Is the Proposed East African Monetary Union an Optimal Currency Area? A Structural Vector Autoregression Analysis

Steven K. Buigut and Neven T. Valev*

1. Introduction

The treaty of 1999 to revive the defunct East African Community (EAC) ratified by Kenya, Uganda, and Tanzania[1] came into force on July 2000 with the objective of fostering a closer co-operation in political, economic, social, and cultural fields. To achieve this, an East Africa Customs Union protocol was signed in March 2004. A Common Market, a Monetary Union, and ultimately a Political Federation of East Africa states is planned. Though the question of a monetary union has been discussed in the political arena there has been no corresponding empirical study on the economic viability of such a union. This article fills the gap and assesses whether the political force driving the EAC towards a monetary union has economic basis. In particular, we focus on the symmetry of the underlying shocks across the East African economies as a precondition for forming an optimum currency area (OCA). As Mundell (1961) and McKinnon (1963) describe, the member countries of a monetary union do not have independent monetary policy, which differs from that of the union as a whole; governments cannot use

* Buigut (corresponding author): Georgia State University, P.O. Box 3992, Atlanta, GA, 30302-3992; Telephone: 770-912-0475; Fax: 404-651-4985; E-mail; sbuigut2@gsu.edu.
Valev: Georgia State University, P.O Box 3992, Atlanta, GA, 30302-3992; Telephone: 404-651-0418; Fax: 404-651-4985; E-mail: nvalev@gsu.edu.

monetary and exchange rate policies to react to a country-specific shock. How serious this limitation is for the union countries depends on the degree of asymmetry of shocks and the speed with which the economies adjust to these shocks. If disturbances are distributed symmetrically across union countries, a common response will suffice. If, however, the countries face mostly asymmetric shocks, the retention of policy autonomy is beneficial.

The methodology used here follows Bayoumi and Eichengreen (1992) who are among the first to identify the underlying structural shocks using the Vector Autoregression (VAR) technique developed by Blanchard and Quah (1989). They measure the incidence of asymmetric demand and supply shocks across members of the former European Community (EC) and compare them with the ones prevailing in the United States. The results indicate that the EU could be divided into a core group of countries with smaller, more correlated shocks than the periphery countries. Since then, a large literature including Bayoumi and Taylor (1995), Ramaswamy and Slok (1998), and Kouparitsas (1999), has applied this methodology or a related approach to different compositions of country groups in Europe. More recently a number of studies have used the same approach to investigate the situation in Central and Eastern European Countries (CEECs) and East Asia. Fidrmuc and Korhonen (2001) and Frenkel and Nickel (2002) use VAR to assess the similarity of shocks between the countries of the Euro area and the CEECs. Studies that have applied the approach to East Asia (e.g. Yuen and Ling (2001) and Zhang et al (2004)), identify tentative groupings of East Asian economies with potential for monetary union.

Although there are a number of economic blocks considering monetary union like the two CFA regions: the West African Economic and Monetary Union (UEMOA)[2] and the region of the Central Bank of Equatorial Africa (BEAC)[3], the Southern African Development Community (SADC)[4], and the EAC, application of this methodology in Africa has been limited. Fielding and Shields (2001) modify the Blanchard and Quah methodology in order to estimate a structural VAR for a small open economy. They identify and compare economic shocks to different members of the two CFA monetary unions. They obtain mixed results. If the policy response to inflation shocks is immediate and inflation is all that matters then one currency would suffice. However, the pattern of output shocks suggests a need to redraw the internal boundaries of the Franc zone. A study by Khamfula and Huizinga (2004) investigates the desirability of a monetary union among the countries of the SADC to gauge which countries are suited to enter a South Africa Monetary Union (SAMU). They employ Generalized Auto-Regressive Conditional Heteroscedasticity model to assess the share of the variation in real exchange rates vis-à-vis South Africa that can be explained by the divergence in monetary and fiscal policies. Their analysis is based on seasonally adjusted monthly real exchange rates for the period 1980-1996. The results from this model indicate low degrees of symmetry of the real exchange rate shocks across most of these countries. The paper concludes that a monetary union among these countries would amass high costs relative to benefits.

