Macroeconomic Shock Transmission in the East African Community: A GVAR Approach

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Abstract: We develop a global vector autoregressive model GVAR to analyze macroeconomic shock transmission among the East African Community countries. The results suggest that there is a significant growth and inflation shock transmissions from Kenya to the rest of the member countries while the transmission in the opposite direction is insignificant. The macroeconomic shocks are reflected more on prices than output. In terms of the magnitudes, a percentage point increase in Kenya’s inflation rate could lead to 0.05 (Rwanda) to 0.35 (Uganda & Tanzania) percentage point increase in inflation rate. The results indicate the significant role of Kenya in terms of managing macroeconomic stability in the bloc.

JEL Classification: C32, C51, F42, F44

1. Introduction

The East African Community (EAC) is one of the vibrant regional economic blocs in Africa. The treaty for establishment of the current East African Community was signed on 30 November 1999 and entered into force on 7 July 2000 following its ratification by the original three partner states – Kenya, Tanzania and Uganda. Burundi and Rwanda joined the EAC in 2007. The objectives of the EAC are to deepen cooperation among member states in political, economic, and social fields—including establishment of a customs union (2005), common market (July 2010), monetary union and ultimately political federation of East African States (Davoodi, 2012).
Successful economic integration and transition towards monetary union depends on synchronization of business cycle and degree of shock transmission across member countries. The growing intra-EAC trade is the main driving forces to facilitate common business cycles or the transmission of shocks in the bloc. However, to our knowledge, there is no empirical work that tried to examine the degree of shock transmission across the EAC countries. The existing literature mainly focus on understanding the extent to which monetary transmission mechanisms differ across EAC countries (Davoodi et al., 2013; Cheng, 2006; Maturu, Maana, and Kisinguh, 2010); how the EAC economies respond for demand and supply shocks (Mafusire and Brixiova, 2012; Buigut, 2009). This paper tries to fill the gap.

We develop a regional variant of a global vector autoregressive (GVAR) model for the EAC bloc, containing Kenya, Rwanda, Uganda, and Tanzania, to examine the strength of output and inflation shock transmission across the bloc. To our knowledge, this is the first attempt to analyze shock transmissions across the EAC countries in a GVAR framework. The GVAR modeling approach, advanced by Pesaran et al (2004) and Dees et al (2007), has become an important empirical tool to understand macroeconomic spillovers. The GVAR model is a multivariate and multi-country framework used to investigate cross-country interdependency. It is also capable of generating forecasts for a set of macroeconomic factors for a set of countries to which they have exposure risks.

The impulse response results from the GVAR model indicate that there is strong growth and price shock transmission from Kenya to the rest of the EAC member countries. While adverse output and price shocks in Kenya could be transmitted to the rest of the member countries, the transmission from the rest of the member countries to the bloc is quite weak. This indicates the asymmetric nature of shocks in the EAC and the dominance of Kenya. The rest of the paper is organized as follows. Section 2 presents the GVAR modeling framework and data related issues. Section 3 discusses the major results and the final section provides a brief conclusion.
2. The Model

We built a global vector autoregressive model (VAR) to assess the importance of global spillover effects on African economies, following Pesaran et al (2004) and Dees et al (2007). The GVAR model combines individual country vector error correction models into a global framework and allows for cross country interdependency. Each country model is linked with the rest through country specific foreign variables and as such a shock in one country could be propagated to the rest of the world.

The foreign variables are constructed using bilateral trade weights between countries to capture the relative importance of each country’s trade partner. This is similar to the route followed by Pesaran et al (2004) and Dees et al (2007). The foreign variables could also be constructed using financial linkage weights as in Galesi and Sgherri (2009). However, the trade weights are more relevant in the context of Africa where trade linkages are much more important.

Our GVAR model is composed of 46 African countries and 30 developed and emerging market countries, covering 90 percent of world GDP. As a result, the model contains 76 country specific VAR models conditioned by weakly exogenous country specific foreign variables and global factors, i.e., \( VARX^* \) models. In each country \( VARX^* \) model, country specific domestic variables are related to deterministic variables, such as time trend, country specific foreign variables, and global variables.

