\partial Y}{\partial RF_1} = \frac{\partial Y}{\partial Z_1} \cdot \frac{\partial Z_1}{\partial RF_1}$$

and

$$\frac{\partial Y}{\partial RF_2} = \frac{\partial Y}{\partial Z_2} \cdot \frac{\partial Z_2}{\partial RF_2}$$

Thus,

$$\frac{\partial Y}{\partial RF_1} = \beta_1 \quad \alpha_1 \quad \frac{Y}{Z_1}$$

$$\frac{\partial Y}{\partial RF_2} = \beta_2 \quad \alpha_2 \quad \frac{Y}{Z_2}$$

The derived marginal products of RF1 and RF2, their values, marginal costs and the ratios between them are reported in Table VIII - 7. In all cases except medium farms in Middle Delta, the marginal product of RF1 is higher than that for RF2. The latter in Medium farms is very small in all regions except North and West Delta. Irrigation operation in medium farms is almost fully mechanised. VMP/MC ratio in small farms is considerably larger for irrigation than for land preparation. This is perhaps due to the low operating cost of irrigation machines relative to animals operating costs.* Small farmers would gain further profit if capital involved in mechanisation was reallocated in favour of irrigation. Unless medium farmers apply machines in activities other than land preparation and irrigation, neither crop yield nor profit are expected to increase substantially.

(3) The marginal product of nitrate in all regions and among classes of farm size is generally low, though Egyptian soil is originally not rich in nitrogen. It is particularly low in Middle Egypt and Upper Egypt. There are, of course, some few insignificant coefficients of nitrate, whilst

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* See appendix p.

TABLE VIII - 7

The Derived Marginal Product of Substituting Animals by Machines, its Value, Marginal Cost and the Ratio Between them Classified into Agricultural Operations

	SMALL FARMS				MEDIUM FARMS			
	MP	VMP	MC*	VMP/MC	MP	VMP	MC*	VMP/MC
N.W. Delta								
RF 1	-	-	-	-	0.021	0.584	0.197	2.964
RF 2	0.352	9.795	0.071	137.964	0.016	0.445	0.058	7.672
M. Delta								
RF 1	0.030	0.799	0.194	4.1185	0.009	0.240	0.193	1.243
RF 2	0.042	1.118	0.053	21.094	0.0006	0.016	0.054	0.296
E. Delta								
RF 1	0.516	12.357	0.190	65.037	0.011	0.263	0.190	1.384
RF 2	0.184	4.406	0.055	80.109	-0.0006	-0.0144	0.056	-0.257
M. Egypt								
RF 1	0.506	12.620	0.1995	63.258	0.0103	0.257	0.1995	1.288
RF 2	0.356	8.879	0.028	317.107	0.001	0.025	0.028	0.893
U. Egypt								
RF 1	0.078	1.704	0.2015	8.457	0.024	0.524	0.2005	2.613
RF 2	0.013	0.284	0.026	10.923	0.0006	0.013	0.027	0.481

* Marginal cost is estimated by using the following equation for each operation separately: $dc_r = kp_2 - p_3$

Where $k = -\frac{\partial x_2}{\partial x_3}$ (table VIII - 1)

p_2 is the cost of machines horsepower per hour

p_3 is the cost of animals power (horse power) per hour

p_3 includes no cost of animals, farm tools and labour used within each operation. (see appendix P)

Sources: Tables VII - 8 and VIII - 2

many others are small but significant. It seems that nitrate is either overdosed, inefficiently used, or perhaps both. International data on chemical fertilisers show that Egypt is one of the leading countries in using chemical fertilisers particularly nitrate (Table I - 4).

While nitrate has been more intensively used in large farms, its marginal product is relatively high compared with small and medium farms. Large farmers might be more efficient in using chemical fertilisers. This is perhaps only partly true. In terms of plant nutrient, small and medium farmers could be using larger amounts of nitrogen than large farmers, because they still use manure which nitrate is intended to replace, inducing the low marginal product of both nitrate and manure. Furthermore, the values of marginal product of manure and nitrate in small and medium farms in many regions is less than the marginal cost. It seems that many farmers are not aware of the consequences of overusing nitrogen.

This is not the case with respect to phosphate. In all regions and farm size classes, the marginal product of phosphate is significantly higher than the marginal product of nitrate. The difference between the value of marginal product and marginal cost of phosphate is generally high in small and medium farms compared with large farms. Technically, some proportional combination between the two types of fertiliser should be considered. While large farmers identify such a technical relation, small and medium farmers are perhaps not aware of it. Reallocation of fertilisers in favour of phosphate might bring an increase in crop yield. Misallocation of fertiliser inputs is rather worse from societys standpoint. Nitrate is largely imported and heavily subsidised,* whilst

* Import price of ton of plant nutrient of nitrate is L.E. 32.9 while it is sold to the farmers at some L.E. 13.2

phosphate is produced locally and priced at the actual cost. (6)

(4) Management efficiency in large farms is positively correlated with crop yield. Marginal product of management is particularly high in North and West Delta. Further improvement in management is therefore likely to bring along a considerable increase in large farmers productivity. Both education and experience appear to be productive factors. Farmers with long experience and a great deal of education are more efficient in utilising their resources. Relative efficiency of large farmers in allocating resources could be attributed to productive managerial ability.

(5) An examination of resource allocation efficiency among stages of cultivation suggests that small farmers are less efficient then medium farmers. (Table VIII-8)*. Further use of machines to replace animals in irrigation is highly profitable to small farmers in all regions. Medium farmers in all regions except North & West Delta would gain small profit if resources were reallocated in favour of land preparation or/and fertilisation. These findings are consistant with the above results.

One general conclusion can be derived from the above investigation. Large and medium farmers are more efficient than small farmers in allocating resources. This would explain the relatively low productivity of the land operated by small farmers. Still, knowledge of the present relative productivity is not sufficient for future policy. Knowledge of relative potential productivity is needed to identify the relevant farm size. Potential productivity is defined as the level of output at which profit is maximised.

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* Crop yield is negatively correlated with time spent in land preparation and irrigation, but positively correlated with time spent in fertilisation. In order to allow for feasible and consistent comparison between stages of production, the marginal product of time spent is converted to be positive in all cases. Crop yield is therefore positively correlated with the reduction in time spent in land preparation and irrigation and with the increase in time spent in fertilisation.

TABLE VIII - 8

Derived Marginal Product of Time Spent within each Operation, its Value, Marginal Cost and the Ratio beteeen them

	SMALL FARMS				MEDIUM FARMS			
	MP	VMP	MC*	VMP/MC	MP	VMP	MC*	VMP/MC
N & W Delta								
Z1	-	-	-	-	0.017	0.473	0.163	2.902
Z2	0.069	1.920	0.014	137.143	0.017	0.473	0.061	7.754
Z3	0.067	1.864	1.432	1.302	0.120	3.339	1.162	2.873
M. Delta								
Z1	0.0153	0.407	0.10	4.070	0.035	0.932	0.769	1.212
Z2	0.0256	0.681	0.032	21.281	0.025	0.666	2.160	0.308
Z3	0.078	2.076	1.497	1.387	0.096	2.556	1.491	1.714
E. Delta								
Z1	0.492	11.782	0.181	65.094	0.029	0.694	0.515	1.348
Z2	0.097	2.323	0.029	80.103	-0.004	-0.096	0.346	-0.277
Z3	0.009	0.216	1.534	0.141	0.049	1.173	1.446	0.811
M. Egypt								
Z1	0.509	12.695	0.201	63.159	0.028	0.698	0.573	1.218
Z2	0.134	3.342	0.0105	318.286	0.008	0.200	0.230	0.870
Z3	0.082	2.045	1.497	1.366	0.081	2.020	1.499	1.348
U. Egypt								
Z1	0.066	1.442	0.171	8.433	0.045	0.983	0.384	2.560
Z2	0.036	0.786	0.073	10.767	0.0015	0.033	0.071	0.465
Z3	0.106	2.315	1.503	1.540	0.072	1.573	1.485	1.059

* Input prices are weighted to the actual time spent by the corresponding input in order to obtain a weighted average price per hour spent within each operation.

Sources Tables VII - 8 and VIII - 2

VIII - 4 Determination of Optimum level of output

On the assumption that none of the input variables is in fixed supply, profit is maximised and output optimised if the VMP / MC ratio is equal unity for all input variables. (7) In practice capital is limited imposing considerable constraints in resource allocation. Unless capital constraint is taken into consideration, the optimisation approach is neither realistic nor meaningful. The estimated production function, price data and capital constraint are combined together in a langregean function for constrained extrema,(8) in an attempt to determine the optimum level of output. At this level, VMP/MC ratios for all input variables are equal, but not necessarily equal unity;

The objective function;

$$Y = AX_1^{\beta_1} X_2^{\beta_2} \ldots\ldots\ldots X_n^{\beta_n}$$

Setting capital constraint equal to the total cost of inputs actually used at the geometric mean of the sample, the restrained function is

$$C = \sum_{i=1}^{n} PiXi$$

Where p_i is the input price and C is the actual available capital.

Combining the two functions into a Langregean function;

$$L = Ax_1^{\beta_1} x_2^{\beta_2} \quad x_n^{\beta_n} - \lambda \quad \left(\sum_{i=1}^{n} Pi\, x_i - C \right)$$

where λ is the langregean multiplier.

By taking the partial derivatives of the langregean function with respect to each input and to λ, and set them equal to zero, we have;

$$\frac{\partial L}{\partial x_1} = A\beta_1 \; x_1^{\beta_1 - 1} \; x_2^{\beta_2} \ldots\ldots x_n^{\beta_n} - \lambda \quad P1 = 0$$

$$\frac{\partial L}{\partial x_2} = A\beta_2 \; x_1^{\beta_1} x_2^{\beta_2 - 1} \ldots\ldots x_n^{\beta_n} - \lambda \quad P2 = 0$$

$$\frac{\partial L}{\partial x_n} = A\beta_n \; x_1^{\beta_1} x_2^{\beta_2} \ldots\ldots\ldots x_n^{\beta_n - 1} - \lambda \; P_n = 0$$

$$\frac{\partial L}{\partial \lambda} = \sum_{i=1}^{n} P_i \; x_i \quad - \; C \qquad = 0$$

Using an iterative method for simultaneous equations, and solving for x_{is} and λ, the magnitude of the inputs which maximise profit under the prevailing restraint is estimated. Substituting the estimated values of x_{is} into the production function, the constrained optimum level of output is determined.

Such an approach is perhaps useful in the economic sense, still it neglects some technical constraints particularly when it applies to the Cobb-Douglas function which assumes unit elasticity of substitution. Substitution between the input variables might be possible at the actual level of inputs used, but not necessarily at the optimum level. In reality substitution between inputs is restricted within certain range at which marginal rate of substitution is equal to zero or infinity (i.e. ridge lines). Outside this range additional quantity of one input will not physically place any of the other inputs. Technical constraints corresponding to the production process in Egyptian agriculture is therefore imposed to rationalise the underlying approach.

Tractors and irrigation machines used on small and medium farms are animals' substitutes. They are labour substitutes only to the extent to which labour and animals are complementary. Machines used at present cannot technically replace labour used in harvesting, picking insects and sowing. A minimum requirement of labour is therefore imposed at a level equivalent to the sample mean of labour needed in harvesting, picking insects and sowing. No restriction is imposed on labour employed in large farms, because large farmers are using a variety of machines which are both animal and labour substitutes. Chemical fertiliser is also restricted, but at a maximum level. An application of chemical fertiliser above a certain level would have adverse impact on crop yield. Relying on a technical report issued by Ministry of Agriculture, a maximum level of 80 and 18 k.g. of plant nutrient for nitrate and phosphate respectively is imposed. (9) Lower bound is not setted because there is no technical basis for such restriction.

Such technical restrictions are also useful in reducing the limitation of constant elasticity of production which characterises the C.D. function. Imposing lower and upper bounds on some inputs would smooth their movement and reduce the range over which their production elasticities change. The estimated optimum level of inputs and output in all regions for all farm size classes is shown in Tables VIII - 9,10 & 11. The estimated optimum level might, particularly with respect to small farms, deviate from the true value. Elasticity of production is unlikely to remain constant for some input variables such as machines, animals and manure of which the used amount is radically changed at the optimum level. Still the suggested optimum level of output may not change dramatically, since the changes in the amount used of the underlying inputs are moving in opposite directions. It would, at least, indicate the probable order of magnitude.

In all regions, the productivity gap* is small in large and medium farms, showing relative efficiency of the present resource allocation. Output will not increase significantly, and input marginal products would not radically change if resources are efficiently reallocated (Table VIII - 13). The relative efficiency of large farmers is perhaps attributed to efficient management, so that further improvement in both

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* The difference between the optimum and actual level of output (Table VIII - 12).