There is however a glaring paucity of empirical work for the East Africa Community. A lone study, Mkenda (2001) employs a Generalized Purchasing Power Parity (GPPP) model developed by Enders and Hurn (1994) to analyze the suitability of the EAC for a monetary union. This approach uses cointegration methods to find if the prospective countries' macroeconomic variables exhibit long-run relationships. Economies suitable for a monetary union experience symmetric shocks to their macroeconomic variables and thus on average 'move' together. GPPP postulates then that the real exchange rates between countries comprising an optimal currency area should be cointegrated. The results from Mkenda's study indicate that the real exchange rates between the EAC countries are cointegrated between the periods 1980-1998, suggesting that the EAC is an optimum currency area. The limitation of this approach is that movements in macroeconomic variables reflect the combined effects of shocks and responses (Angeloni and Dedola, 1999). Hence this methodology does not distinguish disturbances from responses. The identification scheme due to Blanchard and Quah (1989) is one way to achieve this distinction. This study is the first to assess the similarity of underlying shocks in the EAC based on the VAR approach. The rest of the paper is structured as follows: Section 2 introduces the methodology, Section 3 presents the results, and Section 4 concludes.

2. Methodology

The aim is to identify and compare macroeconomic shocks to different East African countries. We focus on shocks to aggregate output growth and inflation. To recover the underlying shocks we use the VAR identification scheme due to Blanchard and Quah (1989) and Bayoumi and Eichengreen (1992). The identification scheme is based on the Aggregate Demand-Aggregate Supply (AD-AS) framework. In this framework, the short-run aggregate supply curve is upward slopping due to sticky wages. A higher price level lowers the real wage, inducing higher employment and raising output. However, in the long-run real wages adjust to price changes so that the long-run aggregate supply curve is vertical at the full employment level of output. The aggregate demand curve is downward sloping both in the short and the long-run to reflect the assumption that lower prices boost demand. Supply shocks such as those originating from changes in technology have long-run permanent effects on the full employment level of output. They reduce prices and increase output. On the other hand, the effect of a permanent shock to the aggregate demand is a short-term rise in output that gradually returns to its initial level as the real wage adjusts. The long-term effect is only a permanent increase in prices. Thus both supply and demand shocks have long-run effects on the level of prices though in opposite directions. A positive demand shock increases prices whereas a positive supply shock lowers them.

Identification of supply and demand shocks

We assume that fluctuations in real output $\{y_t\}$ and the price level $\{p_t\}$ are the result of two underlying types of shocks: supply and demand shocks. Supply shocks have a permanent effect on output, whereas demand shocks have a transitory effect on output. On the other hand, both supply and demand shocks have permanent effects on the price level. A positive supply shock depresses the price level, whereas a positive demand shock increases it.

Assume that the variables are unit root, so that the vector $X_t \equiv \begin{bmatrix} \Delta y_t \\ \Delta p_t \end{bmatrix}$ is stationary.

The joint process of two variables (changes in GDP and the price level) can be represented by an infinite moving average representation of a vector of the two variables and an equal number of structural shocks. Let ε_t be the vector of demand and supply shocks, (ε_{dt}, ε_{st}). Formally, the bivariate moving average of X_t can be represented as:

$$X_t \equiv \begin{bmatrix} \Delta y_t \\ \Delta p_t \end{bmatrix} = \sum_{i=0}^{\infty} L^i \begin{bmatrix} a_{11i} & a_{12i} \\ a_{21i} & a_{22i} \end{bmatrix} \begin{bmatrix} \varepsilon_{dt} \\ \varepsilon_{st} \end{bmatrix} = \sum_{i=0}^{\infty} L^i A_i \varepsilon_{t-i} \tag{1}$$

where Δy_t and Δp_t represent changes in the log of output and prices and L is the lag operator. A_i represents the impulse response function of the shocks to the elements of the vector X_t, and ε_{dt}, ε_{st} are independent white noise supply and demand shocks normalized so that Var(ε_t)=I. To decompose the shocks, the AD-AS framework assumes that demand shocks do not have any effect on output in the long-run. Thus, the cumulative effect of demand shocks on the change of the log of output (Δy_t) must be zero:

