MODELING ECONOMIC FLUCTUATION IN SUB-SAHARAN AFRICA
A VECTOR AUTOREGRESSIVE APPROACH

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1.0 RESEARCH PROBLEM

For most of the twentieth century, especially since the great depression, most macroeconomists have looked upon the sharp fluctuations in output and unemployment as prima facie evidence of major market imperfections and explored what these imperfections may be (Blanchard and fisher, 1990). In the last 15 years, however, some have argued that this is a misguided research strategy, since of research belongs basically can be explained without invoking imperfections. This line of research belongs basically to the real business cycle theory, which proceeds from the assumption that there are large random fluctuations in the rate of technological change (Mankiw, 1990 and Charnvitayapong et al 1995). Because these fluctuations in technology lead to fluctuations in relative prices, individuals rationally alter their labor supply and consumption. Thus the theory explains recessions as periods of technological regress, that is, declines in society's technological ability and assumes that monetary policy is irrelevant for economic fluctuations.

In fact, a controversial result of some current research on this real business cycles is the claim that a common stochastic trend-the cumulative effect of permanent shocks to productivity underlies the bulk of economic fluctuations (king et al, 1991). If confirmed, this will imply that many forces have been relatively unimportant over historical business cycles, including the monetary and fiscal policy shocks in traditional macroeconomics analysis.

This research study therefore intends to show that the hypothesis of a common stochastic productivity has a set of econometric implications that allows us to test for its presence, measure its importance, and extract estimates of its realized value. Moreover, we intend to know how much of the cyclical variation in the research data can be attributed to innovations in the common stochastic trends and whether innovations associated with nominal variables explain important cyclical movements in the real variables.

Building on a venerable economic tradition, it is hoped that the estimated relationships will separate the regular response of policy to the economy from the response of the economy to policy; and therefore producing a more accurate measure of the effects of the policy changes and shocks (Sims et al, 1996). In this way, the proposed model will integrate policy behaviour variously with broad macroeconomic aggregates to provide a fuller understanding of the factors underlying the bulk of economic fluctuations in sub-Saharan Africa. Unfortunately, these economies has remained stagnated, deteriorated and distorted for the past decades (Nwaobi, 1993b,)

2.0 OBJECTIVES OF STUDY

The fundamental aim of this study is to build a specific structural long run model that incorporate the important features of the national economies under study. This objective requires us to carry out the following steps:

1. To construct new classical based vector auto regression models for selected African Economics

2. To examine whether business cycles are mainly the result of permanent shocks to productivity.

3. To identify the role of monetary and fiscal policy during economic fluctuations, using impulse response analysis and persistence profiles (i.e., by considering the effect of variable-specific and system-wide shocks).

4. And finally to compute multivariate dynamic forecasts as well as performing a sensitivity analysis.

3.0 THEORETICAL AND METHODOLOGICAL FRAMEWORK

In a real-business-cycle model with permanent productivity shocks, output Y_t is produced via a constant-returns-to-scale Cobb-Douglas production function:

$$Y_t = \lambda_t k_t^{1-\theta} N_t^{\theta} \qquad (1.1)$$

where k_t is the capital stock and N_t represents labor input. Total factor productivity, λt, follows a logarithmic random walk:

$$\text{Log}\ (\lambda t) = \mu_\lambda + \log(\lambda_{t-1}) + \xi_t \qquad (1.2)$$

where the innovations, (ξ) are independent and identically distributed with a mean of 0 a variance of σ2. The parameter μ_λ represents the average rate of growth in productivity; ξ_t represents deviations of actual growth from this average.

Within the basic neoclassical model with deterministic trends, it is familiar that per capita consumption, investment, and output all grow at the rate μ_λ/θ in steady state. The common deterministic trend implies that the great ratios of investment and consumption to output are constant along the steady-state growth path. When uncertainty is added, realizations of ξ change the forecast of trend productivity equally at all future dates:

$$E_t \log(\lambda_{t+s}) = E_{t-1}(\lambda_{t+s}) + \xi$$

A positive productivity shook raises the expected long-run growth path: there is a common stochastic trend in the logarithms of consumption, investment, and output. The stochastic trend is log $((\lambda_t)/\theta$, and its growth rate is $(\mu_\lambda + \xi)/\theta$, the analogue of the deterministic models common growth – rate restriction,μ_λ/θ. With common stochastic trends, the ratios C_t/Y_t and I_t/Y_t become stationary stochastic processes.

