African Journal of Economic Review, Volume 1I, Issue 2, July 2014

Analysis of Rwandan Economic Performance Before and After the 1994 Genocide

Charles Ruranga,[1,2] Bruno Ocaya[3] and William Kaberuka[4]

Abstract

This article analyses economic performance of Rwanda between 1973 and 2011. The economic history of Rwanda during this period can be divided into three periods i.e. pre-genocide period (1973-1989), inter-genocide period (1990-1994) and post—genocide period(1995-2011). Real GDP (constant 2000 US$) was used as the dependent variable and as a proxy for economic performance. The explanatory variables used were all expressed as percentages of GDP. They included Domestic Investment (DI), Foreign Direct Investment (FDI), Domestic Savings (DS) and Trade (TR).Chow test based on data for the entire period (1973-2011) rejected the null hypothesis of no structural change/break. After exclusion of observations for the conflict and genocide period, the Chow test corroborated by the Wald test further showed strong presence of structural break for the pre and post genocide periods. The apparent existence of structural change for the two regimes suggests that the disequilibrium impact of genocide on the Rwandan economy was transitory. This could be explained by the interventions and policies initiated by post genocide leadership to develop, pacify and unite the people of Rwanda. Although structural change was established for the pre and post genocide periods, the change did not emanate from the shift in the intercept, but rather from slope vectors. This means the unobserved qualitative characteristics of the two regimes were similar but that the policies which led to changes in the explanatory variables impacted differently on performance in the two regimes. Incidentally, it was found out that the bulk of the difference in the models across the two regimes was explained mainly by changes in the intercept, DI and FDI.

Keywords: Economic performance, structural change/break, pooled model, fixed effects model, separate regressions, subset of coefficients.

[1] School of Statistics and Planning, Makerere University, Kampala, Uganda, Corresponding author, P.O.Box 7062, Kampala

[2] School of Economics, University of Rwanda, Butare, Rwanda

[3]* School of Statistics and Planning, Makerere University, Kampala, Uganda, Corresponding author, P.O.Box 7062, Kampala, Uganda Tel: +256 772 932 983. E-mail: bocaya@bams.mak.ac.ug

[4] Makerere University Business School, Makerere University, Kampala, Uganda

1. Introduction

The economic performance of Rwanda from 1973 to 2011 can be analysed as a historical transformation of three periods and two political regimes namely; the pre-genocide period, the period of conflict and genocide; and the post-genocide period. The main economic characteristics of the three periods are distinguishable as follows:

1.1 1973-1989: This was the pre-genocide period where economic strategies were based on import substitution and industrialization policies. External balance on goods and services (% of GDP) declined from -1.8% in 1973 to -11.1% in 1989 while value addition in industry fell from 3.6% to 2.8% for the same period. This period was also marked by rigid price and foreign-exchange controls as well as high export taxes on coffee in order to raise revenue. This period is referred to in this paper as the first regime.

1.2 1990-1994: This was the period in which the Rwandan economy was devastated by conflict and genocide of 1994. The horrendous human consequences of the conflict and genocide led to a huge drop in economic activity. This was also the period when most of the promised aid was cancelled, with donors citing government's failure to meet conditions which included eliminating coffee price guarantees and adoption of structural adjustment programmes.

1.3 1995-2011: This post genocide period is here referred to as the second regime. It was marked by reorganization of society, economic recovery and economic building (Bigsten and Yanagizawa, 2005). Different reforms were instituted and implemented to improve public administration, budgeting and financial management. These reforms among others included: privatization of public enterprises, creation of a system of public accounts, liberalization of the banking sector; and creation of different specialized institutions such as Rwanda Revenue Authority, Nation Tender Board, Auditor General and Anticorruption Commission. In 1999 tax on coffee exports was removed and the maximum tariffs reduced from 100% to 40%. Rwanda also joined the World Trade Organization and its economy then globalized. Since 2000, mid and long-term economic development strategies have been adopted and implemented. These include Poverty Reduction Strategy Papers (PRSP), Economic Development and Poverty Reduction Strategy (EDPRS) and Vision 2020. As a result of these efforts Rwanda's economy grew at an average growth rate of 8.5% per year between 1995 and 2011.

This article provides an analysis of the economic performance of Rwandan economy given the events that unfolded in Rwanda between 1973 and 2011. Using econometric techniques, this study investigates the existence of structural change/break in the performance of the Rwandan economy for the period (1973-2011). The stability analysis of GDP's performance after the period of conflict and genocide (1990-1994) was analysed. All sources of possible structural breaks for the pre and post genocide periods were investigated. Finally, structural change under heterogeneity of the two regimes was examined.

2. Literature review

The variables adopted for this study are based on different researches on the determinants of economic growth undertaken by various authors. Analysed among the principal determinants of economic growth are direct investment and foreign direct investment (Fousekis & Shortle, 1995, Dollar, Iarossi & Mengistae, 2002 , Beddies, 1999, Ghura & Hadjimichael, 1996, Ghura, 1997, Hernandez-Cata, 2000, Ndikumana, 2000, Chari, et al. 1997, Collier & Gunning, 1999, Barro, 1991, Khan & Reinhart, 1990, Wijeweera, Villano & Dollery, 2010).

Savings as a key element in economic development/growth has also been analysed in several studies. These studies assume that higher savings lead to higher investment which in turn increases real output and employment if there are idle resources of labour, land and capital which can be absorbed in the economy (Lewis, 1970). Schmidt-Hebber, Serven & Solimano (1996) conclude that savings and growth reinforce each other and the causality runs from both directions. Ramesh (2011) shows that higher saving and investment lead to higher economic growth, but the reciprocal causality is not observed.

