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B. Van Arkadie

NOTES ON A MODEL OF THE EAST AFRICAN ECONOMY

I. INTRODUCTION

These notes set out the first steps necessary for the construction of a model of the East African economy. A model is a representation of reality designed to illustrate the operation of the economy in a form simple enough to be comprehended as a whole, and inclusive enough to add some dependable insight into reality. At its simplest it will serve as a heuristic device; at its most complex it may be utilized directly in a planning operation.

Models of developing economies run into two kinds of difficulties. The very process of development involves changes in structure which will alter values which experience in developed economies might suggest should be treated as parameters. Secondly, the inadequacy of the data makes the steps from the theoretical construct to econometric estimates or simulation very problematical.

In building any model choices have to be made regarding the relationships to be explicitly treated and those which can be safely ignored. In doing this, decisions will be based on the purpose for which the model is to be used; for example, models of economic growth typically ignore seasonal fluctuations and may even neglect cyclical behavior. In practice, the model will be the embodiment of the main lines of understanding and reasoning about the economy which have been gained from a very diverse range of sources.

These notes are intended to deal with a model which can encompass the major characteristics of the East African economy to help our understanding of the development process over fairly long periods so that light may be thrown on the strategy of development for a whole planning period (i.e. 4-6 years). A planning model to be used for an examination of year to year adjustments in policy would require a more detailed approach than is attempted here and would have to take account much more carefully of the time form of responses to external shocks and to policy adjustments.

These notes are preliminary in that the full implications of the model have not been investigated. The purpose of the paper is to provide an opportunity for the author to draw on the advice and comment of members of the Economic Development Research Project.

The basic requirements of a model of the East African economies.

Any model of economies of the type under consideration must account for inter-sectoral relationships. Within the domestic economy, the relationship between the primary producing sector (predominantly traditional in technique) and the manufacturing and service sector (more "modern") must be treated. Moreover, in East Africa a model of a closed economy would be very misleading, even as a first approximation - the relationship between foreign trade and the world economy on the one hand and domestic economic activity must also be explicitly treated. Therefore it seems likely that an aggregative model, even at the most simplified level, must be developed in terms of three sectors.

It may well be that at a later stage explicit consideration of the implications of the colonial nature of the economics and the structural change resulting from political autonomy should be explicitly introduced into the model. The existence of expatriate personnel with income levels determined by reference to foreign labour markets was an important characteristic of the colonial system in terms of the resulting income and spending patterns. This presentation avoids treatment of this question by ignoring the skilled manpower constraint on development and thus avoiding explicit treatment of professional (high income) manpower inputs. This simplification will be relaxed in a later version. For the moment, there are enough complications in these notes as they stand for one seminar.

In this model distinctions will be made between variables according to whether they are treated as exogenous or endogenous to the model. As the model is developed for policy purposes it will prove useful to distinguish policy variables, dividing these according to whether they are the instruments of policy or the objectives (these are not mutually exclusive). In this discussion passing comment is made regarding policy objectives, but there is no systematic treatment.

The method of attack.

The method of attack is to look at a number of particular relationships separately, and then to consider how the various parts may be fitted together. The first step is to construct a simplified model of the supply constraint on development, which is, in effect, a modified version of Harrod-Domar. The second step is to deal with the structure of demand and the relationship between the domestic savings constraint and the foreign exchange constraint on development. The third step is to consider the relationship between the primary producing sector and the "modern" sector in more detail than in steps one and two. The final section sets out the most important unanswered questions in the paper as it stands.

II. A SIMPLIFIED VERSION OF THE SUPPLY CONSTRAINT.

In the following paragraphs a simple model is set out in which the basic constraint on the growth of the non-primary sector is assumed to be the supply of capital (the skilled manpower problem is ignored). There are two sectors:

- a) Primary: this is assumed to be agricultural, producing primary export crops, food for own consumption and food for the non-primary sector.
- b) Modern: this is assumed to be manufacturing and services, producing for the domestic market.