Following Pesaran et al (2004), assume that there are \( N + 1 \) countries in in the global economy, indexed by \( i = 0, 1, 2, \ldots, N \), where 0 serves a reference country. Each country \( i \) is modeled as a \( VARX^* \) model written as:

\[
\mathbf{x}_{it} = \delta_{i0} + \delta_{i1} t + \Phi_{i} \mathbf{x}_{it-1} + \Lambda_{i0} \mathbf{x}_{it-1}^* + \Lambda_{i1} \mathbf{x}_{it-1}^* + \Gamma_{i0} \mathbf{d}_t + \Gamma_{i1} \mathbf{d}_{t-1} + \mathbf{\varepsilon}_{it} \tag{1}
\]

where \( t = 1, 2, \ldots, T \), \( \mathbf{x}_{it} \) is a \( (k_i \times 1) \) vector of country specific domestic variables for country \( i \), \( \mathbf{x}_{it}^* \) is a \( (k_i^* \times 1) \) vector of foreign variables specific to country \( i \), \( \delta_{i0} \) is a \( (k_i \times 1) \) vector of fixed intercept coefficients, \( \delta_{i1} \) is a \( (k_i \times 1) \) vector of coefficients of the deterministic time trend, \( \Phi_{i} \) is a \( (k_i \times k_i) \) matrix of coefficients associated to lagged
domestic variables, while $\Lambda_{d0}$ and $\Lambda_{d1}$ are $(k_i \times k_i^*)$ matrices of coefficients related to contemporaneous and lagged foreign variables respectively, $d_i$ is a set of common global variables assumed to be weakly exogenous to the global economy, such as oil and commodity prices, and $\Gamma_{i0}$ and $\Gamma_{i1}$ are the matrices of fixed coefficients. The error term, $\varepsilon_{it}$, is a $(k_i \times 1)$ vector of idiosyncratic, serially uncorrelated, country-specific shocks with mean 0 and a nonsingular covariance matrix $\Sigma_{ii} = (\sigma_{ii,ls})$, where $\sigma_{ii,ls} = \text{cov}(\varepsilon_{ilt}, \varepsilon_{ist})$, which is the covariance of the $l^{th}$ variable with the $s^{th}$ variable in country $i$ model. That is, $\varepsilon_{it} \sim i.i.d.(0, \Sigma_{ii})$. We allow the idiosyncratic shocks to be correlated in a limited way as in Pesaran et al (2004). The cross-country covariance, $\Sigma_{ij}$, for $i \neq j$ is thus given by

$$E(\varepsilon_{it} \varepsilon'_{jt'}) = \text{cov}(\varepsilon_{it}, \varepsilon_{jt}) = \begin{cases} \Sigma_{ij} & \text{for } t = t' \\ 0 & \text{for } t \neq t' \end{cases}$$

(2)

where $\Sigma_{ij} = (\sigma_{ij,ls}) = \text{cov}(\varepsilon_{ilt}, \varepsilon_{jst})$, which is the covariance of the $l^{th}$ variable in country $i$ with the $s^{th}$ variable in country $j$.

The domestic variables included are real GDP ($rgdp$), consumer price index ($cpi$), exchange rate ($er$), and interest rate ($r$). In a more compact form,

$$x_{it} = (rgdp_{it}, cpi_{it}, er_{it}, r_{it})$$

(3)

The foreign variables, $x_{it}^* = (rgdp_{it}^*, cpi_{it}^*, er_{it}^*, r_{it}^*)$, are specific for each country, and represent the influence of the trade partners for a given economy. The foreign variables are computed as weighted averages of the corresponding variables for each country. That is,

$$x_{it}^* = \sum_{j=0}^{N} w_{ij} x_{jt}$$

(4)

where the weights $w_{ij}$ are computed as the share of country $j$ in the total trade of country $i$; $w_{ii} = 0, \forall i = 0, 1, 2, ..., N$ and $\sum_{j=0}^{N} w_{ij} = 1, \forall i, j = 0, 1, 2, ..., N$. 