$$\sum_{i=0}^{\infty} a_{11i} = 0 \tag{2}$$

The supply side and demand side shocks can be recovered from estimating a finite order VAR. The optimal lag length (p) is chosen such that its residuals approximate white noise. Each element of vector X_t is regressed on lagged values of all the elements of X_t:

$$X_t = K + \Phi_1 X_{t-1} + \Phi_2 X_{t-2} + ... + \Phi_p X_{t-p} + e_t , \tag{3}$$

where K denotes a vector of constants, Φ_is are the coefficients from the estimating equation and e_t is a vector of the residuals $\begin{bmatrix} e_{yt} \\ e_{pt} \end{bmatrix}$. The vector e_t is a composite of demand and supply shocks. If the process is covariance stationary we can take expectations of (3) to calculate the mean μ of the process:

$$\mu = K + \Phi_1 \mu + \Phi_2 \mu + ... + \Phi_p \mu \tag{4}$$

Subtracting (4) from (3) gives (3) in terms of deviations from the mean:

$$X_t - \mu = \Phi_1 (X_{t-1} - \mu) + \Phi_2 (X_{t-2} - \mu) + ... + \Phi_p (X_{t-p} - \mu) + e_t \tag{5}$$

The VAR(p) in (5) can be represented as a VAR(1) process. To do this, define:

$$\xi_t \equiv \begin{bmatrix} X_t - \mu \\ X_{t-1} - \mu \\ . \\ . \\ X_{t-p+1} - \mu \end{bmatrix}, F \equiv \begin{bmatrix} \Phi_1 \, \Phi_2 ......\Phi_p \\ I_2 \quad 0 .... \\ . \\ . \\ 0..... \quad I_2 \;\; 0 \end{bmatrix}, V_t \equiv \begin{bmatrix} e_t \\ 0 \\ . \\ . \\ 0 \end{bmatrix}$$

Then (5) can be written as VAR(1):

$$\xi_t = F\xi_{t-1} + V_t \tag{6}$$

and recursive substitution of (6) implies that:

$$\xi_{t+s} = V_{t+s} + FV_{t+s-1} + F^2V_{t+s-2} + ... + F^{s-1}V_{t+1} + F^s\xi_t \tag{7}$$

If the eigenvalues of F all lie inside the unit root circle, then $F^s \to 0$ as $s \to \infty$ and the VAR is covariance stationary (Hamilton, 1994). The first two rows of (7) then give the vector moving average (∞) representation of X_t :

$$X_t = \mu + e_t + C_1e_{t-1} + C_2e_{t-2} + C_3e_{t-3} + C_3e_{t-3} + C_4e_{t-4}. \tag{8}$$

where $C_j = F_{11}^{(j)}$ and $F_{11}^{(j)}$ denotes the upper left block of F^j which is the matrix F raised to the j^{th} power. Equations (1) and (8) yield the relationship between the estimated residuals (e_t) and the structural shocks (ε_t):

$$e_t = A_0\varepsilon_t \tag{9}$$

Therefore we need to know the elements of A_0 to calculate the underlying structural supply and demand shocks. The variance-covariance matrix of residuals $E(e_te_t') = A_0E(\varepsilon_t\varepsilon_t')A_0'$ and the C_is are known from estimation. To recover the four elements of A_0 in the two-by-two case we need four restrictions[5]. Two are simple normalizations which define the variances of ε_{dt}, and ε_{st} (usually to one). Since ε_{dt}, and ε_{st} are deemed to be pure shocks, a third restriction applied is to assume that demand and supply shocks are orthogonal so that $E(\varepsilon_{dt}\ \varepsilon_{st}) = 0$ (Bayoumi and Eichengreen, 1992). $E(\varepsilon_t\varepsilon_t')$ then drops out as I_2, and we have $E(e_te_t') = \Omega = A_0A_0'$. The variance-covariance matrix of residuals Ω is a known symmetric matrix. From this we obtain the following three restrictions:

$$\begin{aligned} \mathrm{Var}(e_{yt}) &= a_{11}(0)^2 + a_{12}(0)^2 \\ \mathrm{Var}(e_{pt}) &= a_{21}(0)^2 + a_{22}(0)^2 \\ \mathrm{cov}(e_{yt}e_{pt}) &= E(e_{yt}e_{pt}) = a_{11}(0)a_{21}(0) + a_{12}(0)a_{22}(0) \end{aligned} \tag{10}$$

