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A Statistical Projection Model for the Kenya Economy

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I. Introduction

This paper presents preliminary results of an attempt to design and fit a simple econometric model to the Kenya economy. The purpose of the model is to facilitate the analysis of the implications of development plans and to check the consistency of stated programs of development expenditure and development targets. It is a slightly modified version of the model presented by Professor Paul Clark[1] which was designed to be used in making intermediate-term projections for development planning utilizing only those statistical series available in East Africa. Since the Clark model has been fitted to the Uganda and Tanzania economies, the completion of this Kenya's model should also permit a comparative study of the structure of the three East African economies.

II. Structure of the Model

The model breaks the economy into six sectors, each represented by the gross value added in that sector: agriculture (including preliminary processing, forestry, fishing, hunting); manufacturing; (including mining); construction; transport (including electricity and communication); services (commerce, private services and rents); and government. The value added in each sector is expressed as a function of particular final demands (such as construction and equipment investment), consumer demand (through private income), and intermediate demands.

Imports are broken into seven categories, each related to particular final demands or to the level of Gross Domestic Product. This fine a breakdown of imports permits anticipated changes in import regulations on specific categories of goods to be incorporated in the model in the form of changes in the import parameter values.

Investment in the present model is represented by construction and equipment expenditures, both private and government. Government construction and equipment expenditures are divided into induced and autonomous expenditures, the latter corresponding to the construction and equipment expenditures in the development budget (or, for projection purposes, in the Development Plan). All private investment and the remainder of government construction and equipment expenditure are expressed as functions of the level of urban gross product (which includes manufacturing, government, services, and transport). In this respect, the present model differs from the Clark model (see our equations 15 and 16 and compare with corresponding Clark equations).

[1] Paul G. Clark, "The Rationale and Use of a Projection Model for Uganda," EDRP 39, dated 10.7.64, East African Institute for Social Research, Makerere University College.

Our approach permits the explicit introduction into the model of autonomous or planned levels of government construction and equipment expenditure - items which are clearly not induced or dependent on income levels. Thus we interpret equations 14 and 15 as demand equations (see later note on derivation of parameter values). Clark's model shows all construction and equipment expenditure as a function of urban gross product including those elements which will in fact, be predetermined by the Development Plan. His equations are thus to be interpreted as capital requirements equations which indicate the levels of investment needed to provide the physical capital to accomodate the level of urban product. Each approach has its advantages and weaknesses.

The remaining part of the model expresses government revenues as functions of private incomes and the level of imports. These equations will permit projections to be made of the central government budgetary position during the planning period.

The model is linear and the effort has been made to keep it as simple as is consistent with reasonable predictive accuracy. Clearly, additional variables could be added to the product equations (1-6) and perhaps to others, but each such addition adds not only to the algebraic difficulties of finding the reduced form of the model but, more importantly, to the difficulties in estimating parameter values.

The main steps in this exercise have been (1) estimating the parameter values in the structural equations, 1-20; (2) deriving the algebraic form of the reduced form parameters (the "multipliers" of the exogenous variables); (3) computing the numerical values of the reduced form parameters. Further testing of the model is required and, if these tests are passed, it is intended to apply the model to a detailed analysis of the Kenya Development Plan, 1964-70.

III. The Model

(see Appendices I and II for definitions of variables)

Identities:

1. $GDP \equiv P_a + P_g + P_m + P_s + P_t + P_k$
2. $U \equiv P_g + P_m + P_s + P_t$
3. $M \equiv M_a + M_m + M_v + M_i + M_f + M_k + M_q$
4. $E \equiv E_a + E_m$
5. $E_a^* \equiv E_a + T$
6. $P_a^* \equiv P_a + T$
7. $GDP^* \equiv GDP + T$
8. $K \equiv K_{gr} + K_{gd} + K_p$
9. $K_I \equiv K_p + K_{gr}$
10. $Q \equiv Q_{gr} + Q_{gd} + Q_p$
11. $Q_I \equiv Q_p + Q_{gr}$
12. $R \equiv R_d + R_m + R_i$
13. $Y = GDP - R$

Exogenous Variables: E_a, T, E_m, G, K_{gd}, Q_{gd}

Equations:

1. $P_a^* = a_1 E_a^* + a_2 Y + a_3 E_m$

2. $P_g = g G$

3. $P_m = m_1 Y + m_2 E_m + m_3 Q$

4. $P_s = s_0 + s_1 Y$

5. $P_t = t(P_a^* + P_m)$

6. $P_k = h_0 + h_1 K$

7. $M_a = c_1 Y$

8. $M_m = c_2 Y$

9. $M_v = c_3 Y$

10. $M_i = i_1 GDP^* + i_3 E_m$

11. $M_f = i_0 + i_2 GDP^*$

12. $M_k = j_1 K$

13. $M_q = j_0 + j_2 Q$

14. $K_I = k' U$

15. $Q_I = q' U$

16. $K_p = p_1 K_I$

17. $Q_p = p_2 Q_I$

18. $R_d = r_1 Y$

19. $R_m = r_3 M$

20. $R_i = r_4 Y$

The model thus consists of 13 identities, 20 structural equations and 39 variables of which 6 are exogenous (that is, determined either by government or by world market conditions). The individual structural equations are fairly simple and can be interpreted straightforwardly.