TABLE VIII - 9

The Level of Inputs at Actual and Optimum Level of Output in Small Farms in the Various Regions

	N & W Delta		M. Delta		E. Delta		M. Egypt		U. Egypt	
	Actual	Optim.	Actual	Optim.	Actual	Optim.	Actual	Optim.	Actual	Optim.
X1 Man / Hour	513.510	443.420	492.444	436.394	498.020	435.07	513.600	441.590	487.393	439.411
RF Mach/Animal Ratio	0.599	24.045	3.045	25.400	2.133	68.426	2.596	62.416	8.791	55.039
X4 Nitrogenous	37.422	49.366	46.995	40.251	44.274	40.256	47.339	35.162	53.672	36.776
X5 Phosphate	9.984	11.441	9.676	11.028	9.238	9.442	8.976	18.00	7.997	15.00
X6 Manure	10.680	3.335	3.695	3.670	7.135	0.471	6.078	0.825	1.196	0.499
$\hat{Y}$ Fitted Output	4.657	7.063	4.700	5.514	4.720	11.254	4.865	17.539	4.628	6.189

TABLE VIII - 10

The Level of Inputs at Actual and Optimum Level of Output

in Medium Farms

in the Various Regions

	N. & W Delta		M. Delta		E. Delta		M. Egypt		U. Egypt	
	Actual	Optim.	Actual	Optim.	Actual	Optim.	Actual	Optim	Actual	Optim.
X1 Man / Hour	499.391	454.40	463.47	443.51	472.130	486.540	468.69	440.70	464.17	434.26
RF Mach / Animal Ratio	5.300	11.212	29.132	31.165	15.119	16.311	21.139	46.178	23.480	58.021
X4 Nitrogenous	42.259	44.259	55.914	64.880	53.942	52.395	56.537	36.175	61.447	43.810
X5 Phosphate	11.368	16.69	11.876	18.00	11.472	18.00	10.500	18.00	9.905	16.194
X6 Manure	7.209	9.157	4.246	2.356	5.591	2.61	4.595	7.127	-	-
$\hat{y}$ fitted output	5.537	5.564	5.535	5.610	5.486	5.556	5.377	5.553	5.700	5.867

TABLE VIII - 11

The Level of Inputs at Actual and Optimum Level of
Output in Large Farms
in the various Regions

Input Variables	N & W Delta		M. Delta		E. Delta		M. Egypt		U. Egypt	
	Actual	Optim.	Actual	Optim.	Actual	Optim.	Actual	Optim.	Actual	Optim.
X1 Man / Hour	429.000	452.950	433.500	393.620	438.000	393.690	455.000	484.790	422.000	450.110
x2 Machine	14.695	12.724	14.273	14.070	12.547	18.743	12.915	17.522	21.132	21.252
X4 Nitrogenous	60.261	48.539	67.343	73.759	63.146	36.228	68.290	32.787	73.417	50.328
X5 Phosphate	11.140	17.341	14.917	8. 888	15.537	13.620	18.763	11.629	18.025	14.005
X7 Iprovement	3.723	5.165	4.156	6.468	3.536	4.201	3.881	3.073	4.651	6.426
$\hat{Y}$ Fitted Output	4.943	5.054	5.710	5.870	5.639	5.957	5.545	5.772	5.931	6.106

TABLE VIII - 12

Percentage Increase in Crop Yield

At Optimum Level

	N&W Delta	M. Delta	E. Delta	M. Egypt	U. Egypt
	%	%	%	%	%
Small Farms	51.7	17.3	138.4	260.5	33.7
Medium Farms	0.5	1.4	1.3	3.3	2.9
Large Farms	2.2	2.8	5.6	3.4	3.0

Source:Tables VIII - 9, 10 and 11

TABLE VIII - 13

Inputs Marginal Products at the Actual and Optimum Levels in Small, Medium and Large Farms

	Small Farms		Medium Farms		Large Farms	
	At Actual	At Optim.	At Actual	At Optim.	At Actual	At Optim
N&W Delta						
X1	0.00145	0.0025	0.0024	0.0027	0.0095	0.009
X2					0.128	0.152
RF	0.9258	0.035	0.016	0.007		
X4	0.016	0.018	0.007	0.0065	0.0157	0.020
X5	0.011	0.015	0.008	0.0057	0.0231	0.0152
X6	0.014	0.07	0.034	0.027		
X7					0.206	0.152
M. Delta						
X1	0.0019	0.0025	0.0023	0.0024	0.005	0.0057
X2					0.114	0.119
RF	0.136	0.019	0.007	0.007		
X4	0.004	0.005	0.008	0.007	0.0178	0.017
X5	0.011	0.011	0.015	0.010	0.007	0.012
X6	0.045	0.053	0.014	0.026		
X7					0.180	0.119
E. Delta						
X1	0.001	0.003	0.0025	0.0025	0.007	0.008
X2					0.182	0.129
RF	0.586	0.044	0.0057	0.0055		
X4	0.015	0.039	0.005	0.0056	0.010	0.019
X5	0.017	0.041	0.0146	0.013	0.011	0.013
X6	0.005	0.191	0.01	0.021		
X7					0.145	0.129
M. Egypt						
X1	0.0014	0.0057	0.0025	0.0028	0.0042	0.0041
X2					0.091	0.069
RF	0.753	0.112	0.011	0.005		
X4	0.0008	0.004	0.0023	0.0037	0.0044	0.009
X5	0.058	0.104	0.01	0.0059	0.0042	0.007
X6	0.016	0.425	0.034	0.0226		
X7					0.053	0.007

Source: i. Tables VII 7 and 9
ii. Tables VIII 9, 10 and 11

education and experience would probably contribute to higher productivity in the future. Medium farmers are not as efficient as it may first appear since the machines used are animals' substitutes and confined to few activities. Further use of machines to replace labour in a wider range and better quality could improve their productivity. While small farmers are less productive at present they are potentially highly productive. A substantial increase in production would be achieved if resources were reallocated as suggested in Table VIII-9. Small farmers are not at present efficient in allocating resources not because they are less productive, but perhaps due to the application of incorrect agricultural policy. They could be more efficient than medium and large farmers under the correct policy. If this is true, as it would appear to be, one might argue that no conflict exists between social (i.e. justice in the distribution of wealth and income) and economic (i.e. higher productivity) objectives. This is an interesting and rather promising finding though surprising to some economists in Egypt. It is argued that land redistribution in favour of small farmers might have an adverse affect on agricultural production due to the distruption in the organisation of production.(10)

Some variations, though not significant, exist among the various regions. Farmers in East Delta, Middle Egypt and Upper Egypt are generally less efficient. The trend in the general pattern of the individual inputs in both small and medium farms is not very different between regions. Apart from few exceptions, labour, animals, nitrate and manure are overused, while phosphate and machines are underused. In large farms, higher degree of variations exist among regions. Labour is used more intensively in Middle Delta and East Delta, while machines intensity is less in East Delta and Middle Egypt. Both phosphate and nitrate are overused in all regions except Middle Delta (nitrate) and North & West Delta (phosphate). However, it seems that variations in the pattern of resource allocation is larger among farm size classes than between regions for the same class of farm size.

VIII - 5: A General Approach for Better Farming

One general conclusion emerges: a significant increase in production can be achieved in the short run if small farmers are motivated to reallocate their resources in favour of machines and phosphate. Unless the government makes agricultural machines available on hire, small farmers who lack the necessary finance will not be able to use machines for cultivation.* A large proportion of the foreign exchange needed to finance agricultural mechanisation could be obtained from existing sources. If the use of nitrate is reduced to the above suggested level (Table VIII - 9) the funds saved on subsidy** can be used to import agricultural machines. Moreover, further funds can be obtained if the size of subsidy itself is reduced. The subsidy could be a crucial factor if farmers use little or no chemical fertiliser and are not aware of the agronomic and economic potential of fertiliser, but once they have appreciated the value of fertiliser techniques, they will have a high motivation to continue using fertilizer, since rapid and large returns are forthcoming. Hence, a small or moderate increase in fertiliser price may have limited effects on the demand for it (i.e. price elasticity of demand is relatively low) and the subsidy could therefore be progressively withdrawn. As the farmers use more fertiliser, the return from using it becomes smaller, and the demand for it will, therefore, be sensitive to price changes. (11) Whilst Egyptian farmers demands for fertiliser are characterised by large and regular applications, fertiliser prices are heavily subsidised. Since farmers use more than they should according to profit maximisation criteria, there is no logical justification for such a high subsidy. It seems that the present fertiliser policy has succeeded

* In recent years, this system was introduced but applied in a small scale due to the lack of finance.

** The farm price is fixed at L.E. 0.132 per k.g. of plant nutrient, while the import price is L.E. 0.329.

in promoting the use of fertilisers, but perhaps failed to adjust prices to rationalise farmers behaviour and optimise fertiliser use. Removing the whole subsidy might dramatically reduce farmers demand for fertiliser. Instead a gradual reduction in nitrate subsidy could rationalise fertiliser use and save a considerable amount of foreign exchange to be utilized in promoting mechanisation.

Some 12 million pounds in foreign exchange are needed to mechanise land preparation and irrigation on cotton area operated by small farms. All these funds can be obtained from foreign exchange saved on nitrate subsidy, if full mechanisation is to be achieved in three years. Some 1.7 million pounds can be saved if the amount of fertiliser used is reduced as suggested,* and more than 3 million pounds can be extracted if the subsidy on one kilogramme of nitrogen plant nutrient consumed is reduced from LE. 0.197 to L.E. 0.137.**

Agricultural mechanisation would not only increase small farmers profits as shown above, but also will increase animals production at a lower cost. Releasing animals from agricultural work would substantially increase their production of milk and meat and reduce their food consumption. Table VIII - 14 shows that farmers annual profit could be increased by more than L.E. 72 if a drought animal is removed from the field.

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* The funds saved on subsidy (L.E. 0.197 per k.g. of plant nutrient)

** All calculations are made separately for each region and added together. Sources :Tables VII 1,3 and 7 and Tables VIII - 2,9,10 and 11. Subsidy is arbitrary reduced by 30 per cent so that nitrate price is increased from L.E. 0.132 to L.E.0.192 per kg.

TABLE VIII - 14

Annual Profit gained due to removing animal from the field

	Milk Increase			Meat Increase			Food Reduction *			Total Profit	Number of Anim.	Weighted Average Profit
	Quantity k.g.	Price L.E	Profit L.E.	Quantity k.g.	Price L.E.	Profit L.E.	Quantity k.g.	Price L.E.	Profit L.E.	L.E.	%	L.E.
Cow	370	0.12	44.4	7.5	1.0	7.5	360	0.03	10.8	62.7	40	25.08
Buffalo	560	0.15	84.0	7.5	1.0	7.5	228	0.03	6.84	98.34	45	44.25
Ox(Bullock)	-	-	-	10.0	1.0	10.0	400	0.03	12.0	22.0	15	3.3
Weighted Profit												72.63

* Concentrates.

Sources: i. M.T. RAGAB; A.A. Askar, "Milk Production" Maktabet El Nahda El Masria, Cairo 1958 Tables 9, 13. pp 108 and 117 respectively.

ii Ministry of Agriculture, Institute of Animal.

iii Personal contact with the director of Institute of Animal.

On the other hand, reallocating resources in favour of phosphate would not require additional capital and might save foreign currency. since it is produced locally at a relatively low cost.

Although the present investigation is confined to cotton crop, the major crop, the derived results might be, at least as a probable order of magnitude, valid for many other crops. It was shown in the time series investigation (Chapter VI) that the general behaviour of agricultural resources are rather similar among cotton, wheat and rice. However, significant variation in resource allocation is unlikely to exist among crops for a given farm under the present controlled agricultural policy.

SUMMARY AND CONCLUSION

Summary and Conclusions

The two principal objectives of the study were to test:

1. Investment allocation efficiency among commodity sectors.
2. Resource use efficiency among farms of different size classes and tenure forms in the agricultural sector.

Data derived from the five year plan, 1960-65 were used in measuring the change in the rate of growth and trade deficit (surplus) if investment was reallocated in favour of agriculture. The minimum capital-output ratio criterion was used in reallocating investment among the two commodity sectors. Both an input-output table and a supply-demand table were employed to test consistency and balance between sectors, and to identify sectoral surplus.

Both time series data and cross sectional observations were used separately in testing resource allocation efficiency in agriculture. The whole area was divided into five regions; North and West Delta, Middle Delta, East Delta, Middle Egypt and Upper Egypt. A production function approach assuming all production factors as variables was adopted. All variables were measured as inputs actually used in production regardless of their availability. Linear and non-linear functions of Cobb-Douglas and Constant Elasticity of Substitution forms were tested against the numerical observations to select the algebraic form which gives best fit.

The three major crops; cotton, rice and wheat were investigated in time series function to cover the period 1960-75. A disaggregated linear production function was fitted for each crop in each region. A linear production function was chosen because it gave best fit. The estimated input coefficients were destorted by both multicollinearity and autocorrelation. Multicollinearity was minimised by dropping the variable (s) with insignificant but small coefficient (s). Autocorrelation was solved by employing the generalised least square (GLS) method.