Over the past years, the relationship between foreign trade and economic growth has been the debate of economic research in academia (Chen, 2009). Andersen & Babula (2008) concluded that there is likely to be a positive relationship between international trade and economic growth. Mehrara & Firouzjaee (2011) tested Granger causality relationship between nonoil export and economic growth based on panel cointegration analysis for 73 developing countries during the period 1970-2007. Their results show that there is bi-directional long-run causality between export and GDP growth. Ekanayake (1999) showed that bi-directional causality exists between export growth and economic growth in India, Indonesia, Korea, Pakistan, Philippines, Sri Lanka and Thailand.

Jayachandran & Seilan (2010) found Granger causality relationship from exports to growth rate with no causality relationship from growth rate to exports; and the direction of causality relationship from FDIs to growth rate with no causality relationship from growth rates to FDIs. Most of these studies emphasized Investment, Openness to Trade, Exports, Human capital, Domestic savings and Political factors as the principal determinants of economic growth. However due to their importance and relevance, this study adopted Domestic investment, Foreign direct investment, Domestic savings and Trade as the main explanatory variables of economic performance in Rwanda.

3. Methodology

The analyses of the economic performance of the Rwandan economy before and after the 1994 genocide was based on World Bank (2012) data and covers a period of 39 years (1973-2011). The years 1973-1989 was considered the “pre-genocide” period while 1995-2011 was treated as the “post-genocide” era. The years 1990-1994 is dubbed the “conflict and genocide” period when massive extrajudicial killings took place. Altogether there are 17 observations each for “pre-genocide” and “post-genocide” regimes and 5 observations for the period of “conflict and genocide”.

Real GDP (constant 2000 US$) was the dependent variable adopted as a measure of economic performance. The variables used in the explanation of the economic performance were: Domestic Investment (DI) as percentage of GDP, Foreign Direct Investment (FDI) as percentage of GDP, Domestic Savings (DS) as percentage of GDP; and Trade (TR) as percentage of GDP.

Stability tests or tests of structural break models were employed to analyze the economic performance between 1973 and 2011. These tests are linear restrictions cast in terms of restricted and unrestricted residual sums of squares (RSS) of specified models. The tests are based on the F-statistic defined as

$$F = \frac{(RSS_{i*} - RSS_j)/df_*}{RSS_j/df} \sim F(df_*, df)$$

Where RSS_{i*} is restricted residual sum of squares, RSS_j is the unrestricted residual sum of squares, df_* is the degrees of freedom of the restricted model minus the degrees of freedom of the unrestricted model; and df is the degrees of freedom for the unrestricted model.

The analysis of economic performance before (pre) and after (post) the 1994 genocide was undertaken after dropping inter-genocide observations. The tests for identifying restricted and unrestricted RSS were obtained from a menu of the following models (Greene 2012, Ocaya 2013, Johnston 1984):

The Pooled Model $[Model\ 1\ (RSS_1)]$:

$$\begin{pmatrix} \mathbf{y}_{\text{pre}} \\ \mathbf{y}_{\text{post}} \end{pmatrix} = \begin{pmatrix} \mathbf{i}_{\text{pre}} & \mathbf{X}_{\text{pre}} \\ \mathbf{i}_{\text{post}} & \mathbf{X}_{\text{post}} \end{pmatrix} \begin{bmatrix} \alpha \\ \boldsymbol{\beta} \end{bmatrix} + \begin{pmatrix} \boldsymbol{\varepsilon}_1 \\ \boldsymbol{\varepsilon}_2 \end{pmatrix} \tag{1}$$

Fixed Effects Model $[Model\ 2\ (RSS_2)]$:

$$\begin{pmatrix} \mathbf{y}_{\text{pre}} \\ \mathbf{y}_{\text{post}} \end{pmatrix} = \begin{pmatrix} \mathbf{i}_{\text{pre}} & \mathbf{0} & \mathbf{X}_{\text{pre}} \\ \mathbf{0} & \mathbf{i}_{\text{post}} & \mathbf{X}_{\text{post}} \end{pmatrix} \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \boldsymbol{\beta} \end{bmatrix} + \begin{pmatrix} \boldsymbol{\varepsilon}_1 \\ \boldsymbol{\varepsilon}_2 \end{pmatrix} \tag{2}$$

Separate regression Model $[Model\ 3\ (RSS_3)]$[5]:

$$\begin{bmatrix} \mathbf{y}_{\text{pre}} \\ \mathbf{y}_{\text{post}} \end{bmatrix} = \begin{bmatrix} \mathbf{i}_{\text{pre}} & \mathbf{0} & \mathbf{X}_{\text{pre}} & \mathbf{0} \\ \mathbf{0} & \mathbf{i}_{\text{post}} & \mathbf{0} & \mathbf{X}_{\text{post}} \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \boldsymbol{\beta}_1 \\ \boldsymbol{\beta}_2 \end{bmatrix} + \begin{pmatrix} \boldsymbol{\varepsilon}_1 \\ \boldsymbol{\varepsilon}_2 \end{pmatrix} \tag{3}$$

[5] Note that RSS_3 is also equal to the sum of RSS obtained independently from regressions of each regime.