Thus, let X_t be a vector of the logarithms of output, consumption, and investment at date t, denoted by Y_t, C_t, and I_t. Each component of X_t is expected to be integrated of order one because of the random-walk nature of productivity; yet, the balanced growth implication of the theory implies that the difference between any two elements of X_t is integrated of order zero. However, in systems that incorporate both real nominal variables, additional co integrating relations may plausibly arise. The first is money demand relation:

$$M_t - P_t = \beta_y Y_t - \beta_R R_t + V_t \qquad (1.3)$$

where M_t-P_t is the logarithm of real balances, R_t is the nominal interest rate and V_t is the money-demand disturbance. The other co integrating relation is the fisher relation:

$$R_t = r_t + E_t \Delta P_{t+1} \qquad (1.4)$$

Where r_t is the ex ante real rate of interest, P_t is the logarithm of the price level, and $E_t\Delta P_{t+1}$ denotes the expected rate of inflation between t and t+1. If real balances, output, and interest rates are I (1), while the money – demand disturbance in (1.3) is I (0), then real balances, output, and nominal interest rate are co integrated. If the real rate is I (0) and the inflation rate is I (1), then (1.4) implies that nominal interest rates and inflation are co integrated.

To identify trends and their impulse response functions, let X_t denote an n x 1 vector of time series. The individual series are assumed to be I (1) and to have the wold representation:

$$\Delta X_t = \mu + C(L)\varepsilon_t \qquad (1.5)$$

where is the vector of one-step-head linear forecast errors in X_t given information on lagged values of X_t The e_t's are serially uncorrelated with a mean of zero and covariance matrix ee. To consider the set of structural relations that led to (1.5), we specify the following model:

$$\Delta X_t = \mu + \Gamma(L)\eta_t \qquad (1.6)$$

where η_t is an n x 1 vector of serially uncorrelated structural disturbances with a mean of zero and a covariance matrix Σ_η. The reduced form of (1.6) will be of the form (1.5) with) $\varepsilon_t = \Gamma_o \eta_t$ and $C(L) = \Gamma(L)\,\Gamma_o^{-1}$. Here, identification is achieved through two sets of restrictions. First, the co integration restrictions impose constraints on the matrix of long-run multipliers $\Gamma(1)$ in (1.6). This identifies the permanent components. Second, the innovations in the permanent components are assumed to be uncorrelated with the innovations to the remaining transitory components. This identifies the dynamic response of the economic variables to the permanent innovations. And given a three-variable model with $X_t = (y_t, C_t, i_t)'$. Because there are two co integrating vectors, there is only one permanent innovation, the balanced-growth innovation η_t'. This shock corresponds to ξ_t in the neoclassical model. The other two shocks, η_t^2 and η_t^3, have only transitory effects on X_t Thus, the first identification restriction (the balanced-growth co integrating vectors) implies that the matrix of long run multipliers is

$$\Gamma(1) = \begin{pmatrix} 1 & 0 & 0 \\ 1 & 0 & 0 \\ 1 & 0 & 0 \end{pmatrix} \qquad (1.7)$$

Where the values of the coefficients in the first column of $\Gamma(1)$ are normalized to I to fix the scale of η_t^1. Equation (1.7) serves to identify the balanced-growth shock as the common long-run component in X_t, since the innovation in the long run forecast of X_t is $(1\ 1\ 1)'\ \eta_t^1 = C\ (1)\varepsilon_t$ which can be calculated directly from the reduced form (1.5). The second restriction, that η_t^1 is uncorrelated with η_t^2 and η_t^3 is used to determine the dynamic effects of η_t^1 on Xt, that is to identify the first column of $\Gamma(L)$.

To introduce nominal shocks, the above three-variable real model is augmented by real balances, nominal interest rates, and inflation. The resulting six-variable model has three common stochastic trends, and this makes identification more complicated. The following restrictions are used to identify the model. First, as in the model with k=1, we assume that $\eta_t^1$and η_t^2 are uncorrelated. Second, the permanent shocks, η_t^1, are assumed to be mutually uncorrelated. Third, A is assumed to be lower triangular, which permits writing A= A$\prod$, where A is a matrix with no unknown parameters and $\prod$ is a K x K lower triangular matrix. A can be chosen in a way that associates each shock with a familiar economic mechanism: the first disturbance is interpreted as a balanced-growth shock, the second is a long-run neutral inflation shock and the third is a permanent real-interest-rate shock. This constrained reduced form is estimated as a VAR with error-correction terms (i.e., a vector error-correction model (VECM)

However, is important that the analysis of co integration be accompanied by some estimate of the speed with which the economy or the market under consideration return to their equilibrium state, once shocked. (Pesaran and shin, 1996) Such an analysis would be particularly valuable in cases where there are two or more co integrating relation characterizing equilibrium, possibly in different markets, Where we will be able to estimate the relative adjustment speeds of different markets to words their respective equilibrium Basically, there are four possible methods that can be used to Characterize and estimate the time profile of the effect of shocks on one more cointegrating relations. All these approaches are based on explicit relationship that we drive between the cointegrating relation and the current and lagged values of the shocks in the convergence to equilibrium.