The meaningfulness and accuracy of the estimated time series functions were limited by the availability and reliability of data. Cross sectional data were therefore used to test relative efficiency among farms of different sizes and tenures. 529 farms were randomly selected to provide data for the cotton cropping year 1975. Three classes of farm size, small (< 5 Feddans), medium (5-< 20 Feddans) and large (20 or more Feddans) were considered. The relative efficiency of the two tenure forms; owners and tenants within small and medium farms were also examined. Two techniques were employed:

(a) A single function of Cobb-Douglas form was applied separately for each farm size class, to test resource allocation efficiency over the whole production period. A regression was also fitted to the separate subsamples of owners and tenants.

(b) A two-stage model was employed for testing resource allocation efficiency among stages of cultivation. The whole production period is split into sub-periods corresponding to the various operations. To test resource allocation efficiency within each stage of cultivation, a separate linear function was fitted for each operation by regressing time actually spent in each operation against the relevant inputs used. Crop yield was then non-linearly regressed against the time actually spent in each operation to test resource allocation efficiency among stages of cultivation. The investigation was confined to small and medium farms.

High intercorrelation between machine and animal power variables prevailed, inducing difficulty in interpretating the least squares estimates of the function coefficients. Hence the two correlated inputs were replaced by their ratio as a single variable. In all cases, the estimated coefficient of machine-animal ratio was significant.

A management index in large farms was derived to investigate the impact of managerial ability on productive efficiency. The degree of education and years of experience were examined against land productivity.

Relative efficiency among farms of different size classes, tenure forms, and regions was tested in terms of input marginal product and profit maximisation, by comparing the estimated value of marginal product of each factor to its cost or price. Both actual and potential productivity were measured and investigated. An optimisation technique using a Langregean function for constrained extrema was employed to determine the optimum level of output and hence to identify the best relevant farm class to the Egyptian agriculture.

The analysis conducted in this study indicated the following findings:

1. The rate of growth would be accelerated, and agricultural surplus could be increased inducing a considerable reduction in trade deficit during the period 1960-65, if investment was reallocated in favour of agriculture.

2. The general behaviour of the resource use pattern in agriculture is rather similar among the crops under study, implying insignificant difference in relative efficiency.

3. Variations in resource allocation efficiency among regions for a given class of farm size are not large, and significantly less than variations between farm size classes in the same region. Reallocation of

an input factor between regions would not bring along a considerable change in production.

4. Differences in relative efficiency between owners and tenants within each farm size class is not significant. Changes in the present pattern of ownership are unlikely to improve productive efficiency.

5. Farm size is positively correlated whith the marginal product of labour, animal power and manure, but negatively correlated with the marginal product of machine power and phosphate. The marginal product of Nitrate is generally low in all farm size classes.

6. In all regions, large and medium farmers are significantly more efficient than small farmers in allocating resources. A substantial increase in production will not be forthcoming if resources employed by large and medium farmers are reallocated. The relative efficiency of large farmers is perhaps attributed to management efficiency which is positively correlated with crop yield. Long term changes such as improvements in education, and experience, and the application of new agricultural techniques might contribute to a higher productivity. Medium farmers are not as efficient as it may first appear, because machines used are animal substitutes and confined to a few activities. Further use of machines to replace labour in a wider range and better quality might improve their productivity.

7. Resources are inefficiently allocated in small farms. Labour, animal power, nitrate and manure are overused, while machines and phosphate are underused. In all regions the value of marginal product of labour, though not zero is less than wage rate implying the existance of surplus labour on small farms. Furthermore, resources are misallocated among

stages of cultivation. Small farmers would gain further profit if resources were reallocated in favour of machines and phosphate.

8. Crop yield is highly correlated with time spent in cultivation. A reduction in time spent in irrigation through the application of irrigation machines would bring a considerable increase in both production and profit to small farmers.

9. Although small farmers are at present less productive than large and medium farmers, they are potentially highly productive. The applied optimisation techniques suggested that small farmers would be more productive than large and medium farmers if resources were efficiently allocated. So long as the right policy is applied,small farms would be relevant to the Egyptian agriculture and no conflict will exist between social (i.e. Justice in the distribution of wealth and income) and economic (i.e. higher productivity) objectives.

The findings of this study indicated that policies aimed at providing agricultural machines such as tractors and irrigation machines on a hire basis through the co-operatives would not only improve productive efficiency of the majority of farmers (i.e. the small farmers), but also is likely to increase animal production substantially and reduce their intakes of food. Capital required to finance agricultural mechanisation can be obtained from existing resources, if the subsidy on nitrogenous fertiliser is reduced by some 30 per cent. This is confined to cotton production, the crop under investigation.

APPENDICES

APPENDIX 'A'

Yields for the major crops in Egypt (1952 - 75)

Year \ Crop Yield	Cotton (1)		Rice (2)		Wheat (3)	
	Yield	Index	Yield	Index	Yield	Index
1952	4.19	100	1.46	100	5.18	100
1953	4.48	107	1.63	112	5.74	111
1954	4.11	98	1.91	131	6.41	124
1955	3.41	81	2.16	148	6.36	123
1956	3.66	87	2.31	158	6.56	127
1957	4.11	98	2.32	159	6.46	125
1958	4.40	105	2.10	144	6.62	128
1959	4.85	116	2.19	150	6.52	126
Average	4.151	100	2.01	100	6.231	100
Stad. error	0.455		0.3176		0.506	
Coef. of variation	0.1096		0.158		0.081	
1960	4.68	100	2.127	100	6.86	100
1961	3.21	67	2.157	101	6.92	101
1962	5.12	109	2.469	116	7.30	106
1963	5.12	109	2.325	109	7.40	108
1964	5.66	121	2.25	106	7.72	113
1965	5.02	107	2.24	105	7.41	108
1966	4.40	94	2.11	99	7.57	110
1967	4.72	101	2.24	105	6.91	101
1968	5.25	112	2.28	107	7.16	104
1969	5.79	124	2.28	107	6.79	99
Average	4.888	118	2.248	112	7.204	116
Stand. error	0.753		0.105		0.325	
Coef. of variation	0.154		0.047		0.045	
1970	5.48	100	2.42	100	7.75	100
1971	5.90	108	2.36	98	8.55	110
1972	5.82	106	2.32	96	8.69	112
1973	5.43	99	2.28	94	9.82	127
1974	5.26	96	2.132	88	9.17	118
1975	4.98	91	2.309	95	9.72	125
Average	5.478	132	2.304	115	8.95	144
Stand. error	0.344		0.97		0.783	
Coef. of variation	0.063		0.042		0.087	

(1) Kentar per Feddan (Kentar = 157.5 K.g., Feddan = 0.96 acre)
(2) Dariba per Feddan (Dariba = 940 K.g.)
(3) Ardab per Feddan (Ardab = 150 K.g.)

Sources : 1. CAPMS, "Statistical Year Book", Cairo, various years, op. cit.
2. Ministry of Agriculture, Department of Agricultural Economics and Statistics, Cairo.

APPENDIX B Estimated Coefficients and Related Statistics (Cotton) Linear and Non-Linear (Cobb-Douglas) Production Function

	N & W Delta		M. Delta		E. DELTA		M. Egypt		U. Egypt	
	Linear	Non-Linear	Linear	Non-Linear	Linear	Non-Linear	Linear	Non-Linear	Linear	Non-Linear
Const.	4.3726	0.933	9.868	4.629	16.225	2.199	39.205	14.784	-29.226	-7.406
t. stat.	(7.827)	(-0.054)	(13.006)	(4.042)	(1.051)	(0.562)	(-2.651)	(1.918)	(-2.055)	(-1.122)
X_1	0.0049**	0.5616	-0.0027***	-0.338	0.000	0.048	-0.0087	-0.907	-0.0028	0.511
t. stat.	(5.314)	(2.313)***	(-2.939)	(-1.971)	(0.0015)	(0.875)	(-2.704)	(-1.406)	(-0.402)	(0.479)
X_2	0.3205***	0.0373	0.517***	0.123	0.867	0.142	0.778	0.172	1.334	0.927
t. stat	(2.852)	(0.451)	(2.781)	(1.274)	(2.407)***	(1.015)	(2.00)	(0.892)	(2.450)	(0.805)
X_3	0.0065	0.0451	0.0132	0.0710	-0.0065	-0.086	-0.0516	-0.163	0.140	0.325
t. stat	(2.191)	(0.495)	(1.452)	(0.571)	(-0.329)	(-0.046)	(-2.633)	(-1.027)	(1.781)	(0.34)
X_4	-0.0868*	-0.5027***	-0.0109	0.0293	-0.0956	-0.113	-0.0383	0.428	-0.0854	0.688
t. stat	(-7.242)	(-2.472)	(-0.580)	(0.148)	(-1.755)	(-0.344)	(-0.364)	(0.7024)	(-0.783)	(0.555)
X_5	-0.0256	0.0297	-0.0995	-0.328	-0.133	-0.271	0.0604	0.0117	0.318	-0.205
t. stat	(-0.922)	(0.1845)	(-1.271)	(-1.536)	(-0.530)	(-0.581)	(0.801)	(0.0686)	(0.914)	(-0.303)
X_6	-0.0414	10.1035	-0.143**	-0.0582	0.0528	0.162	0.220	0.429	-0.287	-0.149
t. stat	(-1.017)	(-0.7681)	(-3.294)	(-1.360)	(0.293)	(0.449)	(2.178)	(1.373)	(-1.770)	(-1.134)
X_7	-0.0242	-0.0736	-0.0433	-0.0683	-0.0063	-0.0364	-0.0473	-0.082	-0.310	-0.060
t. stat	(-0.944)	(-0.6186)	(-1.148)	(-0.559)	(-0.053)	(-0.163)	(-0.494)	(-0.802)	(-2.154)	(-0.353)
X_{71}	-0.1706**	-0.2746***	-0.0804**	-0.133	-0.008	-0.112	-0.0391	0.0255	0.0257	0.0284
t. stat	(-8.547)	(-2.5882)	(-2.423)	(-1.684)	(-0.073)	(-0.662)	(-0.331)	(0.206)	(0.267)	(0.479)
X_8							-9.610	-7.077	2.837	0.181
t. stat							(-2.475)	(-1.735)	(1.241)	(0.048)
W	-0.2901**	-0.1126	-1.061	-0.1074	-7.541	-1.899	5.895	1.452	1.727	1.128
t.stat	(-4.623)	(-1.527)	(-0.980)	(-0.482)	(-0.612)	(-0.652)	(0.690)	(0.701)	(0.430)	(1.047)
T	0.2925*	0.0651**	-0.0904	-0.004	0.0073	0.0123	0.0927	-0.008	0.906	-0.038
t.stat	(6.396)	(3.136)	(-1.579)	(-0.130)	(0.042)	(0.250)	(0.467)	(-0.229)	(1.897)	(-0.324)
$\bar{R}^2$	0.96	0.813	0.919	0.824	0.622	0.334	0.706	0.269	0.872	0.672
F. stat	32.496*	6.664	15.838**	7.069	3.140	1.651	3.835	1.435	9.014	3.416
D.W.	3.483	1.9794	3.097	2.4508	2.096	2.673	3.395	3.183	3.177	3.171
Aut Coef.	-0.742	-0.048	-0.5606	-0.356	-0.060	-0.346	-0.786	-0.623	-0.596	-0.609

* Significant at the 1% level. ** Significant at the 5% level. *** Significant at the 10% level.