The purpose of the exercise is to provide a first view of what determines the rate of growth of the modern sector.

a) Primary sector:

Output of export crops: A

Price received by the producer
(including distribution costs): p_a

Price received on world market: p_e

Food crops sold to the modern sector: F

Price received for food crops: p_f

Primary sector demand for non-primary
products: D_m

(All prices are relative to the price level in the modern sector)

The primary sector demand for food for own consumption, a self-balancing item, is neglected. The income and price elasticity of demand for this item might have an important effect on the supply of export crops and food crops for the modern sector. It should be noted that for the sake of simplicity the distribution services associated with agricultural exports are treated as part of the primary sector; the difference between the price received by the primary sector and the export price consists of the surpluses of marketing boards and the proceeds of export taxes.

Primary sector demand for non-primary products: It is assumed that the primary sector spends its entire cash income on the products of the modern sector or on imports. As, for the moment, there is no explicit production function for the agricultural sector, the distribution of these spending decisions as between consumption and investment items is neglected. The demand of the primary sector is therefore represented:

$$(1) \quad D_m = P_a A + P_f F$$

Supply function for the agricultural sector:

$$(2) \quad A = f_1(P_a, P_f)$$

$$(3) \quad F = f_2(P_a, P_f)$$

The supply of exports crops and food is determined by the price levels for those two; climatic effects are neglected. Obviously, the failure to deal more explicitly with agricultural inputs is no more than a first approximation. Perhaps more serious is the aggregation of output and price levels; both output and prices are vectors, and the response of the output vector to changes in the price vector will depend on the particular prices which have changed as well as the change in the general level.

Nevertheless, within the liberties of model-building, the method of statement does illustrate a basic choice which may become important during the process of development - the choice of feeding an expanding urban labour force or expanding agricultural exports. Whether that choice must yet be faced is an empirical question still largely unanswered.

b) Modern sector: Output of modern sector: Z
Rate of growth of Z : r_z
Elasticity of Z w r.t. Z
capital (K): $e_k (= \frac{dZ/dK}{Z/K})$
Elasticity of Z w r.t.
Labour (L): $e_l (= \frac{dZ/dL}{Z/L})$
employed
Rate of growth of capital: r_k
Rate of growth of employment: r_l

The most simple assumption regarding supply conditions in the "modern" sector would be that input/output relationships were determined by fixed technical coefficients. In such a case the supply constraint would be determined by the scarcest factor and output and the other inputs would expand at the rate of expansion of that factor. Although such an assumption may often be reasonable in the case of the individual plant using a given technique, it is much less so at more aggregate levels, in which case factor proportions can change as a result of the change in the composition of output. The treatment of the production function and input/output relationships is never very satisfactory in explanations of economic growth; however, it is desirable to render explicit the nature of the restrictive assumptions often made.

Assuming a neo-classical production function (i.e. some substitution between factors) and assuming the neutrality of technical change then the rate of growth of output can be treated as follows:

$$(3) \quad r_z = e_k r_k + e_l r_l + j$$

where j is the rate of technical improvement.
If constant returns to scale is assumed, which implies that $e_k + e_l = 1$, then:

$$(4) \quad r_z = (e_k + e_l) r_k + e_l (r_l - r_k) + j \\ = r_k + e_l (r_l - r_k) + j$$

The basic assumption must be that the growth in the capital stock is a major constraint on the rate of growth of output; if this is so then an important determinant of the rate of growth of output is the degree to which labour can be substituted for capital (i.e. the degree to which r_l is greater than r_k in equation (4).) Under the neutral technical change assumption it must be supposed that this will be determined by the behaviour of wage rates (in the private sector because of the concern over objectives of the re-investible surplus). The simplest assumption that might be made for equation (4) would be that $r_l = r_k$, (i.e. the same result as assuming fixed coefficients) that is employment grows at the same rate as the capital stock. Then output would be growing faster than both capital and labour at a rate j , and, if labour is employed until its wage equals its marginal product, the wage rate would be increasing at a rate j (as also would the profit rate). If this simplifying assumption is dropped then further progress requires more detailed specification of the production function.