Change in subset of Coefficients Model [*Model* 4 (RSS_4)][6]

$$\begin{bmatrix} \mathbf{y}_{\text{pre}} \\ \mathbf{y}_{\text{post}} \end{bmatrix} = \begin{bmatrix} \mathbf{X}_{\text{pre}} & \mathbf{0} & \boldsymbol{W}_{\text{pre}} \\ \mathbf{0} & \mathbf{X}_{\text{post}} & \boldsymbol{W}_{\text{post}} \end{bmatrix} \begin{bmatrix} \boldsymbol{\beta}_{\text{pre}} \\ \boldsymbol{\beta}_{\text{post}} \\ \boldsymbol{\beta} \end{bmatrix} + \begin{pmatrix} \boldsymbol{\varepsilon}_1 \\ \boldsymbol{\varepsilon}_2 \end{pmatrix} \tag{4}$$

Under the assumption that $\boldsymbol{\varepsilon}_1, \boldsymbol{\varepsilon}_2 \sim N\left(0, \sigma^2\right)$ and independently distributed, the RSS and the degrees of freedom associated with OLS estimation of these models will be used to carry out the *Chow/structural change test* for differential intercepts and differential slope vectors. For the two regimes, the test is defined by the statistic

$$F = \frac{(RSS_{1^*} - RSS_3)/k}{RSS_3/(n-2k)} \sim F\left(k, (n-2k)\right)$$

Where n is the total number of observations for pre and post genocide periods; and k is the number of estimated coefficients from the pooled model[7]. The restricted model for this test is model 1 while the unrestricted is model 3. The hypothesis is

$H_0 : \alpha_1 = \alpha_2, \beta_1 = \beta_2$ (there is no structural break/change)

$H_a : \alpha_1 \neq \alpha_2, \beta_1 \neq \beta_2$ (there is structural break/change)

The acceptance of the null hypothesis would suggest stability/similarity of the two regimes and justification of analysis based on a single pooled model. The rejection of the null hypothesis would not be informative since the structural change can originate from the intercepts, or the slopes, or both. The following tests would be necessary in order to establish the true source (s) of change arising from the rejection of the null hypothesis:

3.1 Test of differential intercepts

For this test model 1 is the restricted while model 2 is the unrestricted model 3 with the hypothesis

$H_0 : \alpha_1 = \alpha_2$

$H_a : \alpha_1 \neq \alpha_2$

The F-statistic is obtained from

$$F = \frac{(RSS_1 - RSS_2)/1}{RSS_2/(n-k-1)} \sim F\left(1, (n-k-1)\right)$$

[6] Note in this model that β_{pre} *and* β_{post} are coefficient vectors of X_{pre} *and* X_{post} respectively while β is a common coefficient vector for W_{pre} *and* W_{post}. The X_{pre} *and* X_{post} are changing (varying) variables while W_{pre} *and* W_{post} are constant (non-changing) variable(s) for the two periods.

[7] In E-Views the same test is conducted through stability tests with the appropriate breakpoint(s). Similarly, since the "pre" and "post" genocide number of observations are the same (balanced), the same test may also be obtained through the Wald coefficient test on the equality of the respective coefficients in model 3.

The F-statistic for this test may also be cast in terms of R^2 in the restricted and unrestricted models as[8]

$$F = \frac{(R^2_{Unrestricted} - R^2_{restricted})/1}{1 - R^2_{Unrestricted}/(n-k-1)} \sim F\left(1,(n-k-1)\right)$$

3.2 Test of differential slope vectors

Model 2 is the restricted and model 3 is the unrestricted with the hypothesis being

$$H_0 : \beta_1 = \beta_2$$
$$H_a : \beta_1 \neq \beta_2$$

The F-statistic for this test is

$$F = \frac{(RSS_2 - RSS_3)/(k-1)}{RSS_3/(n-2k)} \sim F\left((k-1),(n-2k)\right)$$

3.3 Test of stability of subset of coefficients

This test is based on the coefficients of variables allowed to remain constant (i.e., W_{pre} *and* W_{post}). The F-statistic is given by

$$F = \frac{(RSS_4 - RSS_3)/q}{RSS_3/(n-2k)} \sim F\left(q,(n-2k)\right)$$

Where q is the number of coefficients in the subset of variables assumed to be constant (stable). Since the "pre" and "post" genocide number of observations are balanced, this same test may also be obtained through the Wald coefficient test on the equality of coefficients of variables allowed not to change (remain constant) in model 3.

3.4 Test of structural change with unequal error variances (Heteroscedasticity of subsamples)

This is a Wald test for a Chow/structural break test in large subsamples under the assumption that the "pre" and "post" genocide error variances are different[9]

$$\left[\text{ i.e., } \boldsymbol{\varepsilon}_1 \sim N\left(0,\sigma_1^{\,2}\right), \boldsymbol{\varepsilon}_2 \sim N\left(0,\sigma_2^{\,2}\right)\right]$$

Under the null hypothesis of no structural break the Wald statistic is given by

$$\boldsymbol{W} = \left(\hat{\boldsymbol{\theta}}_{\text{pre}} - \hat{\boldsymbol{\theta}}_{\text{post}}\right)' \left(\hat{\mathbf{V}}_{\text{pre}} + \hat{\mathbf{V}}_{\text{post}}\right)^{-1} \left(\hat{\boldsymbol{\theta}}_{\text{pre}} - \hat{\boldsymbol{\theta}}_{\text{post}}\right) \xrightarrow{Asym.} \chi^2(k)$$

[8] Note also that the F-test can be obtained in E.Views through the Wald coefficient test on the equality of intercept dummies of the fixed effects model (model 2). For balanced sub-sample observations, the same test is conducted in E-Views 7.0 and above by testing for *redundant coefficients* after estimation of the fixed effects model in panel option.

[9] This test may also be viewed as a test of the appropriateness of applying Chow test to subsamples.

Where $\hat{\boldsymbol{\theta}}_{pre}$ and $\hat{\boldsymbol{\theta}}_{post}$ are consistent and asymptotically normally distributed estimators based on the "pre" and "post" genocide observations respectively. The $\hat{\mathbf{V}}_{pre}$ and $\hat{\mathbf{V}}_{post}$ are the asymptotic covariance matrices based on the "pre" and "post" genocide estimators.