Estimated coefficients and related statistics (Wheat) Linear and Non-linear (Cobb Douglas) production function

(17 samples)

	N & W Delta		M. DELTA		E. DELTA		M. EGYPT		U. EGYPT	
	Linear	Non-Linear	Linear	Non-Linear	Linear	Non-Linear	Linear	Non-Linear	Linear	Non-Linear
Constant	0.077	2.979	2.554	2.336	-8.441	1.721	13.582	1.686	22.168	2.485
t. stat	(0.0036)	(1.448)	(0.407)	(2.524)	(-1.298)	(1.400)	(2.423)	(2.249)	(4.285)	(2.341)
X_1	-0.006	0.0184	0.0019	-0.054	0.0218	0.285	0.0232**	0.394***	0.0028	-0.207
t. stat	(-0.245)	(0.0429)	(0.142)	(-0.325)	(1.967)***	(1.126)	(3.040)	(2.248)	(0.345)	(-1.115)
X_2	0.641	0.372	0.360	0.087	0.098	0.092	0.360***	-0.155	0.176***	-0.031
t. stat	(0.859)	(1.255)	(1.439)	(0.971)	(0.843)	(1.046)	(2.023)	(-0.549)	(1.894)	(-0.568)
X_3	-0.018	-0.398	0.0073	0.009	0.0126	0.152	-0.0047	-0.119	-0.003	-0.208**
t. stat	(-0.672)	(-1.131)	(0.459)	(0.0595)	(1.087)	(1.423)	(-0.477)	(-1.588)	(-0.325)	(-2.336)
X_4	0.0045	0.211	-0.066	-0.075	-0.108***	-0.269	-0.151**	-0.452	0.0713	0.472**
t. stat	(0.304)	(0.253)	(-0.833)	(-0.347)	(-2.014)	(-1.304)	(-2.896)	(-1.595)	(1.954***)	(2.623)
X_6	0.0813	0.0136	0.029	0.042	0.0305	-0.007	0.0979	0.0953	-	
t. stat	(0.151)	(0.429)	(0.153)	(0.998)	(0.713)	(-0.09)	(1.817)	(1.553)	-	
H.V.	0.718	0.0525	5.003	-0.073	6.307**	0.006	5.376**	0.011	5.247**	-0.032
t. stat	(0.235)	(0.275)	(1.0799)	(-0.47)	(2.703)	(0.294)	(3.243)	(0.811)	(2.628)	(-1.784)
W	8.422	-0.021	4.542	0.0814	11.817**	1.520***	-6.807	-0.0365	-18.087*	-1.865*
t. stat	(0.414)	(-0.006)	(0.762)	(0.134)	(2.358)	(2.132)	(-1.40)	(-0.055)	(- 3.430)	(-3.299)
T	-0.124	-0.056	0.251	0.0223	0.423***	0.047***	0.285***	0.038	-0.027	-0.031**
t. stat	(-0.310)	(-0.687)	(0.727)	(0.645)	(2.243)	(2.007)	(2.394)	(2.172)***	(-0.294)	(-2.313)
$\bar{R}^2$	0.663	0.552	0.761	0.739	0.91	0.852	0.829	0.692	0.755	0.841
F. stat	4.939**	3.468	7.358*	6.660**	21.204*	12.569*	10.700*	5.486**	8.039*	13.157*
D. W.	2.452	2.299	1.694	1.843	1 .996	1.478	2.886	1.376	1.661	2.705
Aut Coef.	-0.258	-0.168	0.1399	0.003	-0.021	0.257	-0.451	0.183	0.136	-0.383

* Significiant at the 1% level
** Significant at the 5% level
*** Significant at the 10% level

Estimated coefficients and related statistics (Rice)

Linear and non-linear (Cobb-Douglas) production function

	N & W DELTA Linear	N & W DELTA Non-Linear	M DELTA Linear	M DELTA Non-Linear	E. DELTA Linear	E. DELTA Non-Linear
Constant	1.906	1.853	0.151	1.772	0.977	1.058
	(2.225)	(1.536)	(0.241)	(2.747)	(0.664)	(1.884)
X_1	0.0002	-0.0775	-0.0008	-0.078	-0.0011	0.0814
	(0.150)	(-0.385)	(-1.565)	(-0.756)	(-0.799)	(0.594)
X_2	0.8067**	0.283**	0.505	0.250	0.939	-0.107
	(3.483)	(2.968)	(2.087)	(1.350)	(1.638)	(-0.792)
X_3	-0.0004	-0.0061	-0.0024	-0.078	0.0021	0.0833
	(-0.419)	(-0.0702)	(-0.093)	(-0.798)	(0.617)	(0.657)
X_4	-0.0193	-0.222	-0.0057	-0.095	0.000	-0.0793
	(-2.054)	(-1.569)	(-2.548)	(-0.513)	(0.000)	(-1.539)
X_5	0.0345	0.0891	0.0396	0.1103	-0.0064	-0.0896
	(1.424)	(0.964)	(1.582)	(1.194)	(-0.175)	(-1.693)
$\bar{X}_6$	0.004	0.0143	0.0105	0.0195	-0.0067	0.120***
	(0.457)	(0.568)	(1.398)	(1.075)	(-0.111)	(2.186)
X_7	-0.0488	-0.0041	0.1125	0.116	0.164	-0.116**
	(-0.315)	(-0.146)	(0.765)	(0.309)	(0.267)	-2.782
X_{71}	0.0692	-0.019	0.4125	0.122	0.084	0.00781
	(0.498)	(-0.207)	(2.055)	(0.620)	(0.229)	(0.067)
H.V.	0.253	-0.0997	0.674	0.259	0.999	1.388***
	(1.648)	(-1.835)	(1.073)	(0.736)	(0.513)	(2.683)
W	0.135	0.0980	1.582	0.626	-0.234	-0.186
	(0.205)	(0.327)	(2.027)	(1.526)	(-0.408)	(-1.781)
T	-0.0197	-0.0352	-0.0755**	-0.0214	-0.0067	-0.0036
	(-1.346)	(-0.309)	(-3.108)	(-1.183)	(-0.090)	(0.223)
$\bar{R}^2$	0.914	0.902	0.910	0.830	0.826	0.903
F. stat	15.538*	13.608**	14.930*	7.665**	7.491**	17.287*
D.W.	2.277	2.474	3.299	3.170	2.617	2.442
Aut. Coeff.	-0.3151	-0.39	-0.673	-0.635	-0.45	0.39

* Significant at the 1% level

** Significant at the 5% level

*** Significant at the 10% level

APPENDIX C   CORRELATION MATRIX   N & W DELTA   (COTTON)

	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_{71}	W	T
Y	1.00	-0.228	0.635	-0.484	0.326	-0.312	-0.600	-0.198	-0.328	0.255	0.441
X_1		1.00	-0.558	0.540	-0.508	-0.400	0.188	0.619	-0.199	0.133	-0.706
X_2			1.00	-0.924	0.867	0.304	-0.625	0.324	0.102	0.271	0.924
X_3				1.00	-0.885	-0.411	0.573	-0.375	-0.193	-0.215	-0.936
X_4					1.00	0.628	-0.486	0.419	0.055	0.107	0.904
X_5						1.00	0.133	0.704	0.283	-0.141	0.552
X_6							1.00	0.261	0.361	-0.501	-0.442
X_7								1.00	0.438	0.057	0.589
X_{71}									1.00	-0.312	0.253
W										1.00	0.166
T											1.00

M. DELTA (COTTON)

	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_{71}	W	T
Y	1.00	-0.198	0.331	-0.239	0.071	-0.732	-0.156	-0.373	-0.267	-0.271	0.140
X_1		1.00	0.092	0.113	0.105	-0.163	0.231	-0.282	-0.196	0.348	-0.121
X_2			1.00	-0.867	0.940	-0.012	0.417	0.359	0.359	-0.712	0.913
X_3				1.00	-0.865	-0.128	-0.124	-0.422	-0.559	0.913	-0.926
X_4					1.00	0.241	0.395	0.465	0.447	-0.695	0.931
X_5						1.00	0.088	0.681	0.266	-0.134	0.293
X_6							1.00	0.099	0.1003	0.018	0.219
X_7								1.00	0.451	-0.559	0.618
X_{71}									1.00	-0.604	0.505
W										1.00	-0.857
T											1.00

E. DELTA (COTTON)

	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_{71}	W	T
Y	1.00	0.411	0.492	-0.218	0.226	-0.364	0.150	-0.207	-0.187	-0.271	0.226
X_1		1.00	0.358	-0.373	0.277	-0.083	-0.025	0.046	-0.149	-0.288	0.219
X_2			1.00	-0.810	0.900	0.186	-0.172	0.327	0.263	0.0716	0.867
X_3				1.00	-0.917	-0.487	0.241	-0.378	-0.462	0.014	-0.888
X_4					1.00	0.405	-0.283	0.439	0.426	0.149	0.932
X_5						1.00	-0.115	0.662	0.455	-0.305	0.489
X_6							1.00	-0.173	0.006	-0.137	-0.265
X_7								1.00	0.487	0.166	0.619
X_{71}									1.00	0.084	0.561
W										1.00	0.147
T											1.00

M. EGYPT (COTTON)

	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_{71}	X_8	W	T
Y	1.00	-0.328	0.477	0.226	-0.279	-0.594	0.184	-0.509	-0.246	-0.524	0.049	-0.318
X_1		1.00	-0.089	-0.065	-0.081	0.159	0.0755	-0.109	-0.27	-0.059	-0.058	-0.126
X_2			1.00	-0.452	0.526	-0.085	-0.572	-0.091	-0.003	0.023	-0.423	0.428
X_3				1.00	-0.909	-0.582	0.879	-0.376	-0.409	-0.687	0.593	-0.865
X_4					1.00	0.630	-0.906	0.552	0.495	0.664	-0.548	0.98
X_5						1.00	-0.459	0.630	0.622	0.655	-0.459	0.652
X_6							1.00	-0.425	-0.262	-0.425	0.410	-0.854
X_7								1.00	0.706	0.384	0.0536	0.641
X_{71}									1.00	0.553	-0.288	0.597
X_8										1.00	-0.475	0.686
W											1.00	-0.462
T												1.00

U. EGYPT (COTTON)

	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_{71}	X_8	W	T
Y	1.00	0.357	0.111	-0.528	0.689	0.274	-0.322	0.475	0.631	0.439	0.140	0.541
X_1		1.00	-0.168	-0.369	0.361	0.533	-0.032	0.630	0.423	0.273	0.081	0.479
X_2			1.00	0.381	-0.493	-0.435	-0.408	-0.210	-0.259	-0.457	-0.476	-0.620
X_3				1.00	-0.791	-0.377	-0.350	-0.694	-0.745	-0.864	-0.325	-0.897
X_4					1.00	0.62	0.155	0.741	0.861	0.720	0.259	0.930
X_5						1.00	-0.047	0.638	0.594	0.0818	0.030	0.607
X_6							1.00	0.266	0.276	0.532	0.458	0.329
X_7								1.00	0.838	0.566	0.088	0.792
X_{71}									1.00	0.655	0.188	0.822
X_8										1.00	0.436	0.810
W											1.00	0.387
T												1.00

N & W DELTA (WHEAT)

	Y	X_1	X_2	X_3	X_4	HV	X_6	W	T
Y	1.00	-0.636	0.847	-0.718	0.571	0.641	-0.454	0.746	0.682
X_1		1.00	-0.453	0.267	0.021	-0.54	0.051	-0.741	-0.123
X_2			1.00	-0.823	0.834	0.711	-0.677	0.639	0.906
X_3				1.00	-0.843	-0.535	0.737	-0.421	-0.911
X_4					1.00	0.592	-0.789	0.262	0.972
HV						1.00	-0.4	0.702	0.607
X_6							1.00	-0.062	-0.775
W								1.00	0.379
T									1.00

M. Delta (Wheat)

	Y	X_1	X_2	X_3	X_4	HV	X_6	W	T
Y	1.00	-0.348	0.909	-0.802	0.794	0.619	-0.366	0.806	0.843
X_1		1.00	-0.303	0.108	-0.138	-0.494	-0.380	-0.472	-0.031
X_2			1.00	-0.844	0.868	0.605	-0.527	-0.774	0.911
X_3				1.00	-0.764	-0.477	0.547	-0.726	-0.900
X_4					1.00	0.768	-0.661	0.671	0.942
HV						1.00	-0.313	0.508	0.588
X_6							1.00	-0.135	-0.659
W								1.00	0.720
T									1.00

E. Delta (Wheat)

	Y	X_1	X_2	X_3	X_4	HV	X_6	W	T
Y	1.00	0.034	0.872	-0.827	0.912	0.770	-0.857	0.855	0.912
X_1		1.00	-0.146	-0.103	0.099	-0.269	-0.228	-0.265	0.163
X_2			1.00	-0.81	0.884	0.691	-0.827	0.784	0.896
X_3				1.00	-0.797	-0.469	-0.878	-0.769	-0.914
X_4					1.00	0.789	-0.891	0.774	0.952
HV						1.00	-0.551	0.723	0.620
X_6							1.00	-0.743	-0.941
W								1.00	0.758
T									1.00

M. EGYPT (Wheat)

	Y	X_1	X_2	X_3	X_4	HV	X_6	W	T
Y	1.00	0.112	0.811	-0.717	0.777	0.728	-0.513	-0.284	0.829
X_1		1.00	0.0478	0.131	0.223	-0.0995	-0.194	-0.132	0.0653
X_2			1.00	-0.753	0.867	0.631	-0.740	-0.247	0.898
X_3				1.00	-0.852	-0.508	0.636	0.550	-0.918
X_4					1.00	0.602	-0.693	-0.582	0.966
HV						1.00	-0.425	-0.006	0.612
X_6							1.00	0.152	-0.723
W								1.00	-0.508
T									1.00

M. EGYPT (Wheat)

	Y	X_1	X_2	X_3	X_4	HV	W	T
Y	1.00	-0.156	0.723	-0.635	0.638	0.015	-0.433	0.678
X_1		1.00	-0.151	0.298	-0.075	0.035	0.207	-0.269
X_2			1.00	-0.689	0.675	0.235	-0.044	0.781
X_3				1.00	-0.786	-0.315	0.012	-0.916
X_4					1.00	0.553	0.065	0.897
HV						1.00	0.053	0.386
W							1.00	0.035
T								1.00

N & W DELTA (RICE)