Perhaps the most popular form of production function assumed in practise is the Cobb-Douglas function, which has the property that e_k and e_l are constants. In such a case, if it is assumed that labour is employed to the point where its marginal product is equated with the wage rate, the rate of growth of employment and of output can be shown to be related to the behaviour of the wage rate. For example, if the W.A. Lewis "unlimited supply of labour" conditions held then the wage rate might well be constant. With a constant wage rate, a Cobb-Douglas function, neutral technical progress and labour being paid its marginal product, then employment will grow at the same rate as output. (i.e. if the elasticity and the marginal product are both constant then so is the average product). In such a situation the following relationship holds.

$$(5) \quad r_z = r_k + e_l (r_z - r_k) + j$$

from which

$$(5a) \quad r_z = r_k + \frac{1}{1 - e_l} j = r_k + \frac{1}{e_k} j$$

However, useful as the Cobb-Douglas form is for illustrative purposes, there is no reason to suppose that it is in practise generally applicable. If it is not generally applicable, or if technical progress is not neutral, then the relationships between the growth of employment, capital, output and the wage rate becomes very complicated. *

* For a fairly general treatment of this problem see John C.H. Fei and Gustav Ranis, "Innovation, Capital Accumulation and Economic Development", American Economic Review, June, 1963.

In practise, it seems likely that detailed examination of the labour market and the employment problem will demand a model more sophisticated than this: it will be necessary to find out much more about the "residual", which is subsumed under the general heading technical change in such simple production function models. The changing composition of the labour force its educational skills and the supply of professional and organizational

manpower all demand explicit treatment. Such a treatment is probably the most important missing link in our understanding of the relationship between growth and employment.

In fact, many informed observers believe that in East Africa there has been, during recent years, a process of substitution of capital for labour, that is r_k has been larger than r_e . Although this belief has been held regarding the performance of a number of developing countries in recent years, a satisfactory explanation has still to be offered. In East Africa it is difficult to tell the degree to which substitution has taken place, because the period in question has been one of less than full capacity utilization; therefore it has been difficult to tell the extent to which the evidently positive rate of capital accumulation has been combined with an increase in capital employed. More light should be thrown on this problem by an empirical investigation of the recent employment history of East Africa, which the author is currently undertaking.

For the moment the argument proceeds on the basis of equations (4) (with restriction $r_e = r_k$) or (5a) (with $r_1 = r_2$)

under the alternative assumptions of a wage rate. In both cases the supply constraint on the rate of growth is the rate of growth of the capital stock, employment being determined by the wage rate and the rate of growth of output.

The Capital Constraint.

What determines the supply constraint on the rate of growth of capital? The first exercise will be based on the assumptions: that income can be spent on consumption or investment goods, without structural constraints on the supply of the particular goods; and that there is no net import of capital. These assumptions imply:

(6) Exports(E) = Imports (M)
and the definitions for the primary sector above imply:

(7) $E = p_e A$ Using the additional notation:
Non-subsistence supply Y
Wage rate: w
Propensity to consume of workers: c_w
Propensity to consume of profits: c_p

the following can be developed:

(8) $Y = Z + M + p_f F$

Apply (6) and (7)

(9) $Y = Z + p_e A + p_f F$

Total supply may be allocated between consumption or investment activities:

(10) $Y = C + I$

(11) $C = c_w wL + c_p (Z - wL) + D_m$
 $= c_w wL + c_p (Z - wL) + p_a A + p_f F$

$$(12) \quad Y = c_w WL + c_p (Z - wL) + p_a A + p_f F + I$$

$$(13) \quad Z + p_e A + p_f F = c_w WL + c_p (Z - wL) + p_a A + p_f F + I$$

from which:

$$(14) \quad I = Z - (c_w WL + c_p (Z - wL)) + (p_e - p_a) A$$

$$(15) \quad I = (1 - c_w \frac{WL}{Z} - c_p \frac{(Z - wL)}{Z}) Z + (p_e - p_a) A$$

$$(16) \quad \frac{I}{K} = (1 - c_p + (c_p - c_w) \frac{wL}{Z}) \frac{Z}{K} + (p_e - p_a) \frac{A}{K}$$

Equation (16) shows the determinants of the rate of growth of the capital stock $\frac{I}{K}$ in this model. The first term describes saving $\frac{I}{K}$ generated by the modern sector, which depends on the propensity to consume of the two income groups and the distribution of income between wages and profits. The second term represents savings extracted from the agricultural sector through a process of taxation or through the profits of the marketing boards.

