AGGREGATE SUPPLY IN KENYA: PRODUCTION FUNCTIONS FOR 4 MAJOR SECTORS

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ABSTRACT

This paper reports production functions for Kenya's Traditional, Agriculture, Industry and Service sectors, estimated from annual time series data over the period 1954 to 1972.

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This paper reports production functions for the Traditional, Agriculture, Industry and Services sectors. They are estimated from annual data series compiled for the period 1954-1972. It is planned that the four production functions reported (which, together with the exogenous Government sector, account for all of Kenya's GDP) will form part of the macro-econometric model of Kenya outlined in /_2_/

It was hoped that data series back to 1947 might be employed in the estimates, but it was not possible to obtain data on investment in structures broken down by sector and consequently the required capital stock figures could not be compiled.

Traditional Sector

Value added, in constant prices, for the traditional sector was taken to be a function of the rural labour force, time (to pick up improvements in methods) and a weather variable. The rural population in Kenya was used as a proxy for the rural labour force.

A Cobb-Douglas production function with these inputs gives

$$VT = Ae^{rt} NT^{\alpha} W^{\gamma} \qquad (1)$$

and taking logarithms we obtain the estimating equation

$$\log VT = \log A + rt + \alpha \log NT + \beta \gamma \log W \qquad (2)$$

Where VT is value-added in the Traditional (Non-Monetary Economy) sector in constant (1964) prices r is rate of exogeneous technical progress t is time trend

NT is the rural population

W is a weather variable (deviations from average rainfall for six provinces of Kenya weighted by areas of high potential land)

The size of the coefficient α should give some indication of returns to labour in the Traditional sector, assuming that fertile land (not included in the function) is fixed in supply. However, estimates of equation (2) showed collinearity between t and log NT (correlation coefficient is 0.941).

In an effort to break the collinearity estimates were made with the function constrained to various degrees of returns to scale.

Equation (1) was transformed to

$$VT/NT^{\alpha} = Ae^{rt}W^{\gamma} \qquad (3)$$

giving

$$\log (VT/NT^{\alpha}) = \log A + rt + \gamma \log w \qquad (4)$$

Equation (4) was estimated for eleven values of α ranging from 0.0 to 1.0. The results are in Table I (t values in parentheses).

It can be seen from these results that as α decreases, the coefficient of the weather variable, γ changes very little, but the rate of technical progress rises from 1.6% to 4.5% (this is a manifestation of the collinearity problem: as less of the rise in output is attributed to the rise in the labour input - by lowering α - so more is attributed to technical progress). The improvement of the fit from explaining 85.5% of the variance to explaining 95.6% is deceptive, for as α falls so the variance of VT/NT^{α} increases - we are explaining a greater percentage of a larger variance.

The most satisfactory procedure would be to draw on a cross-section study of the Traditional sector which might give some magnitude to α . One such study, for Tanzania, is that of Larsen /_3_/ for Sukumoland. He presents, among other things, data on farm income per capitor and hectares per capita for 11 districts in 1968/9.

Now if we include land (H) in our production function (1), we get

$$VT = Ae^{rt}NT^{\alpha}H^{\beta}W^{\gamma} \qquad (5)$$

In a particular area, in a particular year, technical progress (e^{rt}) and weather (W^{γ}) will be constant and can be collapsed

TABLE I

Estimates of Traditional Sector Production Function

Value of α	log A	r	γ	R^2	D.W.
1.0	2.599 (19.84)	0.016 (4.87)	-0.203 (4.73)	0.855	1.59
0.9	2.760 (21.06)	0.019 (5.72)	-0.202 (4.75)	0.874	1.59
0.8	2.920 (22.28)	0.022 (6.58)	-0.201 (4.73)	0.891	1.58
0.7	3.080 (23.49)	0.025 (7.43)	-0.201 (4.72)	0.906	1.58
0.6	3.241 (24.70)	0.028 (8.28)	-0.200 (4.70)	0.918	1.57
0.5	3.401 (25.89)	0.031 (9.12)	-0.200 (4.68)	0.928	1.56
0.4	3.562 (27.08)	0.034 (9.96)	-0.199 (4.66)	0.937	1.56
0.3	3.722 (28.26)	0.036 (10.80)	-0.198 (4.64)	0.944	1.55
0.2	3.883 (29.43)	0.040 (11.63)	-0.198 (4.62)	0.951	1.54
0.1	4.043 (30.58)	0.042 (12.45)	-0.197 (4.59)	0.956	1.54
0.0	4.204 (31.73)	0.045 (13.27)	-0.197 (4.57)	0.960	1.53

into the constant term, giving

$$VT = BNT^{\alpha}H^{\beta} \quad (6)$$

The function now includes all the factors considered important, and there is no reason not to assume constant returns, i.e. that $\alpha + \beta = 1$, or $\beta = 1 - \alpha$, and we can devide (6) through by LT^{α} to obtain

$$VT/NT = B(H/NT)^{\beta} \quad (7)$$

yielding an estimating equation

$$\log(VT/NT) = \log B + \beta \log (H/NT) \quad (8)$$

In running equation (8) on the Larsen data, our estimate of β will enable us to put a value to α from $\alpha = 1-\beta$.