In addition to the foreign variables, the GVAR model contains some global variables, namely oil price \((p_{oil})\), commodity price index \((pc)\), and manufacturing price index \((pm)\). The GVAR model thus allows for interactions among the different economies through three separate but interrelated channels: the contemporaneous dependence of \(x_{it}\) on \(x_{it}^*\) and \(x_{it-m}^*\); dependence of the country-specific variables on common global exogenous variables, \(d_t = (p_{oil}, pc, pm)\); and nonzero contemporaneous dependence of shocks in country \(i\) on the shocks in country \(j\), measured via the cross-country covariances \(\Sigma_{ij}\).

Following Pesaran et al (2004), the country-specific \(VARX^*\) models are estimated individually with the restriction that both the foreign and global variables are weakly exogenous \(I(1)\) variables. Assuming the weak exogeneity of the foreign variables implies that each country is considered as a small open economy. The global variables, \(d_t = (p_{oil}, pc, pm)\), are determined endogenously in the rest of the world model. The exogeneity assumptions hold in practice depends on the relative sizes of the countries/regions in the global model and on the degree of cross-country dependence of the idiosyncratic shocks, \(\varepsilon_{it}\), as captured by the cross-covariances \(\Sigma_{ij}\) (Pesaran et al, 2004: 132). The weak exogeneity in the context of co-integrating models implies no long feedback from \(x_{it}\) to \(x_{it}^*\) without necessarily ruling out lagged short run feedback between the two sets of variables (Dees et al, 2007).

Once the country-specific \(VARX^*\) models are estimated, we stack the \(VARX^*\) models to construct the GVAR model. Consider the \(VARX^*\) model in Eq (1) without the global variables and group both the domestic and foreign variables as \(z_{it} = (x_{it}', x_{it}^*)'\). The country model in Eq (1) could be written as:

\[
A_i z_{it} = a_{i0} + a_{i1} t + B_i z_{i,t-1} + \varepsilon_{it}
\]

where \(A_i = (I_{k_i}, A_{i0})\), \(B_i = (\Phi_i, A_{i1})\) and \(B_i\) are \(k_i \times (k_i + k_i^*)\), and \(A_i\) has a full row rank- \(\text{rank}(A_i) = k_i\).
Collecting all the country-specific variables together in the $k \times 1$ global vector

$$x_t = (x_{0t}', x_{1t}', ..., x_{Nt}')',$$  \hspace{1cm} (6)

where $k = \sum_{i=0}^{N} k_i$ the total number of the endogenous variables, the country-specific variable can be written as:

$$z_{it} = W_i x_t, \quad i = 0, 1, 2, ..., N$$ \hspace{1cm} (7)

$W_i$ is a $(k_i + k_i^*) \times k$ country-specific link matrix constructed on the basis of trade weights that allows the country-specific models to be written in terms of the global variable vector, $x_t$, given in Eq 7.

Substituting Eq (8) in (6), we have

$$A_i W_i x_t = a_{i0} + a_{i1} t + B_i W_i x_{t-1} + \varepsilon_{it}$$ \hspace{1cm} (8)

Stacking these equations yields

$$G x_t = a_0 + a_1 t + H x_{t-1} + \varepsilon_t$$ \hspace{1cm} (9)

where $a_0 = \begin{pmatrix} a_{00} \\ a_{10} \\ \vdots \\ a_{N0} \end{pmatrix}$, $a_1 = \begin{pmatrix} a_{01} \\ a_{11} \\ \vdots \\ a_{N1} \end{pmatrix}$, $\varepsilon_t = \begin{pmatrix} \varepsilon_{0t} \\ \varepsilon_{1t} \\ \vdots \\ \varepsilon_{Nt} \end{pmatrix}$ and

$$G = \begin{pmatrix} A_0 W_0 \\ A_1 W_1 \\ \vdots \\ A_N W_N \end{pmatrix}, \quad H = \begin{pmatrix} B_0 W_0 \\ B_1 W_1 \\ \vdots \\ B_N W_N \end{pmatrix}$$

$G$ is a $k \times k$-dimension matrix with full rank and hence nonsingular. As a result,
we can invert the $G$ matrix to obtain the GVAR model in its reduced form as:

$$x_t = G^{-1}a_0 + G^{-1}a_1t + G^{-1}Hx_{t-1} + G^{-1}\varepsilon_t$$

The GVAR model in Eq (11) can be solved recursively and the dynamic properties of the model are analyzed using generalized impulse response functions (GIRFs).