If we make the (reasonable) assumption that: $c_w = 1$ then:

$$(17) \quad \frac{I}{K} = (1 - c_p) (1 - \frac{wL}{Z}) \frac{Z}{K} + (p_e - p_a) \frac{A}{K}$$

If we make the further assumption that labour is paid its marginal product, and substitute from equation (2) then

$$(18) \quad \frac{I}{K} = (1 - c_p) (1 - e_1) \frac{Z}{K} + (p_e - p_a) \frac{f(p_a, p_f)}{K}$$

The constraint on the rate of growth of output of the modern sector will be equal to equation (18) plus a factor allowing for technical improvement and an increase in labour intensity (see equations (4) and (5a) above.)

This formulation should clarify certain relationships. In the early stage of development the final term in equation (18) will be relatively much more important because of the importance of the agricultural exports sector at that stage. The degree to which the agricultural sector can contribute to the supply of capital for the building of a modern sector will depend on world export markets, the elasticity of supply in response to prices received and, of course, whatever changes in productive conditions shift the supply curve in the agricultural sector. As the modern sector grows savings generated by its own activities become relatively more important, until in a developed economy it becomes the major source of domestic savings.

As the modern sector grows there will be an additional effect operating in the agricultural sector: the point will eventually be reached at which the marginal product of labour transferred from the agricultural sector will become positive and, in the absence of shifts in the agricultural production function, p_f will rise causing a shift from exports to domestic production.* At that stage the possibility of taxing income derived from food sales might be considered, but this would carry with it a number of difficulties (including the possibility that the burden of the tax on food sales would fall on the profits of the modern sector). For the moment, the analysis will be left with a number of ends untied and with a number of possibilities only hinted at.

* See Gustav Ranis and John C.H. Fei "A Theory of Economic Development", American Economic Review, September 1961.

III. STRUCTURAL CHANGE AND THE BALANCE OF PAYMENTS CONSTRAINT.

Section II considered the situation where resources available (either imported or domestically produced) could be shifted freely from one use to another. The constraint on growth was therefore an overall supply constraint. However, in practice resources cannot be readily shifted from one use to another. The industrial structure of an economy introduces extra constraints - domestic productive capacity may not be readily transferred from one use to another, so that the economy may be faced with surplus domestic capacity in one line at the same time as supplying needs through imports in another. The differing import content of differing types of economic activity may result in a balance of payments constraint operating even when idle domestic resources exist. The reverse is also true; in some economies with ample foreign exchange available some domestic supply factor may act as a constraint on further expansion.

For example, in East Africa at present a given expenditure on investment goods will result in more imports than a similar expenditure on consumption items. Indeed, even within the area of investment spending there will be a differential import effect according to whether the expenditure is on construction or equipment. It also seems likely that the distribution of income will not only affect the amount of consumption spending but will also have an impact on its import content. In the process of planning, knowledge of the existing industrial structure can be used to estimate the import content of various expenditures.* The process of development, however,

* See Brian Van Arkadie, "Import Substitution and Export Promotion as Aids to Industrialization in East Africa", EDRP 24, 6.5.64.

involves changes in the industrial structure and the transformation of the relationship between domestic economic activity and international trade.

During the process of development efforts will be made to set up industries to supply domestic demands now satisfied through imports, to achieve this objective high rates of investment will be attempted. Until a very late stage of development equipment expenditures are likely to have a high import content. Therefore, although the ultimate result of development is likely to be a reduction of the importance of the foreign sector, the supply of foreign funds is likely to be a crucial constraint at some stage of development. In models of continental economies (e.g. U.S., U.S.S.R., China) it is quite permissible to neglect the foreign sector and to view the process of development as largely autarchical. In East Africa this would be foolish. This section therefore attempts to establish a framework for treating the potential foreign exchange constraint on development. * *

** For a sophisticated treatment of the operation of alternative constraints on development programme see H.B. Chenery and Michael Bruno, "Development Alternatives in an Open Economy: the Case of Israel", The Economic Journal, March 1962. An article in the same volume of the Journal gives a convincing general case to suppose that the foreign trade prospects of the developing countries are depressing enough to provide added evidence that the foreign exchange constraint will be serious, see Dudley Seers, "A Model of Comparative Rates of Growth in the World Economy," also Economic Journal, March 1962.