The obvious method has been the impulse response approach (Sims1980) used to estimate the time profile of the effect of ‘ particular ‘ shocks on the co integrating relations. But such an analysis is subject to the major criticism that the estimate d impulse response function are not unique and depend on the way the shocks in underling VAR model are orthgonalised. An alternative approach is to consider the resultant time profile of the effect not a system –wide shock on the cointegrating relation .the resultant time profile will be unique and do not require the prior orthogonalization of the shocks.

Following Lee and Pesaran (1993), we measure the impact of system – wide shock on the cointegrating relation by their ‘persistence profile, defined as the scaled difference between the condition variances of the n–step and the (n-1) -step–ahead forecast, and viewed as a function of n, the forecast horizon. This measure readily capture the essential difference that exists between co integrated and noncointegrating relation, and provide unique time profile of the effect of shocks to the cointegrating relation, in the case of relation between I (1) variable that are not co integrated, the effect of a shock persists forever, while in the case of coin grated relation the impact of shock will be transitory and eventually disappear as the economy returns to its steady trend its long run equilibrium

Specifically, we assume the following augmented vector autoregressive Model:

$$Z_t = a_o + a_1 t + \quad \Phi Z_{t-i} + ØW_t + U_t \qquad t = 1,2,\dots,n \qquad (1.8)$$

$$= A^{/} g_t + U_t$$

Where Z_t is an m x 1 vector of jointly determined dependent variable and W_t is a qx1 vector of deterministic or exogenous variable. The statistical framework for the cointegrating VAR is the following general vector error correction mode (VECM)

$$Y_t = \mathbf{a}_{oy} + a_{1y}t - \prod_y Z_{t-1} + \quad \Gamma_{iy} \quad Z_{t-i} + Ø_y W_t + \varepsilon_t, \quad t = 1,2,\ldots, n \qquad (1.9)$$

where $Z_t = (Y_t, X'_t),'Y_t$ is an M_y x 1 vector of jointly determined (endogenous) I (1) variables.

$X_t = M_x$ x1 vector of exogenous I (1) variables.

$$X_t = a_{ox} + \quad \Gamma ix \quad Zt\text{-}i + Ø_x W_t + V_t \qquad (1.10)$$

Wt = q x 1 vector of exogenous/deterministic 1 (0) variables, excluding the intercepts and/ or trends.

However, the disturbance vectors ε_t and v_t satisfy the following assumptions:

$$Ut = \begin{pmatrix} \varepsilon_t \\ \\ v_t \end{pmatrix} \sim \text{iid } (0, \quad) \qquad (1.11)$$

Where is a symmetric positive definite matrix and the disturbances in the combined mode U_t are distributed independently of $W_{t:}$

$$E(U_t/W_t) = 0 \qquad (1.12)$$

The intercept and the trend coefficients a_{oy} and a_{1y} are M_y x 1vector: $\prod_y$ is the long–run multiplier matrices of order M_y x M, where M = $M_x + M_y$: Γ_{1y}, Γ_{2y}, …, Γp-1, y are My x M

Coefficient matrices capturing the short–run dynamic effect: and $Ø_y$ is the My x q matrix of coefficient on the I (0) exogenous variable

1ndeed, (1.9) allow for a sub-system approach in which the M_x vector of random variable, X_t is the forcing variable, or common stochastic trend in the sense that the error correction term do not enter in the sub-system for X_t. Thus our co integrating analysis allows for contemporaneous and short –term feedbacks from Y_t to X_t but require that no such feedback are possible in the 'long–run forcing variable of the system. The co integrating VAR analysis concerned with the estimation of (1.9) when the rank of the long-run multiplier matrix, ∏, could at most be equal to My. Therefore, rank deficiency of ∏ can be represented as

H_r : Rank (∏ y) =r < M_y

Which follows that $\prod_y = \alpha_y$ â' where α and are M_y x r and M x r matrices, each with full column rank, r .In the case where $\prod_y$ is rank deficient, we have Yt ~ I (1), Yt

~ I (0), and â'Zt ~ 1(0) .The r x 1 trend stationary relations, â'Zt, are referred to as the cointegrating relation, and characterize the long run equilibrium (steady state) of the VECM (1.9)