The GVAR model is estimated using data from the African Development Bank, IMF and World Bank sources. In order to have complete data samples, we used several techniques such as backcasting on the average growth rate, interpolation for middle missing values, breaking annual data into quarter data (for GDP) and introduction of seasonality effects.

3. Results

We focus on shocks on the Kenyan economy, the leading economy in the bloc, to examine the strength of shock transmission to the EAC. The results of the shocks to the other economies are contained in the appendix. The GIRFs associated to a one standard error negative shock to Kenya’s growth rate of are plotted in Figures 1. For each member country, the charts show the dynamic response of output growth and inflation over a time horizon of 40 quarters but we focus only on the results over 8 quarters, which is a reasonable period for inference on short-run macroeconomic dynamics. The graphs include the confidence intervals at the 95 percent significance level, calculated using the sieve bootstrap technique with 1000 replications. The responses are statistically significant and fall with the 95 percent confidence interval. Figure 2 provides a comparative result for all the EAC member countries.

Figure 1: Responses to a Negative Shock in Kenya’s Output Growth: Inflation
Figure 2: Responses to a Negative Shock in Kenya’s Output Growth: Growth
The impulse responses show that an adverse shock in Kenya’s growth could be transmitted into the rest of the EAC countries given their trade linkage. The results indicate that output shock in Kenya could be inflationary not only for Kenya but also for the rest of the EAC member countries. A possible channel could be from output shock in Kenya to inflation in Kenya which subsequently transmitted to the EAC member countries as higher import price. The exposure risk for the EAC member countries closely follows the GVAR weighting matrix, i.e., intra EAC trade weight matrix shown below.

<table>
<thead>
<tr>
<th></th>
<th>Kenya</th>
<th>Rwanda</th>
<th>Tanzania</th>
<th>Uganda</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kenya</td>
<td>.</td>
<td>0.21</td>
<td>0.35</td>
<td>0.44</td>
</tr>
<tr>
<td>Rwanda</td>
<td>0.58</td>
<td>.</td>
<td>0.10</td>
<td>0.32</td>
</tr>
<tr>
<td>Tanzania</td>
<td>0.80</td>
<td>0.07</td>
<td>.</td>
<td>0.12</td>
</tr>
<tr>
<td>Uganda</td>
<td>0.75</td>
<td>0.16</td>
<td>0.10</td>
<td>.</td>
</tr>
</tbody>
</table>

*Note: Trade weights are computed as shares of exports and imports*

Figure 3 provides the GIRFs for a positive shock to Kenya’s inflation. The results indicate some degree inflation synchronization between Kenya and the rest of the members in the bloc, although to a limited extent for Rwanda. Similar to our results above, inflationary pressures in Kenya could be transmitted to the rest of the bloc members through the trade link.
Although shocks in the Kenyan economy transcend beyond its boarder, both growth and inflation shocks in the other economies do not seem to affect Kenya significantly, indicating the relative resilience of the Kenyan economy (see Appendix 1). On the other hand, shocks in Rwandan economy do not seem to affect the EAC members significantly while comparable shocks in Tanzanian and Ugandan economy have some impacts with the magnitude lower than that of Kenya.

4. Conclusion

This paper looks at macroeconomic shock transmission in the East African Community bloc in a global VAR framework. Unlike the traditional approaches of testing
for monetary transmission mechanism using a single country model, the proposed GVAR model generalizes multivariate cointegration analysis to allow for weakly exogenous, structural I(1) variables. This methodology is hence particularly suitable for small open economies. It deals first with error-correcting terms on the country-level which allows for richer dynamics and more efficient estimation. One can stack this information in a second step into a multi-country system that can be used to investigate impulse response functions on a bloc level.

The results based on generalized impulse response functions show that both growth and inflation shocks in Kenya have significant effects on the rest of the member countries. The effects of the shocks vary significantly from country to country depending on the strength of trade links. While shocks in the Kenyan economy affect the other member countries significantly, the converse is not true indicating the dominance of Kenya in the bloc. This underscores the importance of Kenya in maintaining macroeconomic stability in the regional bloc.

REFERENCES


16. DING, D., and I. MASHA (2012): "India’s Growth Spillovers to South Asia"