A development plan presumably will consist of (1) planned levels of government expenditure, G, K_{gd}, Q_{gd}, and (2) descriptions of intended structural and institutional changes that are to be brought about through means other than the levels of these expenditures. An example of the latter would be new import regulations which might serve to reduce the ratio of food imports to private income (equation 7) from its historical value, and new tariff levels which would increase the ratio of duties to the value of imports (equation 19). Development plans of the second type can be taken into account during the process of estimating the parameters of the equations by changing the parameter values from those derived from historical time series. On the other hand, tracing the implications of the planned levels of government expenditures and the anticipated levels of the exports requires deriving mathematically the relevant multipliers of these predetermined variables, i.e. deriving the so-called reduced form of the model as presented above. This reduced form consists of a system of 33 linear equations derived by tedious but simple algebra from the structural equations and identities. Each reduced form equation expresses one endogenous variable as a linear function of the six exogenous variables on which all values ultimately depend. The coefficients of these reduced form equations are the "multipliers" of economic interest.

IV. Parameter Estimation

The very act of building a model embodies our hypothesis that there exist stable relationships among the variables, i.e. that linear relationships with fixed coefficients can approximate the connections among the variables over a sufficiently long period as to make the model useful for intermediate term forecasts (5-7 years). The Kenya economy has been passing through a period of considerable change, especially since 1960, so that the effects of factors which might validly be considered to be unchanging over a period of 5-7 years in other economies (distribution of income, tastes, size distribution of business firms, composition of industrial production and import, etc.) must be watched carefully in Kenya. That is to say that stable economic relationships of simple form are likely to be hard to find. We have indeed found this to be the case with respect to some of the structural equations.

Three procedures have been combined in estimating the structural parameters: (1) analysis of manufacturing input data from the Census of Manufacturing 1961 to determine certain parameters (e.g. parameters a_1, a_3, m_2); use of constraints which the parameters must approximately fulfil (e.g. $a_3 + m_2 + i_3 = 1$) and certain theoretical considerations of a technological nature (e.g. for equations 14 and 15); seeking of a line of best fit to observed data points (e.g. equations 2, 4, 5, 6, 7, 8, 9, 11, 12, 13, 16, 17, 19, 20). The data used are for 1957-63.

In the following Table 1, we present our estimates of the parameters and compare them to Clark's values for the Uganda and Tanzania economies. There are, of course, several instances where the parameters are not strictly comparable because of the differences in structure of the models.

Table 1

Comparison of Parameter Values for the Kenya, Uganda, and Tanzania Economies.

Parameter	Kenya Model	Uganda Moderate Projection	Tanganyika 1/	
a_1	.908	1.000	1.0	
a_2	.022	.131	.02	
a_3	.098	.300	.3	
c_1	.080	.0558	.068	
c_2	.077	.141	.126	
c_3	.050	.0331	.023	
g	.718	.740	.920	2/
h_0	.000	---	---	
h_1	.362	.546	.650	
i_0	2.430	---	---	
i_1	.095	.0221	.010	
i_2	.033	.0217	.025	
i_3	.430	.2	.2	
j_0	3.950	---	---	
j_1	.250	.178	.180	
j_2	.650	.689	.604	
k'	.260	.285	.320	2/
m_1	.118	.0649	.112	
m_2	.425	.5	.5	
m_3	.151	---	---	
p_1	.513	.458	.372	2/
p_2	.880	.944	.879	2/
q'	.171	.215	.270	2/
r_1	.105	.0467	.058	
r_3	.155	.308	.230	
r_4	.120	.090	.083	
s_0	4.20	---	---	
s_1	.375	.313	.183	
t	.387	.132	.241	

1/ P.G. Clark, "The Tanganyika Plan", EDRP No. 56, 30.11.64

2/ Tanganyika and Uganda parameter values not strictly comparable to Kenya values due to differences in definitions of variables.

V. The Reduced Form Multipliers

The reduced form parameters or multipliers give the ultimate impact on the variables of the model of a unit change in one of the exogenous variables (Ea, T, Em, G, Kgd, Qgd). By ultimate impact we mean the accumulated effect that sustained change in an exogenous variable would have on an endogenous variable such as GDP, Y, Pm, or M. The reduced form of a linear simultaneous equations model of the present type permits one to "trace" all of the "circular flow effects" of a change in autonomous expenditure on levels of income, final expenditure, value added in the various sectors, etc. In Table 2, we present the most important multipliers for the Kenya economy as derived from the present model

Table 2

"Multipliers"

Change in Indicated Endogenous Variable per Unit Change in Indicated Exogenous Variable