	Y	X_1	X_2	X_3	X_4	X_5	HV	X_6	X_{71}	X_{71}	W	T
Y	1.00	-0.83	0.891	-0.836	0.589	0.377	-0.107	-0.636	0.606	0.367	0.490	0.774
X_1		1.00	-0.890	0.842	-0.757	-0.675	-0.037	0.450	-0.643	-0.511	-0.516	-0.905
X_2			1.00	-0.944	0.853	0.456	-0.255	-0.527	0.590	0.388	0.344	0.950
X_3				1.00	-0.875	-0.573	0.200	0.454	-0.513	-0.415	-0.387	-0.926
X_4					1.00	0.642	-0.34	-0.169	0.391	0.373	0.144	0.902
X_5						1.00	0.277	0.047	0.460	0.534	0.533	0.599
HV							1.00	0.150	0.157	0.076	0.423	-0.227
X_6								1.00	-0.424	-0.356	-0.520	-0.437
X_7									1.00	0.531	0.691	0.634
X_{71}										1.00	0.653	0.534
W											1.00	0.422
T												1.00

M. DELTA (RICE)

	Y	X_1	X_2	X_3	X_4	X_5	HV	X_6	X_7	X_{71}	W	T
Y	1.00	0.028	0.421	-0.329	0.0259	-0.433	0.895	-0.272	0.127	-0.231	0.0858	0.132
X_1		1.00	-0.641	0.636	-0.511	0.155	-0.047	0.293	-0.628	-0.527	0.778	-0.754
X_2			1.00	-0.914	0.829	-0.347	0.531	-0.295	0.466	0.269	0.741	0.902
X_3				1.00	-0.842	0.071	-0.364	0.051	-0.485	-0.346	0.739	-0.944
X_4					1.00	0.033	0.098	0.132	0.32	0.276	-0.679	0.878
X_5						1.00	-0.620	0.715	0.252	0.064	0.0978	0.004
HV							1.00	-0.452	0.068	-0.357	0.0632	0.188
X_6								1.00	-0.182	-0.170	0.142	-0.094
X_7									1.00	0.432	-0.472	0.625
X_{71}										1.00	-0.373	0.505
W											1.00	-0.798
T												1.00

E. DELTA (RICE)

	Y	X_1	X_2	X_3	X_4	X_5	HV	X_6	X_7	X_{71}	W	T
Y	1.00	-0.033	0.562	-0.184	-0.027	0.0165	0.843	-0.542	0.467	-0.113	0.317	0.127
X_1		1.00	-0.668	0.874	-0.746	-0.434	-0.145	-0.453	0.454	-0.128	-0.715	-0.847
X_2			1.00	-0.870	0.735	0.511	0.571	0.255	0.608	0.263	0.828	0.863
X_3				1.00	-0.898	-0.585	-0.324	-0.490	-0.455	-0.303	-0.769	-0.968
X_4					1.00	0.62	0.086	0.628	0.423	0.330	0.644	0.936
X_5						1.00	0.047	0.366	0.556	0.322	0.338	0.657
HV							1.00	-0.532	0.269	0.145	0.465	0.252
X_6								1.00	-0.078	0.317	0.282	0.526
X_7									1.00	-0.097	0.469	0.526
X_{71}										1.00	0.476	0.364
W											1.00	0.821
T												1.00

APPENDIX D

The Calculation Matrix of the final selection of the included variables in Cotton production function

N & W DELTA

	Y	X_1	X_2	X_4	X_6	X_{71}	T	W
Y	1.00	-0.228	0.635	0.326	-0.599	-0.328	0.441	0.255
X_1		1.00	-0.558	-0.508	0.188	-0.199	-0.706	0.133
X_2			1.00	0.867	-0.625	0.102	0.924	0.271
X_4				1.00	-0.486	0.055	0.904	0.107
X_6					1.00	0.361	-0.442	-0.501
X_{71}						1.00	0.253	-0.312
T							1.00	0.166
W								1.00

M. DELTA

	Y	X_1	X_2	X_5	X_6	X_{71}
y	1.00	-0.252	0.426	-0.747	0.0961	-0.258
X_1		1.00	0.064	-0.204	0.334	-0.204
X_2			1.00	-0.149	0.539	0.399
X_5				1.00	-0.128	0.346
X_6					1.00	0.213
X_{71}						1.00

E. DELTA

	Y	X_2	X_4	X_5	W
Y	1.00	0.592	0.226	-0.364	-0.211
X_2		1.00	0.90	0.184	0.072
X_4			1.00	0.405	0.149
X_5				1.00	-0.305
W					1.00

M. EGYPT

	Y	X_1	X_2	X_3	X_5	X_6	X_7	X_8	W
Y	1.00	-0.449	0.363	0.471	-0.804	0.310	-0.553	-0.863	0.015
X_1		1.00	0.025	-0.099	0.190	0.027	- 0.366	0.234	-0.446
X_2			1.00	-0.471	-0.348	-0.613	-0.209	-0.099	-0.457
X_3				1.00	-0.538	0.964	0.455	-0.687	0.479
X_5					1.00	-0.372	0.584	-0.765	-0.296
X_6						1.00	-0.429	-0.053	0.407
X_7							1.00	0.597	0.362
X_8								1.00	0.127
W									1.00

u. EGYPT

	Y	X_2	X_3	X_6	X_7	X_8	T
Y	1.00	0.347	-0.497	-0.41	0.453	0.386	0.53
X_2		1.00	-0.038	-0.323	-0.143	-0.206	-0.350
X_3			1.00	-0.243	-0.758	-0.822	0.833
X_6				1.00	0.243	-0.482	0.218
X_7					1.00	0.562	0.899
X_8						1.00	0.742
T							1.00

The Correlation matrix of the final selection of the included variables in Rice production function

N & W DELTA

	Y	X_2	X_4	X_5	HV	T
Y	1.00	0.888	0.494	0.0719	0.182	0.845
X_2		1.00	0.823	-0.021	0.396	0.980
X_4			1.00	0.124	-0.493	0.867
X_5				1.00	-0.690	0.198
HV					1.00	-0.293
T						1.00

M DELTA

	Y	X_1	X_2	X_3	X_5	HV	X_{71}	W	T
Y	1.00	0.00004	0.264	-0.065	-0.856	0.912	-0.235	0.094	-0.09
X_1		1.00	-0.768	0.819	0.386	-0.226	-0.655	0.902	-0.856
X_2			1.00	-0.949	-0.593	0.509	0.371	-0.854	0.917
X_3				1.00	0.388	-0.318	-0.465	0.922	-0.968
X_5					1.00	-0.945	0.076	0.322	-0.267
HV						1.00	-0.257	-0.202	0.160
X_{71}							1.00	-0.510	0.603
W								1.00	-0.926
T									1.00

E. DELTA

	Y	X_2	HV	X_7	T
Y	1.00	0.562	0.843	0.467	0.127
X_2		1.00	0.571	0.507	0.863
HV			1.00	0.269	0.252
X_7				1.00	0.526
T					1.00

The correlation matrix of the final selection of the included variables in Wheat production function

N & W DELTA

	Y	X_1	X_2	HV	W
Y	1.00	-0.691	0.86	0.684	0.805
X_1		1.00	-0.487	-0.564	-0.769
X_2			1.00	-0.748	0.678
HV				1.00	0.754
W					1.00

M. DELTA

	Y	X_2	HV	W
Y	1.00	0.873	0.469	0.702
X_2		1.00	0.497	0.661
HV			1.00	0.302
W				1.00

E. DELTA

	Y	X_1	X_2	HV	W
Y	1.00	-0.112	0.687	0.612	0.567
X_1		1.00	-0.344	-0.419	0.590
X_2			1.00	0.414	0.435
HV				1.00	0.500
W					1.00

M EGYPT

	Y	X_1	X_2	X_4	HV	W	T
Y	1.00	0.198	0.896	0.778	0.921	-0.109	0.862
X_1		1.00	0.276	0.576	0.0647	-0.545	0.447
X_2			1.00	0.891	0.813	-0.191	0.95
X_4				1.00	0.664	-0.563	0.97
HV					1.00	0.103	0.734
W						1.00	-0.449
T							1.00

U. EGYPT

	Y	X_2	X_5	HV	W
Y	1.00	0.723	0.638	0.015	-0.433
X_2		1.00	0.675	0.235	-0.044
X_5			1.00	0.553	0.0651
HV				1.00	0.0532
W					1.00

Appendix E

Serial No.

Region : ....

Village : .... Size of holding : ....

Name of the Farmer

No. of Family Members

Experience in years

Farm Size S M L

Tenure O T SH

Education I P S H

1. Output

* Crop yield per Feddan Total production
* Staple length L LM M
* Price per unit

2. Land

* Rent per Feddan
* Taxes paid as a holder (per Feddan)
* Taxes paid as an owner (per Feddan)

3. Labour

	Land prepart.	Irrigation	Sowing	Fertilization	Plant protect	Harvesting
Man/day						
(Family Labour)						
- Adult (male)						
- Fem. or Child						
Man/day						
(Hired Labour)						
- Adult (male)						
- Fem. or Child						

	Land prepart.	Irrigation	Sowing	Fertilization	Plant protect	Harvesting
Wage/day						
- Adult (male)						
- Fem. or Child						

4. Machines

Type	Owned or Hired	Purpose	Horse power	Working hours	Market price	Fare (if hired)
1.						
2.						
3.						
4.						
5.						

5. Farm Tools

Type	Owned or Hired	Purpose	Working hours	Man/ hour	Market price	Fare (if hired)
1.						
2.						
3.						
4.						

6. Animals

Land preparation	Owned or Hired	Horse power	Working hours	Man/ hour	Market price	Fare (if hired)
Cow						
Buffalo						
Bullock (Ox)						
Irrigation						
Cow						
Buffalo						
Bullock (Ox)						

7. Fertilizer

Type	Proportion of plant nutriant	Quantity per Feddan in K.g.	Controlled price	Market price	Man/hour
* Nitrogenous					
* Phosphate					

8. Manure

Quantity per Feddan in C. Meter: ....

Market price : ....

Man/hour : ....

9. Seeds

* Quantity per Feddan   Purchase price   Man/hour

10. Insecticides

* Cost of Insecticides : ....

Cost of machines used : ....

Man/hour : ....

11. Improvement

Type	Purpose	Total Cost at current price	Expected Life
1.			
2.			
3.			
4.			

12. Total Cost Classified to Operations (per Feddan)

Land preparation	Irrigation	Sowing	Fertili-zation	Plant protection	Harvesting

13. Total Cost Classified to Inputs (per Feddan)

Labour	Machines	Animals & Farmstock	Nitrate	Phosphate	Manure

Seeds	Insecticides	Improvement	Others	Rent

14. Profit per Feddan

15. Other Information and Comments

	Slacks	Peaks
* Labour working hours a day		
* Machines capacity		
* Animal working hours a day		

Appendix F

Estimated Input Coefficients and Related Statistics Classified to Regions and Forms of Tenure in Both Small and Medium Farms

	Small Farms			Medium Farms		
	All Farms	Owners	Tenants	All Farms	Owners	Tenants
N & W Delta						
C (log)	- 0.488 (- 0.661)	- 2.264 (- 2.068)	- 0.932 (- 0.47)	- 0.116 (- 2.244)	- 4.589 (- 0.765)	- 3.702 (1.911)
X_1	0.154** (2.266)	0.245** (2.784)	0.023 (0.095)	0.232* (37.024)	0.158* (11.123)	0.169** (2.91)
X_2	0.144* (6.984)	0.191* (5.782)	0.184** (2.411)	0.016* (3.515)	0.114* (9.311)	0.094** (-21.53)
X_3	0.022 (0.214)	0.167 (1.146)	0.085 (0.245)	- 0.008 (- 1.007)	- 0.043 (- 0.860)	- 0.052 (- 1.34)
X_4	0.095 (0.998)	0.247 (1.626)	0.372 (1.205)	0.058* (5.206)	0.019 (1.753)	0.037 (1.46)
X_5	0.024*** (1.922)	0.015 (0.775)	0.010 (0.271)	0.012 (1.659)	0.029* (8.007)	0.026* (3.714)
X_6	0.039** (2.639)	0.022 (0.945)	0.004 (0.103)	0.043* (35.334)	0.370* (49.373)	0.037* (6.22)
$\bar{R}^2$	0.94	0.95	0.92	0.94	0.95	0.95
F. Stat	114.557*	73.525*	27.887*	378.600*	92.35*	94.469*

Appendix F (Cont'd)