To develop a simple model, the argument abstracts from the differences between varying types of investment and consumption spending and concentrates on the difference between the two major categories. For simplicity, the effect of income distribution on the level of consumption (an important element in section II) is ignored.

An additional variable is introduced: foreign investment and aid (V) where the constraint holds:

$$(19) \quad M = E + V \\ = p_e A + V$$

using the same assumption regarding export earnings introduced in Section II.

Total non-subsistence supply (Y) is then:

$$(20) \quad Y = Z + p_e A + V + p_f F,$$

that is, domestic production plus imports.

The important additional assumption is that there is some relationship between the composition of spending and the level of imports; here it is represented by a simple linear import demand equation:

$$(21) \quad M = nC_1 + mI, \text{ with } m \text{ greater than } n,$$

and where C_1 is the consumption of modern (non-food) products.

Retaining the assumption that the agricultural sector disposes of its income on modern products, and simplifying the consumption function of the modern sector, so that consumption is straightforwardly dependent on the level of output in the modern sector, the following function is adopted:

$$(22) \quad C_1 = (cZ - p_f F) + (p_a A + p_f F)$$

where the expression in the first parentheses represents consumption in the modern sector, and that in the second parentheses represents consumption by agricultural producers. But Z is determined by the level of demand:

$$(23) \quad Z = (1 - n)C_1 + (1 - m)I$$

Substituting (23) in (22):

$$(24) \quad C_1 = c(1 - n)C_1 + c(1 - m)I + p_a A \\ = \frac{c(1 - m)}{1 - c(1 - n)} I + \frac{p_a A}{1 - c(1 - n)}$$

Substituting (24) in (21):

$$(25) \quad M = \frac{nc(1 - m)}{1 - c(1 - n)} I + mI + \frac{np_a A}{1 - c(1 - n)} \\ = \frac{nc + m(1 - c)}{1 - c(1 - n)} I + \frac{np_a A}{1 - c(1 - n)}$$

But applying the constraint (19) to (25)

$$(26) \quad \frac{nc + m(1 - c)}{1 - c(1 - n)} I + \frac{np_a A}{1 - c(1 - n)} = p_e A + V$$

Solving for I:

$$(27) \quad I = \frac{1 - c(1 - n)}{nc + m(1 - c)} V + \frac{p_e (1 - c(1 - n)) - np_a A}{nc + m(1 - c)} A$$

Dividing through by \bar{K} , the foreign exchange constraint on the rate of growth of the capital stock is obtained:

$$(28) \quad \frac{I}{\bar{K}} = \frac{1 - c(1 - n)}{nc + m(1 - c)} \frac{V}{\bar{K}} + \frac{p_e (1 - c(1 - n)) - np_c}{nc + m(1 - c)} \frac{A}{\bar{K}}$$

Similarly, by substituting (22) in (23) the domestic supply constraint on the rate of growth of the capital stock can be obtained:

$$(29) \quad \frac{I}{\bar{K}} = \frac{1 - c(1 - n)}{1 - m} \frac{Z}{\bar{K}} - \frac{1 - n}{1 - m} \frac{p_a A}{\bar{K}}$$

Equations (28) and (29) provide two alternative constraints on the rate of growth of the capital stock, which in section II has been shown to be the basic constraint on the rate of growth of the non-agricultural sector. Through a process of extreme simplification the two constraints are stated in terms of three parameters: a propensity to consumer (c), and two propensities to import, (n) and (m). There are two essentially exogenous variables, (p_e) and (V). The price received by the agricultural sector, (p_a), is a policy variable. Agricultural output, although inherently an endogenous variable, is left for the moment unexplained and therefore, in terms of the model, exogenous. Apart from direct action on (p_a) public policy can indirectly affect (c), (n) and (m) through tax policies and other controls. Also, these three parameters operate as constants in the short run but through the agency of structural change become strategic variables in the longer run.