The final restriction is to impose the condition that demand shocks have no long term effects on output as in (2). In terms of the VAR this implies:

$$\sum_{i=0}^{\infty}\begin{bmatrix} c_{11i} & c_{12i} \\ c_{21i} & c_{22i} \end{bmatrix}\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} = \begin{bmatrix} 0 & * \\ * & * \end{bmatrix} \tag{11}$$

These restrictions allow the matrix A_0 to be uniquely defined and hence the demand and supply shocks to be identified. Two series of exogenous shocks are obtained and the correlations of these shocks computed for the East African countries.

3. Results

- **Data**

The main data source used in this study is the IMF's *International Financial Statistics*. This is supplemented by comparable figures from the World Bank's *World Development Indicators* and the African Development Bank *Country Statistics*. Annual data for the five Eastern Africa countries cover the sample period from 1970 to 2001. Real GDP growth is used to measure changes in output, while changes in the implicit GDP deflator represent price changes, both rebased to 100 in 1995 for all countries. For each country we use the first difference of the natural logs of real GDP and the implicit GDP deflator for estimation. Although they are available, it is worth noting that the quality of reported data by these countries, particularly Uganda, Rwanda, and Burundi may have been affected by civil unrest in these countries - Uganda throughout most of the early 1980s and Rwanda and Burundi in the early 1990s.

Identifying supply and demand shocks

The time series properties of the variables were investigated using the Augmented Dickey-Fuller test and it was found that both variables are I(1). Therefore the first differences of the variables are used to ensure stationarity. Tests for stability show that the eigenvalues of (F) in (6) all lie inside the unit root circle (see Appendix). The VAR is thus covariance stationary. For estimation of the empirical two-variable VAR the number of lags is set to two in all cases since both the SBIC and AIC statistics indicate that all models have an optimal lag length of one or two. From the estimated VAR the underlying supply and demand shocks were recovered as described in section 2.

The sizes of the underlying demand and supply shocks constrained to be of unit variance are provided in Table 1. The shocks vary from country to country in magnitude and frequency, with the supply shocks showing more dispersion. Tanzania has experienced the widest swings in demand shocks but the smallest swings in supply shocks. Rwanda has the widest range in supply shocks. It has experienced the most severe negative supply shock too. Conversely, Burundi seems to experience milder shocks.

The larger the size of the shocks the more difficult it is to maintain a fixed exchange rate. This is particularly true of the supply shocks that may require more painful adjustments. These shocks are graphed in Fig 1(a) and (b). The graphs indicate that the shocks are relatively equally distributed between negative and positive shocks. The demand shocks however were larger during the mid-eighties for all countries with the exception of Burundi. Demand shocks though seem to have declined after the later part of 1980s for all countries.

Generally the supply shocks experienced by the countries show more pronounced and more frequent peaks and troughs than the demand disturbances, and there are no indications of a tendency of these shocks to converge. The early nineties were especially turbulent years for Rwanda, and to a lesser extend Burundi, due to civil war in those countries. Large negative shocks are evident during this period. Uganda experienced similar large negative shocks during the early eighties for the same reason. Kenya experienced large positive shocks in the mid-seventies due to a boom in coffee prices – a primary export commodity for that country.

Correlations of supply and demand shocks across EA countries

Tables 2 and 3 report the correlation coefficients of the identified supply and demand shocks among the East African countries with positive and significant correlations highlighted. If the correlations are positive they are considered symmetric and if negative they are considered asymmetric. The more symmetric the shocks, the more feasible it becomes for a group of countries to establish a monetary union. We look first at the supply shocks as these are more critical since they are more likely to be invariant to demand management policies (Bayoumi and Eichengreen, 1994). Supply shocks have permanent output effects, whereas demand shocks only have transitory effects. Considering the contemporaneous supply shocks in Table 2, only the supply shocks for Kenya and Burundi are positive and significantly correlated. Tanzania and Rwanda experience shocks that are positively correlated but the correlation coefficients are not statistically significant. Tanzania and Uganda's contemporaneous supply shocks are negatively correlated (asymmetric) with those experienced by other countries, although the lagged values show a different picture. The supply shocks experienced by Kenya are positively and significantly correlated with those of Tanzania lagged one period, suggesting that supply shocks in Tanzania are transmitted to Kenya. Supply shocks are also correlated with a lag between Burundi and Rwanda, and Burundi and Tanzania. Tanzania also has shocks that are positively correlated with those faced by Uganda lagged two years.