4. Graphical analysis

This section analyses trends of variables used in this study for the period 1973-2011. Real GDP (constant 2000 US$) for the post-genocide period (1995-2011) were much higher than those for the pre-genocide period (1973–1989). Having dipped during the year of genocide in 1994, the trend of real GDP (Figure 1) show that the post-genocide periods on the average increased two times over the pre-genocide periods. This change may be attributed to policies and programs adopted by the Government in the implementation of EDPRS and Vision 2020.

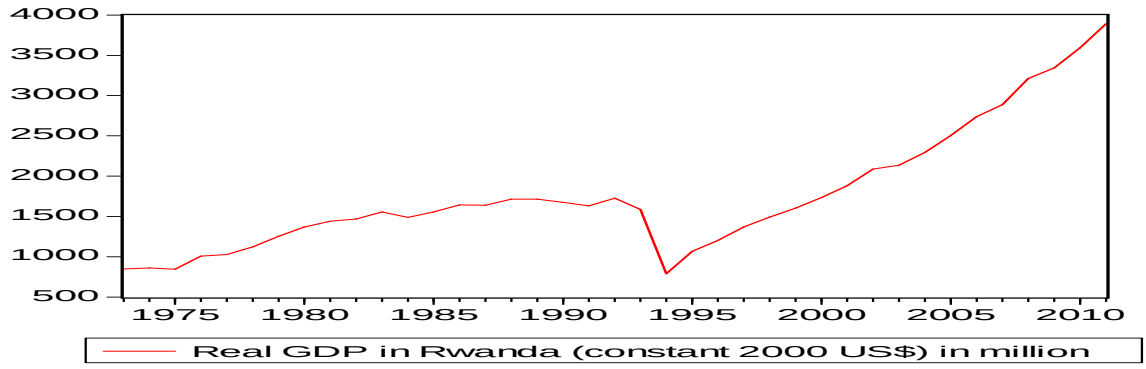

Figure 1: GDP (constant 2000 US$ in millions), Rwanda, 1973-2011.
Source: World Bank, World development indicators, 2012.

Figure 2 also shows that domestic investment as a share of GDP (DI) was also generally higher in the post genocide periods in comparison with the pre genocide periods. The trend indicate that DI plummeted during the year of genocide and gradually picked up thereafter due to renewed confidence in the post genocide regime.

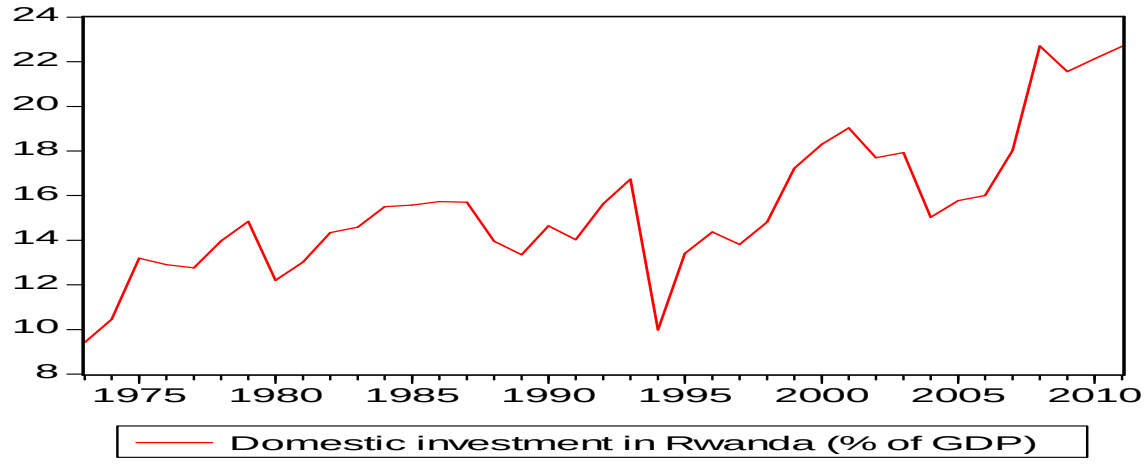

Figure 2: DI as % of GDP, Rwanda, 1973-2011.
Source: World Bank, World development indicators, 2012.

Foreign direct investment (FDI) declined dramatically during the period of conflict and genocide and remained low for most of the earlier years of the post genocide period. This was largely associated with erosion of foreign investor confidence in the political stability of Rwanda. From 2007, FDI increased significantly peaking in 2009 . This may be explained by measures government undertook to attract and promote foreign investment during this period. This among others included efforts in improving conditions of doing business (AfDB, AUC, & UNECA, 2012). Figure 3 below gives the trend of FDI.

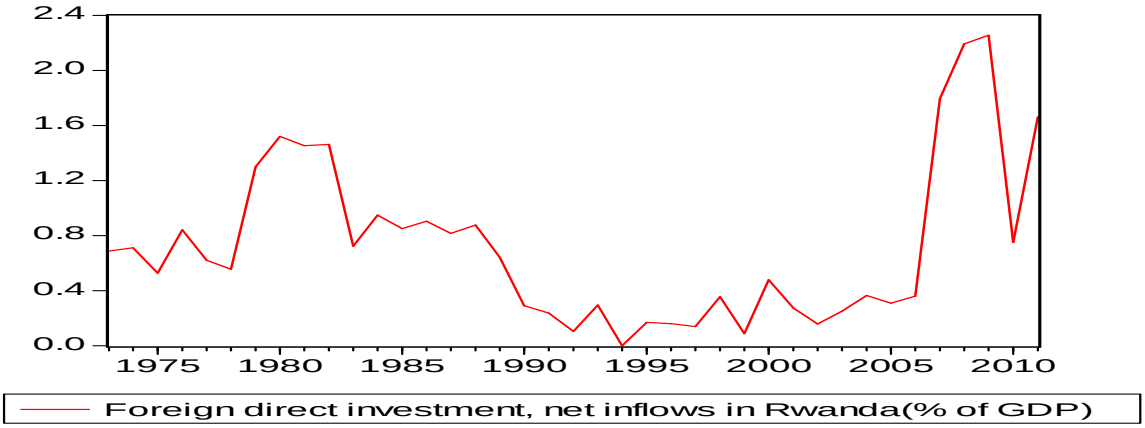

Figure 3: FDI as % of GDP in Rwanda, 1973-2011
Source: World Bank, World development indicators, 2012.