The operation of the model in the course of growth.

Despite the incomplete nature of the model it is possible to suggest some of the possibilities during the development of the economy. This will be done by investigating:-

- (i) the effect of changes resulting from adjustments in the basic structure of the economy: that is the effect of shifts in (n) and in $\frac{A}{\bar{K}}$.
- (ii) the effect of changes in the exogenous variable, (p_e).
- (iii) the effect of changes in the policy variable, (p_a).

(1) Structural changes.

During the process of growth there are few elements of the economic system which can be treated strictly as parameters. However, of the multitude of shifts and changes which could occur it seems reasonable to concentrate on two as the strategic shifts involved in programmes of industrialization. The first of these is the effect of the expansion of domestic industry through a process of import substitution. At the initial stages this will take the form of the attempt to produce domestically goods of simple technique which were previously imported. Such a policy will result in a decline in (n), because it is likely that such goods will be predominantly consumer goods. (This presumption demands some qualification, as the material inputs for the construction industry are often produced domestically early in development, while the changing level of income per head may generate a shift in demand towards consumer goods with higher import content.) Secondly, the growth of the non-agricultural sector is likely to lead to a decline in the relative importance of agricultural export earnings, which would appear in equation (28) as a decline in $\frac{A}{\bar{K}}$.

The first effect can be illustrated by evaluating $d(\frac{I}{K})/dn$ in the two cases. In the case of the foreign exchange constraint, the result is:

$$(30) \quad d(\frac{I}{K})/dn = \frac{c((m-1)(1-c))V}{(nc + m(1-c))^2 K} + \frac{cp_e(m-1) + p_a m(c-1)}{(nc + m(1-c))^2} \frac{A}{K}$$

Both of these terms are clearly negative, therefore as (n) declines the foreign exchange constraint becomes less stringent. On the other hand, the domestic output constraint changes as follows:

$$(31) \quad d(\frac{I}{K})/dn = \frac{c}{1-m} \frac{Z}{K} + \frac{1}{1-m} \frac{A}{K}$$

(31) being positive the domestic constraint becomes more stringent with the decline in (n). This result is hardly surprising.

The effect of changes in $\frac{A}{K}$ are not so straightforward. From (28) the effect of changes in $\frac{A}{K}$ on the foreign exchange constraint can be obtained:

$$(32) \quad d(\frac{I}{K})/d(\frac{A}{K}) = \frac{p_e(1-c(1-n)) - np_a}{nc + m(1-c)}$$

This term will be positive when the numerator is positive. Thus the effect on the foreign exchange constraint depends on the value of the term: $p_e(1-c(1-n)) - np_a$. If that term is positive, then the decline in $\frac{A}{K}$ will render the foreign exchange constraint more stringent; if negative the reverse effect will hold. The term will be positive if:

$$(33) \quad \frac{n}{1-c+cn} < \frac{p_e}{p_a}$$

But, if $n < 1$, then $\frac{n}{1-c+cn} < 1$.

It may therefore be concluded that as long as $p_e > p_a$ the decline in $\frac{A}{K}$ will make the foreign exchange constraint more stringent.

(Translated into more straightforward terms this implies that as long as the agricultural sector is a net supplier of capital resources to the modern sector the decline in its relative importance will increase the stringency of the foreign exchange constraint). The effect on the domestic constraint is indicated by:

$$(34) \quad d(\frac{I}{K})/d(\frac{A}{K}) = -\frac{1}{1-m} \frac{n}{p_a}$$

This indicates that as agricultural exports decline in relative importance the domestic constraint becomes less stringent.

Therefore there are two important structural changes occurring during the process of development which have opposing effects on the two constraints.

(ii) The effect of exogenous fluctuations in the export price level which are not passed on to the producer is solely on the foreign exchange constraint. This effect can be derived from (28):

$$(35) \quad d(\frac{I}{K})/d(p_e) = \frac{1-c(1-n)}{nc + m(1-c)} \frac{A}{K}$$

This term is clearly positive. A rise in export prices would have an effect on the domestic constraint only through changes in prices received by producers in turn affecting consumption.