The demand shocks shown in Table 3 are even less symmetric than the supply shocks. The contemporaneous demand shocks experienced by Rwanda are positively and significantly correlated with the demand shocks in Burundi, and also with the shocks faced by Uganda and Tanzania. There is also a significant positive correlation between demand shocks faced by Tanzania and Kenya lagged two periods. The other correlations are either insignificant or asymmetric.

The correlations seem to follow trade patterns observed among the EA countries. Rwanda and Burundi are two very tiny neighboring economies with historical links. Their demand and supply shocks show significant correlation. Trade links among the East African countries have traditionally been greater between Kenya and the other countries, with a surplus in favor of Kenya. Kenya has a relatively more developed manufacturing sector and exports processed products to the other EA countries, with Tanzania and Uganda being the major destination. There is some trade between Uganda and Tanzania. Kenya and Tanzania are also the transit routes for the goods of the other three landlocked countries. This may explain the lagged linkage in the shocks. A positive supply shock in Tanzania is transmitted to Kenya, while a positive supply shock in Uganda is transmitted to Tanzania. What is surprising is the lack of correlation between shocks experienced in Kenya and Uganda - Kenya's leading trade partner. Analyses of shocks during the sub-periods 1974-1987 and 1988-2001 do not show any indication of increased symmetry in the correlation coefficients between the two periods. Overall, most of the correlation values are either low or asymmetric and do not show much support for a monetary union in contrast to the findings of Mkenda (2001). The correlations for EA countries seem much more asymmetric compared to the correlations for CFA zone obtained by Fielding and Shields (2001) and more comparable to those found for the SADC by Khamfula and Huizinga (2004). But as Frankel and Rose (1998) show, greater trade flows between countries leads to more highly correlated business cycles. Thus countries that may appear to be poor candidates for inclusion in a monetary union may turn out to be suitable candidates after joining the union. Hence more integration in the EA countries may lead to more symmetry of supply and demand shocks.

Impulse response

In addition to isolating the underlying disturbances, it is beneficial to compare the response of the economies to the shocks in terms of the magnitude and speed of adjustment. This can be done by looking at the impulse response functions. The larger the size of the shock, the more disruptive its effects will be on the economy. Similarly, the slower is the adjustment after disturbances, the larger will be the cost of maintaining a single currency.

Figures 2(a)-(c) show the impulse response functions of output and the price level to a positive one unit demand and supply shock. The impulse response functions for prices in Figure 2(a) indicate that the over-identifying restriction is satisfied for all countries – except Tanzania. The accumulated effect of supply shocks on prices is negative for all countries except for Tanzania which exhibits a small but positive effect. While both supply shocks and demand shocks have long-run effects on the price level, demand shocks produce a gradual increase in prices over time, whereas supply shocks produce a steady decline in prices as predicted by the AD-AS model. As shown in Figure 2b an expansionary supply shock induces positive long-run output effects for all the countries. The response functions for the EA countries seem not to differ much, with the exception, already mentioned, for the response of prices to supply shocks in Tanzania. The functions seem to follow more or less similar patterns. The bulk of the adjustment of output to a supply shock occurs within the first three to four years for these countries, with Uganda taking slightly more time. This is the same time of adjustment for the European Community countries found by Bayoumi and Eichengreen (1992). The long-run effect is around 0.03 to 0.08. The adjustment of prices to supply shocks is also within the first three years and of a similar absolute magnitude (less than 0.1) for the four countries. However the effect in Uganda is much larger, exceeding 0.6. These long-run effects are however more similar for the EA countries relative to those found for the CFA zone.

The same is true of adjustments of prices to demand shocks. Overall, Figure 2c suggests that the speeds of adjustment, as well as the long-run effect, are similar across countries with the exception of Uganda. From these results it would seem that the four countries (except Uganda) have similar magnitude and speed of adjustment to the shocks, tentatively pointing to a possibility of sustaining a monetary union.