Except for the slump in the year of genocide (1994), Figure 4 shows that domestic savings as a share of GDP (DS) has remained low and more or less the same for the pre and post genocide periods. Domestic savings as percentage of GDP has continued to be very low with an average of 1.8% of GDP for all periods. This is associated with the poor culture of savings and lack of financial capacity which is common in many developing countries.

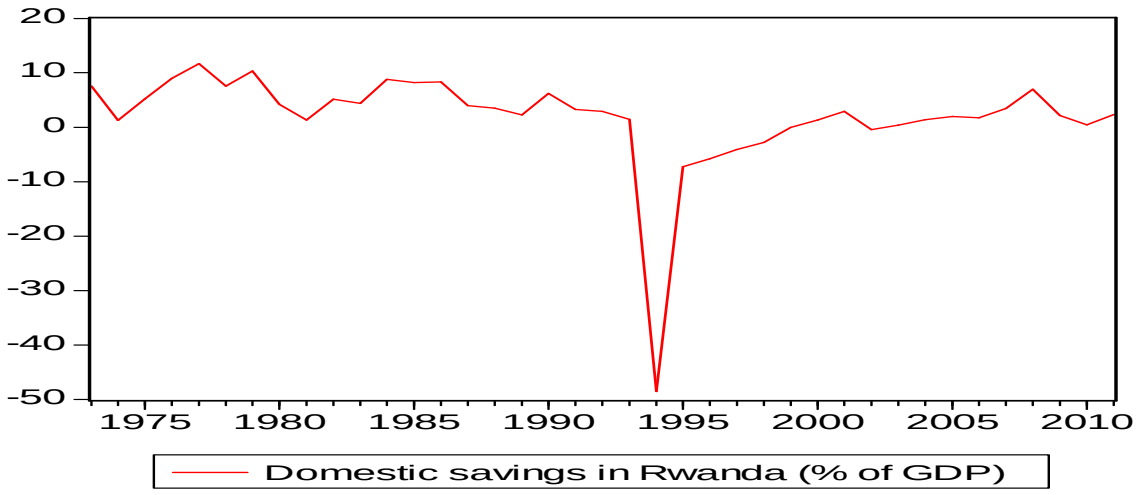

Figure 4: DS as % of GDP, Rwanda, 1973-2011.
Source: World Bank, World development indicators, 2012.

Trade is measured as the sum of exports and imports. The trend of trade as percentage of GDP is given in Figure 5. Apart from the year of genocide when imports of goods and services substantially increased to address the challenges of conflict and genocide, there is no discernable difference in the pattern of trade between pre and post genocide periods in Rwanda. The share of exports compared to imports have remained very low thereby increasing Rwanda's dependence on the rest of the world and keeping external balance of trade perpetually negative.

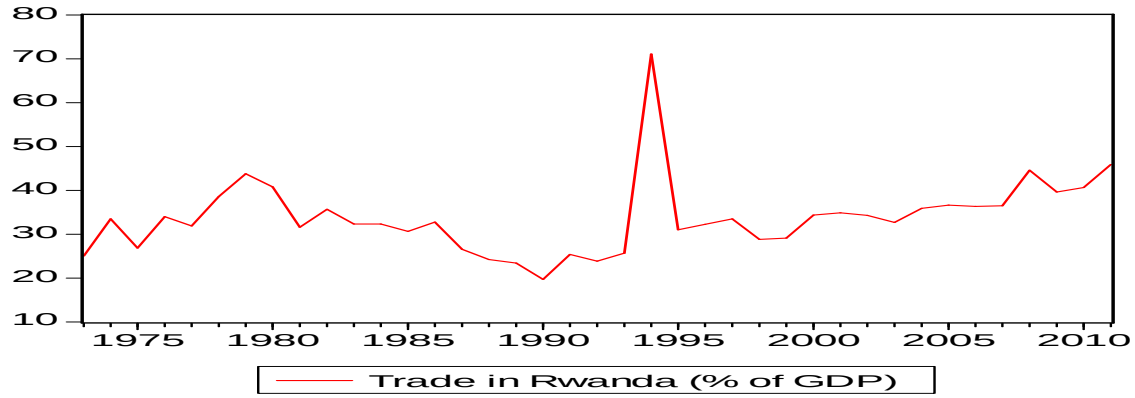

Figure 5: Trade as % of GDP, Rwanda, 1973-2011.
Source: World Bank, World development indicators, 2012.

5. Model estimation and Analysis[10]

Analysis of real GDP performance in Rwanda was first carried out through the test for "structural break" for the entire period (1973-2011). The test was extended to the "pre" and "post" genocide period after excluding the period of conflict and genocide (1990 -1994). Further tests were explored in order to establish possible sources of structural breaks after the period of conflict and genocide. Finally, a test of structural change under the heterogeneity (unequal variances) of the "pre" and "post" genocide periods was undertaken.

5.1 Structural break for all the periods (1973-2011)

The real GDP pooled regression results for the entire period (pre genocide, inter genocide & post genocide) is presented in Table 1. The tests for structural change are given in Table 2.

[10] Estimation and tests were carried out using EViews 5.0.