Endogenous Variables	Exogenous Variables						
	Constant £ mn.	Ea	Em	T	G	Qgd	Kgd
GDP	8.350	2.585	1.523	.579	1.597	.365	.680
U	7.519	1.493	1.280	.605	1.436	.329	.281
Y	5.574	1.968	1.110	.424	1.217	.197	.494
Pa*	..123	.952	.122	.917	.027	.004	.011
Pm	.852	.273	.589	.066	.181	.183	.066
Ps	6.290	.745	.416	.159	.457	.074	.185
Pt	.377	.474	.275	.380	.080	.072	.030
Pk	.708	.140	.121	.057	.135	.031	.388
Pg	0	0	0	0	.718	0	0
K	1.9[illegible]5	.388	.333	.157	.373	.086	1.073
Q	1.2[illegible]6	.255	.219	.103	.245	1.056	.048
M	9.8[illegible]6	.965	1.058	.388	.685	.792	.479
R	2.7[illegible]6	.597	.414	.155	.380	.167	.185

One of the most interesting features of Table 2 is the large impact of agricultural exports, Ea, on GDP. This impact is perhaps better understood if we rewrite the reduced form equation for GDP:

$$GDP = 8.350 + 2.585\ (Ea + T) + \ldots + .579\ T - 2.585\ T$$

$$= 8.350 + 2.585\ Ea^{*} + \ldots - 2.006\ T$$

or $$\Delta GDP = 2.585\ \Delta Ea^{*} + \ldots - 2.006\ \Delta T$$

Ea* measures the quantity of agricultural export (i.e. exports at constant prices), whereas ΔT measures the change in value due to price changes, quantity remaining constant. It should be noted that an increase in agricultural export prices is represented by a decrease in T. Thus a unit increase in the value of agricultural exports by one unit, quantity remaining constant, will increase GDP by 2.585 units; whereas price increases sufficient to raise the value of exports by one unit, quantity remaining unchanged, will increase GDP by 2.006 units.

The impact of both agricultural and manufactured exports on imports is surprisingly large. The reduced form equations for the total imports may be rewritten

$$M = 9.816 + .965\ (Ea+T) + 1.058\ Em + .388\ T - .965\ T + \ldots$$

or

$$\Delta M = .965\ \Delta Ea^{*} + 1.058\ \Delta Em - .577\ \Delta T$$

In this form, the equation shows that increases in the value of agricultural exports due to price increases have a much smaller impact on imports than do quantity increases.

Even if a range of, say ±20% is allowed for error in the estimates of these import coefficients, the heavy impact of exports on imports cannot be ignored. These findings, if borne out in further tests of the model, have obvious implications for development policy in the areas of import substitution and restriction and agricultural policy.

Appendix I

Definitions of Variables & Sources

(Most references are to Tables of the 1963 Kenya Statistical Abstract)

GDP = gross domestic product, Table 130 (a)

P_a = gross product of agriculture, including preliminary processing, forestry, fishing, and hunting, Table 130(a)

P_m = gross product of manufacturing, including mining and quarrying, Table 130(a)

P_k = gross product of construction, Table 130(a)

P_t = gross product of transport, including electricity, water, storage, and communications, Table 130(a)

P_s = gross product of services, including commerce, private services, rents, banking, insurance, and real estate, Table 130(a)

P_g = gross product of government, including civil department, local authorities, defense, and public services, Table 130(a)

U = urban product = $P_g + P_s + P_m + P_t$

M_a = imports of food, SITC 0, 1, 4, Tables 40, 49, 50.

M_m = imports of consumer manufactures, parts of SITC 5, 6, 7, 8, 9 (see Appendix II for detailed list)

M_v = imports of consumer vehicles, parts of SITC 6, 7

M_i = imports of intermediate goods, parts of SITC 2, 5, 6, 8, 9 (see Appendix II)

M_f = fuel imports, SITC 3 plus electricity imports, Tables 40, 49, and 50.

M_k = imports of construction materials, parts of SITC 2, 6, 7, 8 (see Appendix II)

M_q = equipment imports, parts of SITC 7, 8

E = domestic exports plus inter-territorial exports, Tables 35, 47, 48.

E_a = agricultural exports, SITC 0, 1, 2, 4

E_m = manufactured exports, SITIC 3, 5, 6, 7, 8, 9

T = terms of trade adjustment = E_a (at 1958 prices) less E_a (using aggregate price index, Table 44 as corrected, adjusted to 1958 base)

K = construction investment, government plus private, Table 132.

K_{gd} = government construction on development account, Table 125

K_{gr} = government contruction on recurrent account, Table 125, plus EACSO Trading Services, Table 132

K_p = private construction, Table 132

Q = equipment investment, Table 132

Q_{gd} = government equipment on development account, Table 125

Q_{gr} = government equipment on recurrent account Table 125, plus EACSO Trading Services, Table 132

Q_p = private equipment, Table 132

G = Central government expenditures on recurrent and development account, less construction and equipment on recurrent and development accounts, Table 125

R = government revenues, Table 124, less public debt transactions and grants from abroad, for fiscal year beginning in any calendar year.

R_d = direct taxes, including income tax, GPT, and other, Table 124(a)

R_m = revenue from customs, Table 124(a)

R_i = $R - R_d - R_m$