It is however, important to recognize that in the case where the vecm (1.9), contains deterministic trends (i.e. aiy = o), in general there will also be a linear trend in the cointegrating relations. Thus, combining the equation systems (1.9) and (1.10), we have

$$Z_t = a_o + a_{1t} - Z_t\text{-}1 + \prod Zt\text{-}_{1n} + \sum^{P-1} \Gamma i \quad Z_{t-i} + Ø\, W_t + U_t$$

(1.13) for t = 1,2, …,n, where

$$Zt = \begin{pmatrix} Yt \\ Xt \end{pmatrix} \quad Ut = \begin{pmatrix} Uyt \\ Vt \end{pmatrix} \quad ao = \begin{pmatrix} aoy \\ aox \end{pmatrix} \quad al = \begin{pmatrix} aly \\ 0 \end{pmatrix}$$

$$\prod = \begin{pmatrix} \prod y \\ 0 \end{pmatrix} \quad \Gamma i = \begin{pmatrix} \Gamma iy \\ \Gamma ix \end{pmatrix} \quad Ø = \begin{pmatrix} Øy \\ Øx \end{pmatrix}$$

which is the vector error correction form of (1.8). in the case where ∏ is rank deficient, the solution of (1.13) involves common stochastic trends, and is given by

$Z_t = Z_o + b_o t + b_1 \{t (t + 1)/2\} + C(1) S_t + C^* (L) (h_t - h_o)$ (1.14)

Where $ht = ØW_t + U_t$ (1.15)

$St = \quad Ui, t = 1,2,\ldots$ (1.16)

$b_o = C(1)a_o + C^* (1)a_1$ (1.17)

$b_1 = C(1)a_1$ (1.18)

$C(L) = C(1) + (1-L)C^*(L)$ (1.19)

$$C^*(L) = \sum_{i=o}^{\infty} Ci^*L^i$$

where L is the one period lag operator and the M x M matrices, Ci*, are obtained recursively from

$Ci^* = C^*_{i-1}\,\Phi_i + \ldots + C^*_{i-p}\,\Phi_p \quad i = 1,2,\ldots$ (1.20)

With $C^*o = Im – C(1) \quad Ci^* = 0, i < 0$, and

$\prod C(1) = 0 = C(1) \prod$ (1.21)

The matrices $\Phi_{1,} \Phi_2,\ldots, \Phi_p$ are the coefficient matrices in the VAR form of (1,13), and in term of $\prod$, Γ_2, …..and Γ_{p-1} are given by

$\Phi_1 = \Gamma_m - \prod + \Gamma$

$\Phi_i = \Gamma_i - \Gamma_i -1 \qquad I=2,3\ldots,p-1$

$\Phi p = - \Gamma\, p-1$

From solution (1.14) it is clear that, in general, Z_t will contain a quadratic trend. When $a_1 \neq 0$, the quadratic trend disappears only if $C(1)\, a_1=0$, otherwise the number of independent quadratic trend terms in the solution of Z_t will be equal to the rank of c (1). And hence depends on the number of cointegrating relations. Since rank {C (1)= m-r and without some restrictions on the trend coefficients, $a_{1,} \prod_r$ the solution (1.14) has the unsatisfactory property that the nature of the of the trend in Z_t varies with the assumed number of the cointegrating relations. This outcome can be avoided by restricting the trend coefficients namely, by setting $a_1 = II_{\mathbf{r}}$ and using (1.18) and (1.12), we have

$$b_1 = C(1)a_i = c(1) \prod_r = 0$$

and the VECM in (1.13) becomes

$$Z_t = a_o - \prod (Z_{t-1} - r_t) + \quad \Gamma_i \quad Z_{t-i} + ØW_t + U_t \quad (1.22)$$

Using (1.14), the cointegrating relations, $\hat{a}^{/}Z_t$, can also be derived in terms of the shocks Ut-i,i =0,1,2,…….., and the current and past values of 1(0) exogenous values.

Pre-multiplying (1.14) by $\hat{a}^{/}$ and bearing in mind the cointegrating restrictions $\hat{a}^{/}C$ (1)=0, we obtain

$$\hat{A}^{/} Z_t = \hat{a}^{/}Z_o + (\hat{a}^{/}b_o) + \hat{a}^{/}C^*(L)(h_t - h_o) \quad (1.23)$$

Using (1.17) we also have

$$\hat{a}' b_o = \hat{a}' C^*(1)a_1 \qquad (1.24)$$

And hence when $a_1 \neq 0$, the cointegrating relations, $\hat{a}' Z_t$ in general, contain deterministic trends; which do not disappear even if a_1 is restricted. Indeed, when a_1 =Iir, the coefficients of the deterministic trend in the cointegrating relations are given by

$$\hat{a}' bo = \hat{a}'C^* (1) \prod_r$$

But using this result in (1.23), we have

$$\hat{a}' Z_t = \hat{a}' Z_o + (\hat{a}' r)t + \hat{a}'C^* (L)(h_t - h_o) \qquad (1.25)$$

A test of whether the cointegrating relations are trended can be carried out by testing the following restrictions:

$$\hat{a}' r = 0 \qquad (1.26)$$

Referred to as co-trending restrictions.