Table 1: Pooled Regression estimates for all periods

Dependent Variable: GDP
Method: Least Squares
Sample: 1973 2011
Included observations: 39

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1446.525	418.7610	-3.454298	0.0015
DI	203.3175	21.16845	9.604739	0.0000
FDI	245.0446	141.8223	1.727828	0.0931
DS	-10.34520	11.09046	-0.932801	0.3575
TR	-2.535553	11.46195	-0.221215	0.8262
R-squared	0.789502			
Adjusted R-squared	0.764738			
Sum squared residual	4766474			

Table 2: Tests of structural change for all periods

Chow Breakpoint Test: 1990 1995
Null Hypothesis: No breaks at specified breakpoints
Varying regressors: All equation variables
Equation Sample: 1973 2011

F-statistic (Chow)	2.895515	Prob. F(10,24)	0.0160

The results of the pooled regression model show that the selected explanatory variables explain about 76% of the variation in real GDP with coefficients of DI and FDI being significant at 10% level. Test of structural change given in Table 2 reject the hypothesis of no structural change[11]. This implies the existence of a structural break in economic performance of the Rwandan economy between 1973 and 2011. It establishes the fact that the two regimes and the period of conflict and genocide were individually unique in explaining economic performance of Rwanda. In particular, it confirms the popular view that conflict and genocide were disruptive and very destructive to the Rwandan economy.

5.2 Structural break for pre and post genocide periods

Since the period of conflict and genocide proved to be disruptive and destructive; its observations were dropped. Consequently, the pooled model and structural break tests for the "pre" and "post" genocide periods were carried out and the results are presented in Tables 3 and 4 below

[11] Given the three partitions, the same F-statistic using RSS is also given by the formula

$$F\left(3k-k, n-3k\right)=\frac{(RSS_{1^*}-RSS_3)/\left(3k-k\right)}{RSS_3/(n-3k)}=\frac{(4766474\text{-}2160232)/10}{2160232/24}=\ 2.\ 8955$$

Table 3: The pooled regression estimates for pre and post genocide periods

Dependent Variable: GDP
Method: Least Squares
Sample: 134
Included observations: 34

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1598.409	463.3489	-3.449688	0.0017
DI	189.2122	26.60129	7.112897	0.0000
FDI	262.7998	147.7858	1.778248	0.0859
DS	-25.43034	17.53248	-1.450471	0.1577
TR	9.433151	16.20374	0.582159	0.5650
R-squared	0.799229			
Adjusted R-squared	0.771536			
Sum squared residual	4328217.			

Table 4: Tests of structural change for pre and post genocide periods

Chow Breakpoint Test: 18
Null Hypothesis: No breaks at specified breakpoints
Varying regressors: All equation variables
Equation Sample: 1 34

F-statistic (Chow)	4.817229	Prob. F(5,24)	0.0034

With the removal of the conflict and genocide period, the results of the pooled model for the pre and post periods are comparable to those for the entire period. The coefficient of determination is 77% while DI and FDI remain significant at the 10% level. The F test in Table 4 shows that there has been a structural change in Rwandan economic performance before and after the period of conflict and genocide[12]. This implies that even without the conflict and genocide, the two regimes were uniquely different in their pursuit of policies towards economic growth. Most importantly, the omission of observations for the conflict and genocide period did not bring about stability in the (pooled) regression model, suggesting therefore that the impact of conflict and genocide was transitory (temporary) without permanent ramifications to the Rwandan economy. This may largely be explained by the interventions and policies adopted by post genocide leadership to develop, pacify and unite the people of Rwanda through economic reforms, reconciliation, inclusion and non-discrimination.

[12] The F-statistic from the RSS formula is also given as

$$F\left(k, n-2k\right) = \frac{(RSS_{1^*} - RSS_3)/k}{RSS_3/(n-2k)} = \frac{(4328217\text{-}2160232)/5}{2160232/24} = 4.817$$

5.3 Sources of Structural breaks for pre and post genocide periods

We now examine models which identify possible sources of structural break for the two regimes to determine whether it was due to difference in intercepts, slope vectors, or some combination of both.

The fixed effects model

This model was estimated and used to test for differences in intercepts related to the two regimes which emanate from the non-rejection of the null hypothesis of "no structural change". The results of the estimation and tests are presented in Tables 5 and 6.

Table 5: Estimation of fixed effects model for pre and post genocide regimes

Dependent Variable: GDP				
Method: Panel Least Squares				
Sample: 117				
Sub-samples included: 2				
Total observations (balanced): 34				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1)D1	-1102.237	580.2518	-1.899583	0.0678
C(2)D2	-675.6508	807.9571	-0.836246	0.4101
C(3)DI	152.6730	37.19170	4.105028	0.0003
C(4) FDI	364.4985	163.0151	2.235980	0.0335
C(5) DS	0.054156	25.24189	0.002145	0.9983
C(6) TR	0.581138	17.18872	0.033809	0.9733
R-squared	0.812080			
Adjusted R-squared	0.778523			
Sum squared residual	4051165			

Table 6: Tests of differential intercepts for pre and post genocide regimes

Wald Test:			
Null Hypothesis: C(1)=C(2)			
Test Statistic	Value	Df	Probability
F-statistic	1.914873	(1, 28)	0.1774

Although the adjusted R^2 is high (78%) and the coefficients of DI and FDI are significant at 5% level, the estimates of the fixed effects model show that the intercepts (constant term) for the two regimes are insignificant. The F-test suggests that the basic unobserved qualitative characteristics of variables which spurred growth in Rwanda (infrastructure, institutions, etc.) have not changed significantly in both regimes[13].