	Small Farms			Medium Farms		
	All Farms	Owners	Tenants	All Farms	Owners	Tenants
M Delta						
C (log)	- 4.582 (- 0.675)	- 4.589 (- 0.765)	38.702 (1.099)	- 3.777 (- 1.592)	-14.407 (- 2.180)	- 2.624 (- 0.666)
X_1	0.182 (0.851)	0.158 (0.935)	0.169 (- 1.068)	1.597* (3.073)	2.189* (2.994)	0.534 (1.504)
X_2	0.145*** (1.889)	0.158** (2.725)	- 0.273 (- 0.814)	- 0.126 (- 1.08)	0.393) (0.907)	0.120 (0.307)
X_3	- 0.065** (- 2.842)	- 0.042 (- 1.530)	- 0.163 (- 1.509)	- 0.132 (- 1.146)	0.035 (0.254)	- 0.027 (- 0.200)
X_4	0.035** (2.152)	0.016 (1.285)	0.101 (1.598)	0.067* (3.096)	0.09* (4.682)	0.077* (6.643)
X_5	0.015 (1.106)	0.021** (2.790)	0.09 (1.534)	0.032* (4.990)	0.015 (0.983)	0.049* (4.885)
X_6	0.035* (27.222)	0.036* (23.301)	0.052* (3.422)	0.005* (2.359)	- 0.002 (- 0.379)	0.011** 2.232
$\bar{R}^2$	0.95	0.96	0.95	0.94	0.95	0.94
F. Stat	318.632*	85.35*	94.468*	311.674*	114.420*	51.648*

Appendix F (Cont'd)

	Small Farms			Medium Farms		
	All Farms	Owners	Tenants	All Farms	Owners	Tenants
E Delta						
C (log)	- 1.471 (- 0.714)	- 0.374 (- 0.214)	1.454 (1.296)	- 5.550 (- 1.895)	- 6.984 (- 1.436)	- 10.601 (- 1.323)
X_1	- 0.005 (- 0.279)	0.093 (1.700)	0.010 (0.773)	0.123** (2.156)	0.145 (1.622)	0.077 (1.379)
X_2	0.399 (3.655)	0.007 (1.488)	0.238* (4.087)	0.145* (3.115)	0.155*** (1.830)	0.20*** (2.084)
X_3	0.327 (0.70)	0.029 (0.622)	- 0.297 (- 1.254)	0.036 (1.505)	0.033 (0.880)	0.015 (0.233)
X_4	0.036 (3.357)	- 0.02** (- 2.858)	- 0.017 (- 0.582)	0.04** (2.358)	0.037 (1.577)	0.050 (0.906)
X_5	0.061 (20.350)	0.023* (3.143)	0.071* (8.615)	0.023*** (2.126)	0.017 (0.975)	0.010 (0.330)
X_6	- 0.007 (- 3.233)	- 0.014** (- 2.630)	- 0.016** (- 2.902)	0.006 (1.365)	0.004 (0.624)	0.010 (0.620)
$\bar{R}^2$	0.94	0.94	0.94	0.94	0.94	0.89
F. Stat	78.48*	52.020*	48.36*	126.457*	75.703*	22.348*

Appendix F (Cont'd)

	Small Farms			Medium Farms		
	All Farms	Owners	Tenants	All Farms	Owners	Tenants
M Egypt						
C (log)	- 12.756 (- 1.508)	17.749 (1.767)	- 1.082 (- 0.07)	- 0.255 (- 0.146)	- 0.143 (- 0.053)	- 0.904 (- 0.243)
X_1	1.588 (1.139)	- 1.062** (- 2.354)	- 0.277 (- 0.106)	0.220 (0.86)	0.186 (0.471)	0.671 (1.070)
X_2	0.628 (10.722)	0.799* (3.023)	0.466*** (2.005)	0.082 (1.647)	0.0911 (1.218)	- 0.239 (- 1.114)
X_3	0.326 (1.480)	1.529 (1.534)	0.276 (0.358)	- 0.026 (- 1.307)	- 0.015 (- 0.522)	- 0.177*** (- 1.806)
X_4	0.076 (1.372)	0.133* (3.07)	0.300*** (1.999)	0.025 (1.012)	0.030 (0.944)	0.050 (0.708)
X_5	0.068* (3.068)	0.139* (5.621)	0.059 (1.686)	0.018 (1.701)	0.019 (1.283)	0.007 (0.257)
X_6	0.01 (1.159)	0.051* (4.218)	0.024 (1.795)	0.030* (12.739)	0.028* (8.385)	0.030* (4.351)
$\bar{R}^2$	0.95	0.94	0.91	0.94	0.96	0.93
F. Stat	213.57*	81.02*	89.536*	418.625	209.687	69.909

Appendix F (Cont'd)

	Small Farms			Medium Farms		
	All Farms	Owners	Tenants	All Farms	Owners	Tenants
U Egypt						
C (log)	- 8.442 (- 2.726)	0.742 (0.357)	- 0.195 (- 0.256)	- 4.983 (- 2.277)	- 4.274 (- 4.01)	- 0.638 (- 0.503)
X_1	0.196* (3.020)	- 0.160 (- 0.409)	- 0.636 (- 0.390)	0.850 (1.426)	0.727** (2.545)	2.232* (3.778)
X_2	- 0.001 (- 0.388)	0.004*** (1.916)	0.014 (1.435)	0.217 (0.741)	0.222 (1.477)	- 0.660 (- 1.310)
X_3	- 0.026 (- 1.646)	0.022** (2.159)	0.104 (1.214)	- 0.015 (- 0.107)	- 0.010 (- 0.134)	- 0.765 (- 1.575)
X_4	0.042** (2.888)	0.087* (8.631)	0.089*** (2.241)	0.072* (4.746)	0.073* (9.014)	0.017 (0.862)
X_5	0.043* (4.693)	0.050* (10.428)	0.075* (3.003)	0.003 (0.360)	0.004 (1.012)	- 0.036 (- 0.700)
X_6	0.005* (5.952)	0.009* (14.009)	0.004*** (2.377)			
$\bar{R}^2$	0.96	0.97	0.90	0.95	0.94	0.95
F. Stat	215.53*	528.05*	31.963*	182.422	81.94*	82.03*

Figures between brackets refer to t. statistics

* Significant at the 1% level

** Significant at the 5% level

*** Significant at the 10% level

Appendix G

Correlation Matrix

Small Farms

N & W DELTA

	Y	X_1	X_2	X_3	X_4	X_5	X_6
Y	1.00	0.289	0.931	- 0.924	- 0.688	- 0.245	- 0.398
X_1		1.00	0.048	- 0.082	0.206	- 0.039	0.448
X_2			1.00	- 0.987	- 0.788	- 0.370	- 0.678
X_3				1.00	0.775	0.368	0.659
X_4					1.00	0.446	0.907
X_5						1.00	- 0.398
X_6							1.00

M DELTA

	Y	X_1	X_2	X_3	X_4	X_5	X_6
Y	1.00	0.813	- 0.677	- 0.306	0.285	0.251	0.961
X_1		1.00	- 0.935	- 0.233	0.366	0.143	0.857
X_2			1.00	0.890	- 0.206	0.191	- 0.808
X_3				1.00	- 0.155	- 0.507	- 0.134
X_4					1.00	0.436	0.194
X_5						1.00	0.033
X_6							1.00

E DELTA

	Y	X_1	X_2	X_3	X_4	X_5	X_6
Y	1.00	0.647	0.965	- 0.961	- 0.119	- 0.114	0.040
X_1		1.00	0.608	- 0.601	0.016	- 0.050	- 0.074
X_2			1.00	- 0.999	- 0.129	- 0.171	0.049
X_3				1.00	0.127	0.173	- 0.048
X_4					1.00	0.720	- 0.808
X_5						1.00	- 0.414
X_6							1.00

M EGYPT

	Y	X_1	X_2	X_3	X_4	X_5	X_6
Y	1.00	- 0.62	0.978	- 0.975	0.964	0.737	- 0.447
X_1		1.00	- 0.766	0.762	- 0.419	- 0.006	0.743
X_2			1.00	- 0.997	0.897	0.592	- 0.536
X_3				1.00	- 0.900	- 0.584	- 0.514
X_4					1.00	0.841	- 0.287
X_5						1.00	- 0.211
X_6							1.00

U EGYPT

	Y	X_1	X_2	X_3	X_4	X_5	X_6
Y	1.00	0.493	0.442	- 0.401	0.950	0.850	0.649
X_1		1.00	- 0.558	0.595	0.533	0.765	0.742
X_2			1.00	- 0.999	0.366	- 0.081	- 0.276
X_3				1.00	- 0.328	0.127	0.313
X_4					1.00	0.735	0.551
X_5						1.00	0.756
X_6							1.00

Medium Farms

N & W DELTA

	Y	X_1	X_2	X_3	X_4	X_5	X_6
Y	1.00	0.891	0.491	- 0.473	0.776	0.671	0.601
X_1		1.00	0.739	- 0.723	0.498	0.498	0.320
X_2			1.00	- 0.968	- 0.005	- 0.017	- 0.165
X_3				1.00	0.035	- 0.016	0.169
X_4					1.00	0.860	0.772
X_5						1.00	0.761
X_6							1.00

M DELTA

	Y	X_1	X_2	X_3	X_4	X_5	X_6
Y	1.00	0.695	0.275	- 0.263	0.734	0.721	0.473
X_1		1.00	- 0.430	0.444	0.084	0.630	0.655
X_2			1.00	- 0.999	0.678	- 0.154	- 0.042
X_3				1.00	- 0.676	0.160	- 0.056
X_4					1.00	0.390	0.098
X_5						1.00	- 0.064
X_6							1.00

E DELTA

	Y	X_1	X_2	X_3	X_4	X_5	X_6
Y	1.00	0.687	0.422	- 0.428	0.685	0.919	0.178
X_1		1.00	- 0.844	0.843	0.512	0.454	0.477
X_2			1.00	0.996	- 0.363	- 0.148	- 0.489
X_3				1.00	0.357	0.145	0.496
X_4					1.00	0.611	- 0.390
X_5						1.00	- 0.02
X_6							1.00

M. EGYPT

	Y	X_1	X_2	X_3	X_4	X_5	X_6
Y	1.00	- 0.101	0.665	- 0.672	0.850	0.720	0.251
X_1		1.00	- 0.713	0.728	- 0.404	0.102	0.590
X_2			1.00	- 0.995	0.909	0.596	- 0.496
X_3				1.00	- 0.904	- 0.566	0.470
X_4					1.00	0.820	- 0.265
X_5						1.00	- 0.192
X_6							1.00

U. EGYPT

	Y	X_1	X_2	X_3	X_4	X_5
Y	1.00	0.517	0.763	- 0.733	0.979	0.817
X_1		1.00	- 0.094	0.174	0.471	0.795
X_2			1.00	- 0.991	0.717	0.312
X_3				1.00	- 0.710	- 0.248
X_4					1.00	0.774
X_5						1.00

Appendix H

Correlation Matrix

Small Farms

N & W DELTA

	Y	X_1	RF	X_4	X_5	X_6
Y	1.00	0.289	0.931	- 0.688	- 0.245	- 0.398
X_1		1.00	- 0.054	0.206	- 0.039	0.448
RF			1.00	- 0.787	- 0.370	- 0.676
X_4				1.00	0.446	0.907
X_5					1.00	0.371
X_6						1.00

M DELTA

	Y	X_1	RF	X_4	X_5	X_6
Y	1.00	0.813	- 0.469	0.285	0.251	0.961
X_1		1.00	- 0.732	0.366	0.143	0.859
RF			1.00	- 0.116	0.395	- 0.663
X_4				1.00	0.436	0.194
X_5					1.00	0.033
X_6						1.00

E DELTA

	Y	X_1	RF	X_4	X_5	X_6
Y	1.00	0.647	0.965	- 0.119	- 0.114	- 0.04
X_1		1.00	0.608	- 0.016	- 0.050	- 0.074
RF			1.00	- 0.135	- 0.178	0.053
X_4				1.00	0.72	- 0.808
X_5					1.00	- 0.414
X_6						1.00

M EGYPT

	Y	X_1	RF	X_4	X_5	X_6
Y	1.00	- 0.62	0.978	0.964	0.737	- 0.447
X_1		1.00	- 0.766	- 0.419	- 0.006	0.743
RF			1.00	0.898	0.591	- 0.532
X_4				1.00	0.841	- 0.287
X_5					1.00	- 0.211
X_6						1.00

U EGYPT

	Y	X_1	RF	X_4	X_5	X_6
Y	1.00	0.493	0.421	0.950	0.850	0.648
X_1		1.00	- 0.577	0.533	0.765	0.742
RF			1.00	0.350	- 0.105	- 0.295
X_4				1.00	0.735	0.551
X_5					1.00	0.756
X_6						1.00

Medium Farms

N & W DELTA

	Y	X_1	RF	X_4	X_5	X_6
Y	1.00	0.880	0.505	0.777	0.671	0.608
X_1		1.00	0.774	0.485	0.492	0.261
RF			1.00	0.012	0.048	- 0.184
X_4				1.00	0.859	0.726
X_5					1.00	0.719
X_6						1.00

M DELTA

	Y	X_1	RF	X_4	X_5	X_6
Y	1.00	0.695	0.271	0.734	0.721	0.473
X_1		1.00	- 0.434	0.084	0.630	0.655
RF			1.00	0.679	- 0.156	- 0.049
X_4				1.00	0.390	0.097
X_5					1.00	- 0.064
X_6						1.00