The estimated cross-section equation is (t statistics in parentheses).

$$\log(VT/NT) = \underset{(30.4)}{6.509} \; \underset{(5.15)}{+0.913} \; \log(H/NT) \quad (9)$$

$R^2 = 0.864$

This gives a value of α of around 0.1.

Before we use this value of α in choosing our Traditional sector production function, we need to assure ourselves that the density of population on the land in Kenya is within the range of the Sukumoland observations. The Larsen data is given in Table II.

There is a span of 0.18 hectares per capita to 0.75 hectares per capita.

Table III gives data for the provinces of Kenya in 1969.

Except for the Rift Valley, the densities fall within the Sukumoland range (and this conclusion would still hold if rough adjustments were made for amounts of less fertile land and urban populations in the various provinces). The Rift Valley, however,

TABLE II

District	Gross Farm Income per Capita (Sh)	Hectares Cultivated per Capita
Busega	224	0.32
Nyanza	137	0.18
Sanjo	122	0.19
Nyangwhale	278	0.39
Busanda	155	0.29
Ifindo	255	0.30
Inonelwa	290	0.42
Kakora	292	0.36
Mondo	290	0.23
Megezi	541	0.75
Sumuye	227	0.34

TABLE III

Province	Population ('000s)	High Potential Agricultural land '000 Hectares	Land/Population Hectares per Capita
Coast	944	373	.39
N.Eastern	246	–	.00
Eastern	1,907	503	.26
Central	1,676	909	.55
R. Valley	2,210	3,025	1.37
Nyanza	2,122	1,218	.58
Western	1,328	714	.53

Source : Statistical Abstract.

contains many large farms which would come under the Agriculture sector - there were only 752.6 thousand hectares under small farm cultivation in 1969, and even if population were adjusted for employment in towns and on large farms in the Rift Valley, Traditional activity there almost certainly falls within the Sukumoland population density range.

Thus we would expect the Traditional sector in Kenya to reflect the Sukumoland situation with regard to land shortage, giving a low (around 0.1) elasticity of output with respect to labour input. However, the acceptance of this low labour elasticity does imply a high rate of technical progress (4.2%) in this sector.

Agriculture

Value added in Agriculture was taken to be a function of labour input, agricultural capital stock, exogenous technical progress and weather. A Cobb-Douglas production function with these inputs gives

$$VA = Ae^{rt} LA^{\alpha} KA^{\beta} W^{\gamma} \qquad (10)$$

Where VA is value added in Agriculture (Agriculture, Forestry and Fishing) in constant (1964) prices.

LA is employment in Agriculture
KA is constant (1964) price capital stock in Agriculture
W is a weather variable as in the Traditional sector.

Taking logarithms and estimating, this equation ran into a collinearity problem between logLA and logKA (they have a correlation coefficient of 0.911).

The equation was consequently constrained to give various degrees of returns to scale (arising from possible land scarcity) by considering $\delta = \alpha + \beta$ and taking four values of δ (1.0, 0.9, 0.8, 0.7). The estimating equation was

$$\log(VA/LA^{\delta}) = \log A + rt + \beta \log (KA/LA) + \gamma \log W \qquad (11)$$

The results were as in Table IV (t statistics in brackets).

TABLE IV

δ	logA	r	β	γ	R^2	D.W.
1.0	-0.880	0.044	0.694	-0.057	0.995	2.06
	(4.28)	(8.36)	(6.24)	(2.42)		
0.9	-0.464	0.045	0.615	-0.053	0.996	2.25
	(2.40)	(9.16)	(5.87)	(2.37)		
0.8	-0.049	0.046	0.536	-0.048	0.996	2.42
	(0.26)	(9.42)	(5.38)	(2.28)		
0.7	0.367	0.048	0.457	-0.043	0.996	2.56
	(2.06)	(10.57)	(4.74)	(2.14)		

As δ decreases, the coefficients of t and log W remain fairly stable, but the coefficient of β falls.

The 1967 Input-Output Table for Kenya [1] enables an estimate of factor shares to be made. The share of wages in the value added of the Agriculture, Forestry and Fishing sectors is 32%, giving around 68% to capital (in the form of depreciation, profits and interest paid). Now if factors are paid rewards equal to the value of their marginal products the coefficients α and β will give shares. On this basis, the constant returns production function (i.e. with δ = 1) might appear most appropriate for Kenya as it gives a share of capital (69.4%) closest to the Input-Output value.

<u>Industry</u>

A Cobb-Douglas production function was employed of the form

$$VI = Ae^{rt}LI^{\alpha}KI^{\beta} \qquad (11)$$

Where VI is value added in Industry (Mining and Quarying, Manufacturing and Repairs, Electricity and Water, Building and Construction) in constant (1964) prices.

r is the exogenous rate of technical progress.

LI is employment in Industry

RI is constant (1964) price capital stock in Industry.