[13] The F-test for differential intercepts for this model may also be obtained from the dummy variable model with a common intercept. Using RSS, the F- statistic is also estimated as $F(1,28) = \frac{(4328217\text{-}4051165)/1}{4051165/28} = 1.9149$

Separate Regression Model

The combined separate regression model is a powerful model for carrying out most of the structural stability tests (save for tests of differential intercepts) especially for balanced sub-samples of observations. Since the observations for the two regimes are equal, the separate regression model was estimated and used to test for differential slope vectors and stability of sub-set of coefficients. The results are presented in the ensuing tables

Table 7: Estimation of separate regression model for pre and post genocide regimes

Dependent Variable: GDP				
Method: Panel Least Squares				
Sample: 1: 17				
Sub-samples included: 2				
Total observations (balanced): 34				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C(1) D1	-9.660419	693.4943	-0.013930	0.9890
C(2) D2	-2521.160	925.7656	-2.723324	0.0119
C(3) D1DI	134.0523	44.07771	3.041271	0.0056
C(4) D2DI	60.27472	46.06557	1.308455	0.2031
C(5) D1FDI	360.1830	300.9254	1.196918	0.2430
C(6) D2FDI	77.76220	162.5354	0.478432	0.6367
C(7) D1DS	-24.29816	28.72506	-0.845887	0.4060
C(8) D2DS	35.58846	31.59200	1.126502	0.2711
C(9) D1TR	-20.90791	17.81737	-1.173456	0.2521
C(10) D2TR	103.3020	29.01821	3.559904	0.0016
R-squared	0.899794			
Adjusted R-squared	0.862217			
Sum squared residual	2160232.			

Test of differential slope vectors

The Test of differential slope vectors given in Table 8 is found to be statistically significant implying that the differences in slope vectors were responsible for structural break in the pre and post genocide regimes in Rwanda.[14] This suggests policies which led to changes in the explanatory variables (DI, FDI, DS and TR) impacted differently on the economic performance of the two regimes.

[14] The F-statistic derived from the RSS of respective models is also computed as

$$F(4,24) = \frac{(4051165\text{-}2160232)/4}{2160232/24} = 5.252$$

Table 8: Test of differential slope vectors for pre and post genocide regimes

Wald Test: (Equality of Slope Vectors) Null Hypothesis: C(3)=C(4),C(5)= C(6), C(7)=C(8),C(9)=C(10)			
Test Statistic	Value	Df	Probability
F-statistic	5.252029	(4, 24)	0.0035

Tests of subset of coefficients

The test for differential subset of coefficients examines variation of variables which matter most in explaining structural breaks. It analyses changes in combinations of variables (intercept inclusive) in the model in order to establish those which contribute the bulk to structural change. Among the several models explored, the following were identified and tested:

(i) DS and TR were held constant while the intercept, DI and FDI were allowed to vary in both regimes. The results are presented in Table 9.

Table 9: Test of subset of coefficients assuming DS and TR are constant

Wald Test: Null Hypothesis: C (7) =C (8), C (9) =C (10)			
Test Statistic	Value	Df	Probability
F-statistic	9.679492[15]	(2, 24)	0.0008

(ii) The intercept, DI and FDI were assumed to be constant when DS and TR were varying in both regimes. Table 10 shows the results.

Table 10: Test of subset of coefficients assuming intercept, DI and FDI are constant

Wald Test: Null Hypothesis: C(1)=C(2),C(3)=C(4),C(5)= C(6)			
Test Statistic	Value	df	Probability
F-statistic	4.058216[16]	(3, 24)	0.0182

[15] The RSS formula counterpart for the F-statistic is : $F\left(2,24\right)=\frac{(3902727-2160232)/2}{2160232/24}=\ 9.6795$

[16] The F-statistic for this test is also computed as: $F\left(3,24\right)=\frac{(3256067-2160232)/3}{2160232/24}=\ 4.0582$

(iii) The intercept, DS and TR were held constant while DI and FDI were made to vary in both regimes. The results are given in Table 11.

Table 11: Test of subset of coefficients assuming intercept, DS and TR are constant

Wald Test:			
Null Hypothesis: C (1) =C (2), C (7) =C (8), C (9) =C (10)			
Test Statistic	Value	Df	Probability
F-statistic	6.567033[17]	(3, 24)	0.0021

Although the test of the three model possibilities of subset of coefficients investigated above are statistically significant, the comparative F-results suggest that the bulk of the difference in the models across the two regimes is explained more by changes (variations) in the intercept, DI and FDI as given in (i).

5.4 Structural change with unequal error variances for the two regimes.

The "pre" and "post" genocide regimes can be considered heteroscedastic since they are distinct in their own rights in terms of policies, politics, management, etc. Under this assumption (conviction), the Chow test previously computed to test for structural change no longer applies since the error variances for the two regimes will not be homogeneous. With heteroscedasticity, the Wald test of structural for the two regimes is a χ^2 statistic with 5 degrees of freedom computed as[18]

$$W = \left(\hat{\boldsymbol{\theta}}_{\text{pre}} - \hat{\boldsymbol{\theta}}_{\text{post}}\right)' \left(\hat{\mathbf{V}}_{\text{pre}} + \hat{\mathbf{V}}_{\text{post}}\right)^{-1} \left(\hat{\boldsymbol{\theta}}_{\text{pre}} - \hat{\boldsymbol{\theta}}_{\text{post}}\right) = 22.275, \text{ p-value} = 0.000464173.$$

Where

$$\hat{\boldsymbol{\theta}}_{\text{pre}} = \begin{pmatrix} -9.660419 \\ 134.0523 \\ 360.1830 \\ -24.29816 \\ -20.90791 \end{pmatrix} \quad \hat{\boldsymbol{\theta}}_{\text{post}} = \begin{pmatrix} -2521.160 \\ 60.27472 \\ 77.76220 \\ 35.58846 \\ 103.3020 \end{pmatrix}$$