M EGYPT

	Y	X_1	RF	X_4	X_5	X_6
Y	1.00	- 0.101	0.674	0.852	0.739	0.20
X_1		1.00	- 0.707	- 0.395	0.100	0.580
RF			1.00	0.904	0.588	- 0.485
X_4				1.00	0.829	- 0.311
X_5					1.00	- 0.209
X_6						1.00

U EGYPT

	Y	X_1	RF	X_4	X_5
Y	1.00	0.517	0.743	0.979	0.817
X_1		1.00	- 0.152	0.471	0.795
RF			1.00	0.713	0.266
X_4				1.00	0.774
X_5					1.00

E DELTA

	Y	X_1	RF	X_4	X_5	X_6
Y	1.00	0.687	0.426	0.685	0.919	0.178
X_1		1.00	- 0.844	0.512	0.454	0.477
RF			1.00	- 0.359	- 0.146	- 0.494
X_4				1.00	0.611	- 0.390
X_5					1.00	0.020
X_6						1.00

Appendix I

Estimated input Coefficients and related statistics in Large Farms

All Regions

	N & W Delta	M Delta	E Delta	M Egypt	U Egypt
Constant	0.005 (0.195)	0.072 (0.208)	1.286 (1.116)	0.063 (0.073)	0.206 (0.415)
X_1	0.747 (1.632)	0.338 (1.270)	0.033 (0.095)	0.621* (3.332)	0.294 (1.083)
X_2	0.378* (4.250)	0.304* (7.438)	0.345* (8.817)	0.236* (11.537)	0.281* (6.465)
X_4	0.199** (2.915)	0.275* (3.790)	0.037 (0.265)	- 0.019 (-0.419)	0.128 (1.431)
X_5	0.113 (1.066)	- 0.009** (2.986)	0.086 (1.140)	0.549** (2.141)	0.0043 (0.074)
X_7	0.181 (0.873)	0.265 (0.332)	0.022 (0.300)	- 0.0006 (-0.012)	0.112* (3.031)
$\bar{R}^2$	0.76	0.86	0.90	0.87	0.77
F. Stat	15.641*	31.072*	39.329 *	33.037*	16.540*

Figures between brackets refer to t. statistics

* Significant at the 1% level

** Significant at the 5% level

*** Significant at the 10% level

Appendix J

Estimated Coefficients and Related Statistics within Each Operation

(Stage I)

	Small Farms			Medium Farms		
	All Farms	Owners	Tenants	All Farms	Owners	Tenants
N & W Delta						
"A"						
C				23.670 (135.113)	23.908 (79.574)	23.234 (86.667)
RF1				- 1.208* (- 43.830)	- 1.246* (- 26.856)	- 1.138* (- 26.765)
$\bar{R}^2$				0.98	0.98	0.98
F. Stat				1921.02*	721.218*	716.375*
"B"						
C	33.681 (103.746)	34.316 (54.668)	33.299 (60.291)	38.805 (511.302)	38.810 (343.583)	38.792 (293.706)
RF2	- 5.106* (- 21.317)	- 5.525* (- 12.383)	- 4.997* (- 11.003)	- 0.958* (- 90.918)	- 0.958* (- 62.217)	- 0.962* (- 45.955)
$\bar{R}^2$	0.92	0.91	0.90	0.98	0.98	0.98
F. Stat	454.425*	153.339*	121.074*	826.605*	387.096*	211.87*

Appendix J (Cont'd)

	Small Farms			Medium Farms		
	All Farms	Owners	Tenants	All Farms	Owners	Tenants
"C"						
C				0.394	0.294	0.007
				(- 0.816)	(- 0.425)	(2.847)
X_4	0.126*	0.124*	0.127*	0.133**	0.132***	0.133*
	(274.105)	(150.170)	(150.490)	(2.079)	(2.015)	(5.595)
X_5	0.266*	0.264*	0.262*	0.254	0.262	0.267*
	(324.43)	(189.561)	(151.612)	(1.277)	(0.476)	(8.668)
X_6	0.250*	0.249*	2.251*	0.245*	0.248***	0.250*
	(207.305)	(134.820)	(87.112)	(5.417)	(1.983)	(3.99)
$\bar{R}^2$	0.99	0.99	0.99	0.90	0.84	0.95
F. Stat	14264.11*	4211.37*	4702.80*	114.260*	14.328*	268.038*
M Delta						
"A"						
C	27.757	28.132	27.433	12.060	12.139	11.862
	(96.686)	(50.859)	(52.640)	(172.106)	(107.335)	(164.004)
RF1	- 1.946*	- 2.008*	- 1.865*	- 0.251*	- 0.254*	- 0.237*
	(- 32.118)	(- 17.473)	(- 17.349)	(- 47.214)	(- 29.638)	(- 43.715)
$\bar{R}^2$	0.96	0.95	0.95	0.98	0.98	0.99
F. Stat	1036.71*	305.306*	300.994*	2229.20*	878.426*	1911.01*
"B"						
C	42.151	42.328	41.925	17.935	17.864	18.909
	(262.749)	(255.612)	(97.643)	(91.674)	(52.690)	(69.761)
RF2	- 1.657*	- 1.650*	- 1.624*	- 0.025*	- 0.023*	- 0.039*
	(- 34.013)	(- 36.506)	(- 12.159)	(- 11.834)	(- 7.221)	(- 11.536)
$\bar{R}^2$	0.96	0.98	0.91	0.78	0.79	0.90
F. Stat	1156.91*	1332.65*	147.832*	140.044*	52.141*	133.072*

Appendix J (Cont'd)

	Small Farms			Medium Farms		
	All Farms	Owners	Tenants	All Farms	Owners	Tenants
"C"						
C						
X_4	0.086* (841.822)	0.087* (121.857)	0.088* (132.572)	0.086* (862.875)	0.086* (157.350)	0.086* (681.041)
X_5	0.267* (168.310)	0.266* (270.453)	0.265* (277.614)	0.267* (188.533)	0.267* (311.511)	0.267* (151.954)
X_6	0.250* (283.490)	0.250* (427.683)	0.251* (385.970)	0.250* (198.171)	0.250* (523.673)	0.250* (487.332)
$\bar{R}^2$	0.99	0.99	0.99	0.99	0.99	0.99
F. Stat	4245.459*	1987.803*	1927.322*	3073.070*	1596.51*	1315.76*
E Delta						
"A"						
C	16.071 (3541.81)	16.071 (2045.47)	16.077 (3419.050)	13.294 (249.244)	13.278 (148.592)	13.423 (294.387)
RF1	- 1.048* (-286.98)	- 1.047* (-169.163)	- 1.054* (-276.268)	- 0.369* (- 58.215)	- 0.365* (- 34.963)	- 0.385* (70.602)
$\bar{R}^2$	0.99	0.99	0.99	0.98	0.98	0.99
F. Stat	8236.1*	2862.61*	7632.40*	3388.94*	1222.41*	4984.70*
"B"						
C	41.985 (1613.52)	41.999 (1170.74)	41.989 (1002.35)	25.522 (105.595)	25.449 (57.061)	25.844 (80.333)
RF2	- 1.900* (-215.84)	- 1.902* (-158.722)	- 1.901* (-134.187)	- 0.162* (- 20.427)	- 0.158* (- 10.976)	- 0.169* (- 16.956)
$\bar{R}^2$	0.99	0.99	0.99	0.92	0.89	0.95
F. Stat	1103.69*	409.061*	1150.96*	417.252*	120.478*	287.498*

Appendix J (Cont'd)

	Small Farms			Medium Farms		
	All Farms	Owners	Tenants	All Farms	Owners	Tenants
"C"						
C				- 0.271	- 0.037	0.177
				(- 0.707)	(- 0.172)	(0.294)
X_4	0.087*	0.086*	0.086*	0.089*	0.087*	0.079*
	(396.972)	(711.342)	(461.267)	(12.418)	(22.124)	(6.087)
X_5	0.266*	0.267*	0.267*	0.256*	0.266*	0.229*
	(826.595)	(160.976)	(735.536)	(24.939)	(55.656)	(9.119)
X_6	0.256*	0.251*	0.250*	0.286*	0.251*	0.357*
	(936.910)	(165.565)	(113.826)	(17.029)	(27.100)	(12.918)
$\bar{R}^2$	0.99	0.99	0.99	0.98	0.99	0.97
F. Stat	1103.69*	409.061*	1150.96*	708.246*	3288.24*	165.432*
M Egypt						
"A"						
C	15.992	15.993	15.990	13.142	13.123	13.107
	(246.641)*	(206.658)	(163.01)	(176.194)	(113.403)	(119.889)
RF1	- 0.994*	- 0.991*	- 0.994*	- 0.348*	- 0.339*	- 0.346*
	(-249.516)	(-205.017)	(-168.746)	(- 42.878)	(- 25.483)	(- 30.749)
$\bar{R}^2$	0.99	0.99	0.99	0.97	0.97	0.98
F. Stat	6226.82*	4203.2*	2847.51*	1838.56*	649.364*	945.494*
"B"						
C	54.044	53.916	54.437	26.927	27.044	26.631
	(265.219)	(69.89)	(81.376)	(107.963)	(59.509)	(74.386)
RF2	- 2.654*	- 2.618*	- 2.765*	- 0.122*	- 0.122*	- 0.117*
	(- 43.211)	(-111.056)	(- 13.884)	(- 22.603)	(- 11.820)	(- 15.810)
$\bar{R}^2$	0.97	0.99	0.92	0.93	0.91	0.94
F. Stat	1867.19*	1233.35*	192.757*	510.871*	139.710*	249.968*

Appendix J (Cont'd)

	Small Farms			Medium Farms		
	All Farms	Owners	Tenants	All Farms	Owners	Tenants
"C"						
C	- 0.031	- 0.042	- 0.003			
	(- 1.842)	(- 1.279)	(- 0.309)			
X_4	0.087*	0.087*	0.086*	0.086*	0.086*	0.086*
	(180.007)	(80.407)	(407.205)	(216.079)	(172.675)	(89.541)
X_5	0.265*	0.264*	0.266*	0.266*	0.267*	0.267*
	(242.707)	(94.353)	(701.205)	(303.929)	(215.120)	(150.331)
X_6	0.250*	0.250*	0.250*	0.250*	0.249*	0.251*
	(455.142)	(269.701)	(553.533)	(363.830)	(400.517)	(79.836)
$\bar{R}^2$	0.99	0.99	0.99	0.99	0.99	0.99
F. Stat	2139.85*	5716.83*	11345.5*	2667.33*	1944.08*	570.214*
U Egypt						
"A"						
C	16.190	16.188	16.191	14.399	14.438	14.319
	(929.094)	(511.181)	(175.506)	(558.075)	(295.336)	(551.304)
RF1	- 1.177*	- 1.176*	- 1.176*	- 0.525*	- 0.531*	- 0.511*
	(- 38.933)	(- 20.389)	(- 78.416)	(-121.943)	(- 64.643)	(-119.489)
$\bar{R}^2$	0.97	0.96	0.99	0.99	0.99	0.99
F. Stat	1515.74*	415.718*	614.901*	1487.0*	417.87*	1427.75*
"B"						
C	36.007	35.995	36.097	22.863	22.856	22.841
	(295.745)	(176.091)	(194.608)	(189.379)	(94.204)	(115.221)
RF2	- 0.355*	- 0.355*	- 0.358*	- 0.38*	- 0.38*	- 0.38*
	(- 73.821)	(- 43.864)	(- 48.742)	(- 29.571)	(- 14.586)	(- 18.181)
$\bar{R}^2$	0.99	0.99	0.99	0.96	0.94	0.96
F. Stat	5449.5*	1924.03*	2375.77*	874.889*	212.740*	330.537*

Appendix J (Cont'd)

	Small Farms			Medium Farms		
	All Farms	Owners	Tenants	All Farms	Owners	Tenants
"C"						
C	0.012 (0.371)	0.002 (0.099)	0.002 (0.687)			
X_4	0.088* (89.208)	0.087* (152.93)	0.086* (1726.0)	0.086* (1067.37)	0.087* (184.298)	0.087* (131.87)
X_5	0.268* (49.900)	0.265* (89.354)	0.267* (958.637)	0.267* (114.412)	0.264* (181.311)	0.265* (162.078)
X_6	0.252* (43.304)	0.251* (82.924)	0.250* (818.197)			
$\bar{R}^2$	0.99	0.99	0.99	0.99	0.99	0.99
F. Stat	5652.97*	2771.072*	10614.1*	5036.0*	2401.67*	6444.9*

Figures between brackets refer to t. statistics

A = Land preparation

B = Irrigation

C = Fertilization

* Significant at the 1% level

** Significant at the 5% level

*** Significant at the 10% level

Appendix K

Estimated Coefficients of Education and Experience and Related Statistics in Large Farms