Variance Decomposition

The forecast error variance shows the contribution of each shock to the movements in the two variables of the vector $X_t \equiv \begin{bmatrix} \Delta y_t \\ \Delta p_t \end{bmatrix}$. This gives an indication of which shocks are the more predominant accounting for the variability in vector X_t. This is important because differences in the cause of variability in the countries could be indicative of underlying differences in transmission mechanism and policy strategies of the EA countries which would be obstacles to regional monetary integration. Table 4 shows the proportion of variability of the log of real output due to demand shocks at one to six year time horizon. The proportion due to supply shock is found by subtracting from unity. The supply shocks account for most of the variability of real output in all the East African countries. The supply shocks account for over 80% of all the variability at the six year horizon. This corresponds to results obtained for East Asia (Zhang et al, 2004) for the sample period prior to the crises, and more uniform than those indicated for the European Union by Ballabriga et. al. (1999). In contrast, variance decomposition of the price level indicates that demand shocks account for different proportions of the price level variability across the economies. Demand shocks contribute a much higher proportion of the variation in the price level relative to its contribution to the variability of real output. However the proportions differ markedly among the EA countries, ranging from over ninety percent in Tanzania to around forty in Kenya. Thus, although there are indications that structural supply shocks contribute to output changes in the East African countries in the same way, the contribution to changes in the price level is quite variable.

4. Conclusion.

This paper uses a two variable VAR model to identify supply and demand shocks for East African countries. The purpose is to determine whether these countries are good candidates for a monetary union. The correlation results indicate that contemporaneous shocks among the EA countries are mostly asymmetric. Only the contemporaneous supply shocks for Kenya and Burundi are positive and significantly correlated. However correlations based on the lagged supply shocks show some symmetry related to trade patterns. The correlation results therefore do not show strong support for a currency union at the moment but do indicate the importance of more integration.

The impulse response functions for the EA countries follow a similar pattern, with the exception of Uganda. The bulk of the adjustment of output to a supply shock occurs within the first three to four years and the long-run magnitudes are close. The adjustment of prices to supply shocks is also within the first three years. The magnitude of the response is however much larger in Uganda and the adjustment takes relatively longer. This result shows some support for monetary union among the EA countries. However, variance decomposition show mixed results. The proportions of variability of real output accounted for by supply shocks are similar for all the EA countries. Demand shocks however contribute markedly different proportions of the variation in price level.

So although the contemporaneous shocks are not highly correlated the lagged correlations show that more integration may improve the symmetry of shocks. The speed of adjustment and the effect on variability of real output also seem to be similar, giving some hope to a successful monetary union. These results therefore do not display strong support for forming a currency union in the EA region at the moment, but suggest that more integration of the economies is likely to reduce the asymmetry of shock. It is worth noting that the process of integration is going on, significant being the signing of the customs union treaty earlier this year, and the political will, a factor that has been stressed in Feldstein (1997) as the major motivation for the European monetary union, seems to be present to carry this through.

Finally, symmetry of shocks though important is only one aspect of monetary union. A more comprehensive estimate of the welfare effects of the proposed monetary union could be captured using a multi-country theoretical frame work that reflects some of the region's key economic and political features. This is one area for future research.