The computation of the impulse response function for the cointegrating VAR model can be based on the VECM (1.13), which combines the equation systems for Y_t and X_t given by (1.9) and (1.10), respectively. The solution of the combined model is given by (1.14) and the orthogonalised impulse response function of the effect of a unit shock to the ith variable at time t in (1.13) on the jth variable at time t + N is given by

$$OI_{ijN} = e^{/}j\ (C(1) + C_N^*)\ Te_i \qquad (1.27)$$

Where T is a lower triangular matrix such that =$TT^{/}$, e_i is the selection vector and C(I) and C*N are defined by relations (1.19) to (1.21). This implies that the effects of shocks on individual variable in a cointegrating VAR model do not die out and persist forever.

An alternative approach would be to consider the effect of system-wide shocks or variable-specific shocks on the cointegrating relations, $\hat{a}'Z_t$ rather on the individual variables in the model. The effect of shocks on cointegrating relations is bound to die out, and their time profile contains useful information on the speed of convergence of the model to its cointegrating (or equilibrium) relations. Consider first the time profile of the effect of a unit shock to the variable in Zt on the jth contegrating relation, namely $\hat{a}'_j Z_t$ Using (1.23), we have

$$OI_i(\hat{a}'_j Z_t, N) = \hat{a}'_j A_N Te_i \qquad (1.27)$$

For i = 1, 2, …, m, j = 1,2,…, r, N = 0,1,2, … which give the responses of a unit change in the ith orthogonalized shock (=$\sqrt{\sigma_{ii}}$) on the jth cointegrating relation $\hat{a}'_j Z_t$. The corresponding generalized impulse responses are given by

$$GI_i(\hat{a}'_j Z_t N) = \frac{\hat{a}'_j A_N e_i}{\sqrt{\sigma_{ii}}} \qquad (1.28)$$

For i = 1,2,….,m,j = 1,2,…,r, and N = 0,1,2,…

But given the ambiguities that surround the impulse response analysis with respect to variable specific shocks, we consider the effect of system-wide shocks on cointegrating relations. Such a time profile, referred to as the persistence profile of the effect of system-wide shocks on the jth cointegrating relationship is given by

$$h\ ((\hat{a}'_j Z_t N) = \quad \hat{a}'_j Z_t N \underline{\ \ A'NBi} \qquad (1.29)$$

For j = 1,2,….,r, and N = 0,12,….

The value of this profile is equal to unity on impact, but should tend to zero as $N \rightarrow \infty$, if $\hat{a}'_j$ is indeed a cointegrating vector. The persistence profile, h ($\hat{a}'_j Z_t N$) viewed as a function of N provides important information on the speed with which the effect of system wide shocks on the cointegrating relation, $\hat{a}'_j Z_t$, disappears even though these shocks generally have lasting impacts on the individual variables in Z_t.

The variables to be used are defined as follows:

C = Logarithm of per capita real consumption expenditures

I = Logarithm of per capita gross private domestic fixed investment

Y = Logarithm of per capita "private" gross national product defined as total gross national product less real total government purchases of goods and services.

M = Logarithm of per capita M2 (currency, demand deposits, and saving deposits)

P = Logarithms of the price level measured by the implicit price deflator for our measure of private GNP.

R = The interest rate measured as a treasury bills rate.

4.0 DATA SOURCES AND COLLECTION

The major sources of data for the study will be the published and unpublished data from the various countries ministries, and agencies. Other supplementary sources of data will include the statistical publications of the World Bank, United Nations and the International Monetary Fund. Efforts will be made to collect quarterly data on the variables for the study. We shall also search the various intranets extranets and Internet websites *(http, www, gopher, telnet, etc)* accordingly.

5.0 RESEARCH RESULTS AND DISSEMINATION

Our research result is expected to contribute to public policy making for the various countries studied. This is in addition to contributing to existing knowledge and future research in economics. Our research output will be published accordingly and disseminated to the various professional economists and policy makers in the region. We also intend to present and discuss our research findings before the various academic economists (especially, during the African Economic Research Consortium Network meetings).

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