When transformed by taking logs and estimated, problems again arose with collinearity between time and log KI (correlation coefficient 0.907), so constant returns to scale were assumed (i.e. $\alpha = 1-\beta$), and the following used as an estimating equation

$$\log(VI/LI) = \log A + rt + \beta \log(KI/LI) \qquad (12)$$

This yielded (t statistics in parentheses)

$$\log(VI/LI) = \underset{(20.48)}{-\ 1.094} + \underset{(6.82)}{0.022t} + \underset{(6.71)}{0.553} \log(KI/LI) \qquad (13)$$

$$R^2 = 0.987 \qquad D.W. = 1.38$$

There is evidence of autocorrelation and all that that entails. As far as shares go, the 1967 Input-Output Table shares for the aggregate of sectors considered gives 41% to capital as against the estimated equation, on the neoclassical assumptions, of 55%. However, I feel that the share of wages given in the Input-Output Table for the Building + Construction Industry is implausably high. If this sector is excluded, the capital share rises to a slightly more comparable 48%. Nevertheless, it might appear that labour is getting a wage in the Industry sector in excess of the value of its marginal product.

<u>Services</u>

Again a Cobb-Douglas form (exactly similar to that for Industry), and collinearity 'twixt time and log LS was apparent (correlation coefficient 0.931), so constraining to constant returns gave an estimated equation (t statistics in parentheses)

$$\log(VS/LS) = \underset{(11.20)}{-0.569} + \underset{(2.88)}{0.012t} + \underset{(3.34)}{0.561} \log(KS/LS) \qquad (14)$$

$$R^2 = 0.930 \qquad D.W. = 0.687$$

Where VS is value added in services (Transport, Storage and Communications: Wholesale and Retail Trade; Banking Insurance and Real Estate: Ownership of Dwellings; Other Services; and Domestic Services).

t is a time trend.

KS is constant (1964) price capital stock in Services.

LS is employment in Services.

Once again autocorrelation raises its unwelcome head. As for shares, the 1967 Input-Output Table gives 48% as the share of capital, while equation (14) under the neo-classical assumptions, gives 56%. Again it might appear that labour is getting a wage in excess of the value of its marginal product.

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1. Central Bureau of Statistics. Input-Output Table for Kenya 1967 Ministry of Finance and Planning, 1972.

2. Hodd, M. A Design for an Econometric Model of the Kenyan Economy Working Paper No. 171 Institute for Development Studies, University of Nairobi, 1973.

3. Larsen, Arne. Variation in Income Among Farming Areas in Sukumoland and Related Policy Implications. Paper No. 70.6. Economic Research Bureau, University College Dar es Salaam.

DATA

The data series employed in the estimates are given in the Appendix. The sources and methods are as outlined in 2.

APPENDIX

A.I.

Value added by sector in constant (1964) prices. £K millions.

Year	Traditional VT	Agriculture VA	Industry VI	Services VS	Government VG
1954	55.18	31.20	34.40	69.9	32.56
5	55.45	31.71	42.90	77.8	39.33
6	53.82	36.16	46.19	80.0	37.35
7	62.88	37.26	47.95	85.6	35.21
8	82.92	42.48	45.61	84.9	39.92
9	80.66	43.82	43.82	90.1	34.86
1960	65.29	47.87	45.21	93.7	38.40
1	57.45	46.49	44.60	88.6	37.27
2	92.78	47.36	43.97	88.2	39.03
3	96.44	52.52	42.72	93.3	37.50
4	88.89	54.70	47.29	95.1	42.47
5	79.65	52.06	49.54	103.2	46.41
6	97.57	61.94	53.63	114.0	51.99
7	101.39	60.81	58.50	119.7	56.06
8	105.11	65.70	64.59	129.1	62.57
9	109.02	72.92	68.69	135.3	68.18
1970	112.56	76.83	74.30	147.6	73.75
1	115.98	77.63	82.96	156.7	82.47
2	119.94	88.99	89.07	164.4	90.35

A3

Year	Weather W (INDEX)	Capital stock in constant (1964) prices. K millions (mid year) Agriculture KA	Industry KI	Services KS	Government KG
1954	21.3	51.2	81.5	100.4	43.6
5	15.9	53.3	85.0	112.0	48.1
6	13.3	55.1	91.0	125.2	52.6
7	15.9	56.9	96.7	135.7	57.2
8	10.4	58.7	98.7	142.7	61.0
9	19.2	60.0	99.7	147.8	64.2
1960	25.1	60.7	100.9	152.6	67.6
1	50.9	60.0	100.7	154.5	70.7
2	10.3	57.0	100.2	154.4	73.0
3	8.5	56.7	100.6	155.0	74.2
4	9.6	59.0	101.2	158.2	74.5
5	31.8	60.6	102.5	162.5	74.9
6	14.0	62.9	105.7	166.9	77.1
7	10.8	66.9	112.9	175.7	81.6
8	17.2	70.7	122.5	186.8	88.2
9	19.7	74.2	132.6	198.5	96.6
1970	20.5	77.3	144.8	215.1	106.3
1	24.0	80.4	159.3	235.3	119.0
2	17.0	84.9	178.8	253.0	133.6