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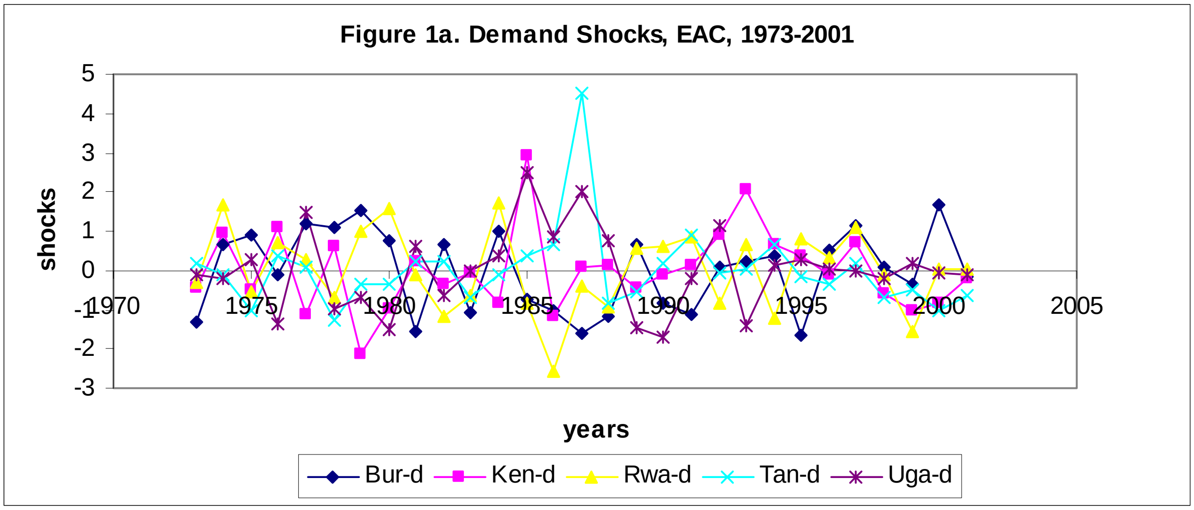
Figure 1a. Demand Shocks, EAC, 1973-2001
shocks
years
5
4
3
2
1
0
-1
-2
-3
1970
1975
1980
1985
1990
1995
2000
2005
Bur-d
Ken-d
Rwa-d
Tan-d
Uga-d

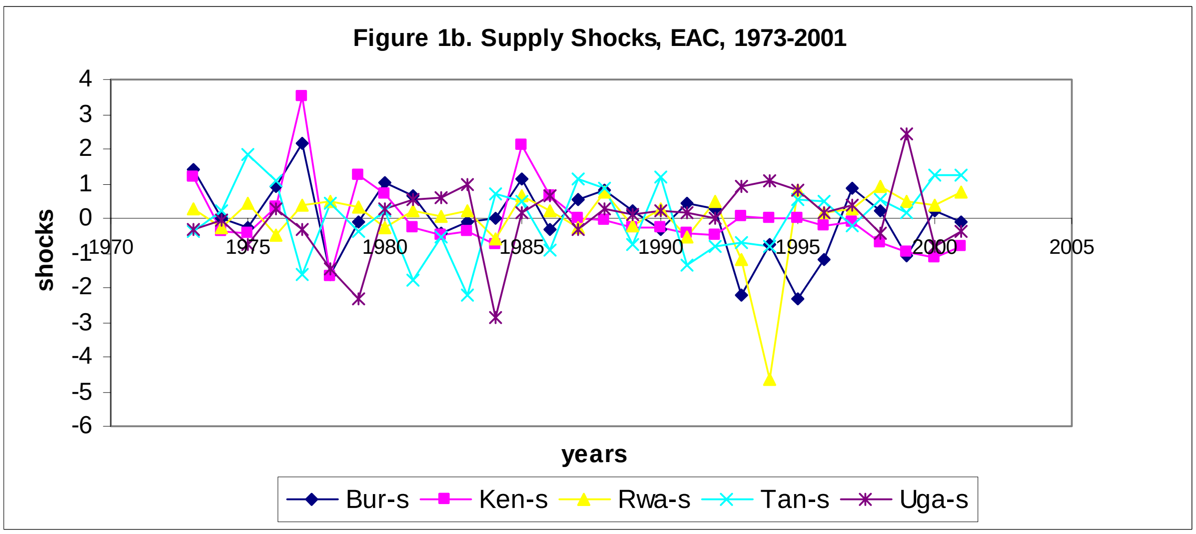
Figure 1b. Supply Shocks, EAC, 1973-2001
shocks
years
4
3
2
1
0
-1
-2
-3
-4
-5
-6
1970
1975
1980
1985
1990
1995
2000
2005
Bur-s
Ken-s
Rwa-s
Tan-s
Uga-s

Figure 2a: Impulse response functions for the price level to a positive supply shock