All Regions

	N & W Delta	M Delta	E Delta	M Egypt	U Egypt
Constant	2.659	4.077	5.428 (9.077)	5.014 (23.026)	5.229 (24.502)
ED	0.403* (3.673)	0.244* (3.383)	0.144*** (1.902)	0.02 (0.649)	0.018 (1.659)
EX	0.102* (4.353)	0.058** (2.83)	0.211*** (1.798)	0.026* (3.097)	0.033* (4.072)
$\bar{R}^2$	0.427	0.30	0.337	0.30	0.44
F. Stat	9.563	5.88	5.606	6.0	9.947

Figures between brackets refer to t. statistics

* Significant at the 1% level

** Significant at the 5% level

*** Significant at the 10% level

Appendix L

Estimated Coefficients and Related Statistics in Large Farms
(One variable for Nitrogeneous and Phosphate)

All Regions

	N & W Delta	M Delta	E Delta	M Egypt	U Egypt
Constant	0.006	0.108 (0.246)	0.023 (0.044)	0.294 (0.223)	0.116 (0.077)
X_1	0.816** (2.457)	0.394 (1.575)	0.603** (2.962)	0.350* (7.427)	0.460* (7.112)
X_2	0.305* (4.606)	0.284* (6.631)	0.418* (22.237)	0.211* (40.893)	0.257* (25.562)
CF	0.319** (2.829)	0.211** (2.764)	0.159* (3.391)	0.028** (2.674)	0.088* (9.036)
X_7	0.121* (3.650)	0.211* (3.079)	0.112* (3.417)	0.036* (3.124)	0.076* (6.344)
I_m	0.258* (4.130)	0.075*** (1.840)	0.125* (5.519)	0.061* (18.827)	0.079* (17.243)
$\bar{R}^2$	0.87	0.87	0.96	0.97	0.94
F. Stat	33.093*	33.086*	111.016*	218.573*	158.463*

Figures between brackets refer to t. statistics

* Significant at the 1% level

** Significant at the 5% level

*** Significant at the 10% level

Appendix M

Correlation Matrix

Large Farms

N & W DELTA

	Y	X_1	X_2	X_4	X_5	X_7	Im
Y	1.00	- 0.373	0.746	0.159	0.219	0.763	0.678
X_1		1.00	- 0.696	- 0.017	0.001	- 0.235	- 0.367
X_2			1.00	- 0.155	- 0.105	0.511	0.507
X_4				1.00	0.626	0.165	- 0.489
X_5					1.00	0.237	- 0.489
X_7						1.00	- 0.466
Im							1.00

M DELTA

	Y	X_1	X_2	X_4	X_5	X_7	Im
Y	1.00	- 0.175	0.880	0.600	0.297	0.277	0.593
X_1		1.00	- 0.347	- 0.323	- 0.443	0.179	- 0.019
X_2			1.00	0.572	0.350	0.040	0.464
X_4				1.00	0.479	- 0.288	0.304
X_5					1.00	- 0.102	- 0.166
X_7						1.00	0.273
Im							1.00

E DELTA

	Y	X_1	X_2	X_4	X_5	X_7	Im
Y	1.00	- 0.527	0.937	0.227	0.603	0.141	0.180
X_1		1.00	- 0.088	0.359	0.299	- 0.317	- 0.264
X_2			1.00	0.059	0.438	0.067	- 0.368
X_4				1.00	0.726	- 0.086	- 0.104
X_5					1.00	0.307	- 0.225
X_7						1.00	- 0.078
Im							1.00

M EGYPT

	Y	X_1	X_2	X_4	X_5	X_7	Im
Y	1.00	0.309	0.873	0.284	0.344	0.100	0.628
X_1		1.00	- 0.031	0.426	0.328	0.240	0.313
X_2			1.00	0.128	0.093	0.056	0.241
X_4				1.00	0.468	- 0.462	0.170
X_5					1.00	- 0.109	0.437
X_7						1.00	- 0.113
Im							1.00

U EGYPT

	Y	X_1	X_2	X_4	X_5	X_7	Im
Y	1.00	- 0.573	0.838	0.078	0.361	0.219	0.693
X_1		1.00	- 0.712	- 0.033	- 0.304	- 0.083	- 0.345
X_2			1.00	- 0.045	0.252	- 0.038	0.296
X_4				1.00	0.729	- 0.324	0.091
X_5					1.00	- 0.046	0.209
X_7						1.00	0.187
Im							1.00

Appendix N

1. Operating cost of machines used in land preparation operation
   At 1975 prices

	Tractor	Plough(1)	Plough(2)
Expected life in years	7	10	10
Annual working hours	1400	500	500
Current value (cash price) E.L.	4500	300	600
+ Interest 6% (compound)	+ 1125	+ 99	+ 198
- Scrapped value 10% of c. value	- 450	- 30	- 60
Net Value	5175	369	738
Fixed Cost per year			
Depreciation	739.286	36.9	73.8
Insurance and tax (tractor)(2% of c. value) (plough) (0.05% of c. value)	90.00	1.5	3.00
Building (garage)	30.00	3.5	3.5
Total Fixed Cost	859.286	41.9	80.3
Recurrent Cost per year			
Fuel (10 litre/hour)	350	-	-
Oil	61.6	-	-
Wages (operator)	288.0	-	-
Repairs and maintenance	773.357	25.83	51.66
Admin. expenses 10% of total cost	233.224	6.773	13.196
Total current cost	1706.181	32.603	64.856
Total cost per year	2565.467	74.503	145.156
Cost per hour	1.832	0.149	0.290
Total cost per hour = 1.832 + 0.239 = 2.071; per H.P. = 0.045		Average Cost 0.239	

Appendix N (Cont'd)

2. Running cost of irrigation machine (12-14 H.P.) at 1975 prices

	Cost
Expected life in years	7
Annual working hours	1400
	L.E.
Current value (cash price)	600.000
+ Interest 6% (compound)	144.000
- Scrapped value (10% of c. value)	60.000
Net value	684.000
Annual Fixed Cost	
Depreciation	97.714
Insurance and tax (2% of c. value)	12.00
Building	8.400
Total Fixed Cost	118.114
Annual Current Cost	
Fuel	98.000
Oil	21.000
Wages	144.000
Repairs and maintenance	68.400
Admin. expenses (10% of total cost)	44.951
Total Current Cost	376.351
Annual Total Cost	494.465
Cost per hour	0.353
Cost per horse power	0.029

Appendix N (Cont'd)

3. Running cost of farm tools employed in land preparation and irrigation at 1975 prices

	Plough	Levelling Scoop	Sakia
Expected life in years	3	5	30
Annual working hours	500	100	6000
	L.E.	L.E.	L.E.
Current value	18.00	20.00	400.00
Interest (6% compound)	2.16	3.600	132.00
Scrapped value	1.008	1.180	26.6
Net value	19.152	22.420	505.4
Running Cost			
Depreciation	6.384	4.484	16.847
Repairs & maintenance	0.933	1.054	3.369
Total Annual Cost	7.317	5.538	20.216
Cost per hour	0.0146	0.0554	0.0337

Appendix N (Cont'd)

4. Operating cost of animals used in agricultural activities at 1975 prices

N & W Delta

	Cow	Buffalo	Bullock
Expected life in years	10	10	10
Annual working hours	1000	1000	1000
	L.E.	L.E.	L.E.
Current value	290	390	345
Interest (6% compound)	95.7	128.7	113.850
Scrapped value	116.0	156.0	138.00
Net value	269.7	362.7	320.85
Fixed Annual Cost			
Depreciation	26.970	36.27	32.085
Insurance	5.800	7.800	6.900
Building	4.500	7.200	7.200
Total Fixed Cost	37.270	51.27	46.185
Medical care	5.800	7.800	6.900
Food	84.110	117.64	93.130
Wages	10.220	10.220	10.220
Admin. expenses	13.740	18.693	15.644
Total Current Cost	113.87	151.353	123.894
Total Cost	151.140	205.623	172.079
Milk	63.75	100.8	-
Manure	28.652	35.568	35.568
Total net cost per year	58.738	69.255	136.511
Cost per hour	0.0587	0.0693	0.1365

Appendix N (Cont'd)

4. Operating cost of animals used in agricultural activities at 1975 prices

	M Delta & E Delta			M Egypt & U Egypt		
	Cow	Buffalo	Bullock	Cow	Buffalo	Bullock
Expected life in years	10	10	10	10	10	10
Annual working hours	1000	1000	1000	1000	1000	11000
	L.E.	L.E.	L.E.	L.E.	L.E.	L.E.
Current value	300	400	360	280	385	350
Interest (6% compound)	99	132	118.8	92.4	127.05	115.5
Scrapped value	120	160	144	112.0	154.00	140.0
Net value	279	372	334.8	260.4	358.05	325.5
Annual Fixed Cost						
Depreciation	27.900	37.200	33.480	26.04	35.805	32.55
Insurance	6.00	8.00	7.200	5.600	7.700	7.00
Building	4.500	7.200	7.200	4.500	7.200	7.200
Total Fixed Cost	38.400	52.400	47.880	36.14	50.705	46.750
Annual Current Cost						
Medical care	6.00	8.00	7.200	5.600	7.700	7.00
Food	84.110	117.64	93.130	84.110	117.640	93.130
Wages	10.768	10.768	10.768	10.038	10.038	10.038
Admin. expenses	13.928	18.881	15.898	13.589	18.608	15.692
Total current Cost	114.806	155.289	126.996	113.337	153.986	125.860
Total Cost	153.206	207.689	174.876	149.477	204.691	172.61
Milk	63.750	100.8	-	63.75	100.8	-
Manure	28.652	35.568	35.568	27.219	33.790	33.790
Total net cost per year	60.804	71.321	139.308	58.508	70.101	139.070
Cost per hour	0.0608	0.0713	0.1393	0.0585	0.0701	0.1391

Appendix N (Cont'd)

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Appendix P

Machines and animals cost weighted to the rate of substitution between them

	Land Preparation				Irrigation			
	P_2 *	K	KP_2	P_3	P_2 *	K	KP_2	P_3
N & W Delta								
S. Farms	0.045	-	-		0.029	9.97	0.289	0.218
M. Farms	0.045	9.675	0.435	0.238	0.029	9.530	0.276	0.218
M Delta								
S. Farms	0.045	9.804	0.441	0.247	0.029	9.537	0.277	0.224
M. Farms	0.045	9.769	0.440	0.247	0.029	9.597	0.278	0.224
E Delta								
S. Farms	0.045	9.741	0.438	0.248	0.029	0.615	0.279	0.224
M. Farms	0.045	9.742	0.438	0.248	0.029	9.654	0.280	0.224
M Egypt								
S. Farms	0.045	9.730	0.438	0.2385	0.029	8.591	0.249	0.221
M. Farms	0.045	9.728	0.438	0.2385	0.029	8.589	0.249	0.221
U Egypt								
S. Farms	0.045	9.799	0.441	0.2395	0.029	8.528	0.247	0.221
M. Farms	0.045	9.776	0.440	0.2395	0.029	8.544	0.248	0.221

* Machines cost is homogeneous all over the country. Farmers buy machines through the Co-operative and dealers' profits are restricted at certain percentage. Machines hire rate is also fixed and stabilized over the whole country.

NOTES

NOTES

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ABSTRACT

THE POSSIBILITY OF INCREASING AGRICULTURAL PRODUCTIVITY IN EGYPT

By
Samir R. Makary

The principal objectives of the study are to test investment allocation efficiency among commodity sectors and resource allocation efficiency among farms of different size classes and tenure forms in the agricultural sector.

In the introduction, we briefly sketch the the characteristics of Egyptian agriculture and investigate the implication of the present agricultural policy.

Part 1 is devoted to testing investment allocation efficiency among the commodity sectors during the period 1960-1965. The arguments for and against agricultural development are analysed with respect to empirical evidence from the past(Chapt. II). A three sectoral approach emphasises the creation of an agricultural surplus in the early stages of economic development is tested with respect to the Egyptian economy during the period 1960-65(Chapt. III). The minimum capital- output ratio criterion is applied in reallocating investment among commodity sectors.

In part 2 resource use efficiency is tested. Both technical and economic theory of production are reviewed, and the major statistical constraints to the application of a production function approach are discussed(Chapt. IV). The previous empirical investigations of production behaviour in Egyptian agriculture are surveyed in Chapter V. In the remaining Chapters, an attempt is made to identify agricultural potentiality in terms of economic efficiency. The study covers the whole area, but at the micro level(i.e. regions). A production function

approach is adopted, and three algebraic forms; linear, Cobb-Douglas, and Constant Elasticity of Substitution functions are tested against the numerical observations. A time series production function is estimated separately for the major crops (cotton, rice and wheat) over the period 1960-75. Cross sectional production functions based on random sampling selected in clusters are estimated for the cotton cropping year 1975. The function is fitted for each farm size class as well as each tenure form within a given farm size class. Two techniques are employed; A single equation model to testing resource allocation efficiency over the production period, and a two-stage model to test resource allocation efficiency among and within stages of cultivation. A maximisation approach for constrained extrema is adopted to determine the optimum level of output for the various classes of farm size, hence to identify the relevant farm size class to Egyptian agriculture. The implications of the findings on agricultural policy are discussed.