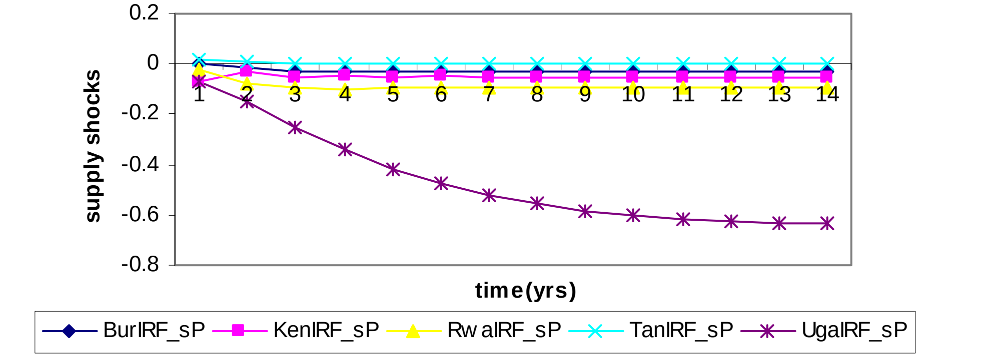

Figure 2b: Impulse response functions of the output level to a positive supply shock

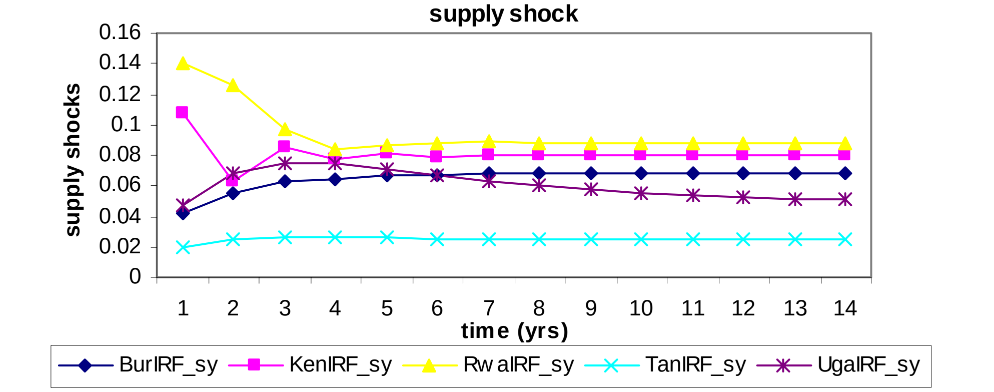

Figure 2c: Impulse response functions of the price level to a positive demand shock

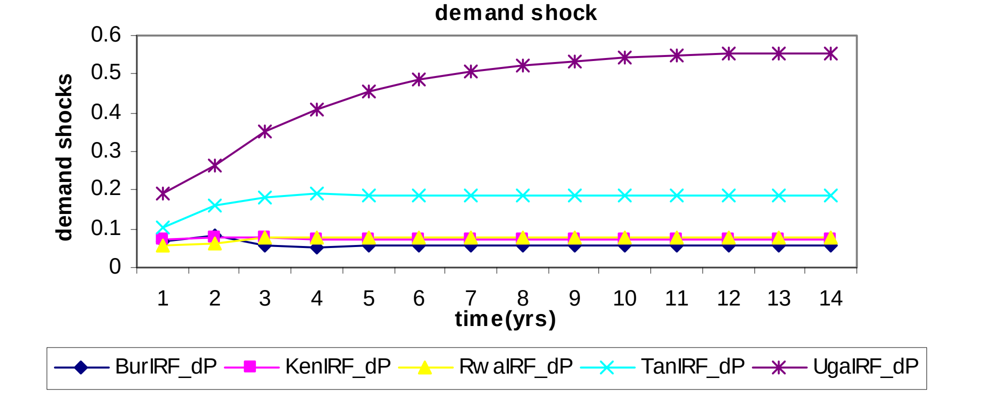

Table1: Descriptive statistics of the shocks; 1973-2001

Country	Demand shocks			Supply shocks		
	Range	Minimum	Maximum	Range	Minimum	Maximum
Burundi	3.3426	-1.6604	1.6822	4.5295	-2.3424	2.1871
Kenya	5.0507	-2.1172	2.9335	5.1810	-1.673	3.5080
Rwanda	4.2894	-2.5657	1.7237	5.6075	-4.6637	0.9438
Tanzania	5.7840	-1.2703	4.5137	4.0294	-2.1997	1.8297
Uganda	4.2164	-1.7122	2.5042	5.3202	-2.8772	2.4430