[17] The RSS formula counterpart is: $F(3,24) = \dfrac{(3933521\text{-}2160232)/3}{2160232/24} = 6.567$

[18] Note that E-Views versions 7.0 computes the same results as we obtained.

$$\hat{\mathbf{V}}_{pre} = \begin{pmatrix} 158858.154973364 & -7953.09814498412 & 11031.1781153038 & 1368.36788453245 & -2096.35681945381 \\ -7953.09814498412 & 641.743765358803 & -776.773797781384 & -107.389886639012 & 17.7581207553251 \\ 11031.1781153038 & -776.773797781384 & 29911.7265131599 & 1229.00610995306 & -1096.17713347629 \\ 1368.36788453245 & -107.389886639012 & 1229.00610995306 & 272.549668017994 & -83.4728483976765 \\ -2096.35681945381 & 17.7581207553251 & -1096.17713347629 & -83.4728483976765 & 104.860274039921 \end{pmatrix}$$

$$\hat{\mathbf{V}}_{post} = \begin{pmatrix} 1430992.99188134 & -24785.2242006616 & 139640.315678823 & 24339.0868063531 & -30454.4288527316 \\ -24785.2242006616 & 3543.14028312361 & -3244.78176561161 & -912.593768633572 & -990.072509132898 \\ 139640.315678823 & -3244.78176561161 & 44109.4476703148 & -1002.86084897146 & -3152.53342875765 \\ 24339.0868063531 & -912.593768633572 & -1002.86084897146 & 1666.43996263373 & -223.188897490781 \\ -30454.4288527316 & -990.072509132898 & -3152.53342875765 & -223.188897490781 & 1405.97166511118 \end{pmatrix}.$$

On the basis of the p-value of 0.000464173, the Wald test rejects the null hypothesis of equality of coefficient vectors in the two regimes. This supports our earlier finding of the existence of structural break using the Chow test. This notwithstanding, it should be noted that the Wald test is valid only in large samples, and our sub samples of 17 observations barely meets the standard.

6. Conclusion

This paper analysed the real GDP as a measure of economic performance in Rwanda between 1973 and 2011. During this period, the country underwent through three distinct historical phases: the pre-genocide period (1973-1989), the period of conflict and genocide (1990-1994); and the post-genocide period (1995-2011). The variables considered to be the main drivers of real GDP were: domestic investment (DI), foreign direct investment (FDI), domestic savings (DS) and trade (TR); all expressed as percentages of GDP.

The period of conflict and genocide was very disruptive and destructive for all the variables studied. On the average, real GDP doubled in the post-genocide periods compared to the pre-genocide periods. This change may be attributed to policies and programs adopted by the Government in the implementation of EDPRS and Vision 2020. DI and FDI were also relatively high in the post-genocide periods due to measures government undertook to attract and promote domestic and foreign investment. However, DS and TR have remained low and more or less of the same magnitude without any clear difference in them between the two regimes.

The pooled, the fixed effects and the separate regression models were used to analyze structural change/break in the economic performance. Chow test rejects the null hypothesis of no structural change for all the periods. The Chow test also rejects the null hypothesis for the pre and post genocide periods after the omission of conflict and genocide period observations. Furthermore, the Wald test of structural change under heterogeneity of the two regimes corroborated the rejection of the null hypothesis. The rejection of the null hypothesis suggests that the disequilibrium impact of conflict and genocide was temporary on the Rwandan economy. This may be explained by the interventions and policies initiated by post genocide leadership to develop, pacify and unite (reconciliation, inclusion & non-discrimination) the people of Rwanda.

Although structural change was established for the pre and post genocide periods, the source of the change is attributed to slope vectors but not simple shifts in the intercepts. This implies the policies which led to changes in the explanatory variables (DI, FDI, DS and TR) impacted differently on the economic performance of the two regimes. It also suggests that the unobserved qualitative characteristics of variables which spur growth in Rwanda (infrastructure, institutions, etc.) did not change significantly in both regimes. Finally, tests on subsets of coefficients found that the bulk of the difference in the models across the two regimes was explained mainly by changes in the intercept, DI and DFI.

References

AfDB, AUC, and UNECA (2012) *African Statistical Yearbook 2012***,** Denmark.

Andersen, L. and Babula, R.(2008) "The Link between Openness and Long-Run Economic Growth," *Journal of International Commerce and Economics*, Web version: July 2008.

Barro, R. J. (1991) "Economic Growth in a Cross Section of Countries," *The Quarterly Journal of Economics*, 106(2), 407-443.

Beddies, C. (1999). "Investment, Capital Accumulation and Growth: Some Evidence from Gambia: 1964-1998." *IMF Working Paper 99/117*, August.

Bigsten, A. and D. Yanagizawa (2005), "Growth and Poverty Reduction: Evaluating Rwanda's First PRS", *Country Economic Report 2005*:9, Sida, Stockholm,

Chari, V.V., Kehoe, P.J., and McGrattan, E. R. (1997). The Poverty of Nations: A Quantitative Investigation, *Research Department Staff Report 204*, Federal Reserve Bank of Minneapolis, Minneapolis.

Chen, H. (2009). "A Literature Review on the Relationship between Foreign Trade and Economic Growth," *International Journal of Economics and Finance*, 1(1):127-30.

Collier, P. and Gunning, J.W. (1999). "Explaining African Economic Performance,"*Journal of Economic Literature*, 37, 64-111.

Dollar D., Iarossi G. and Mengistae T. (2002). "Investment Climate and Economic Performance: Some Firm Level Evidence from India," *Working Paper No. 143*, Centre for Research on Economic Development and Policy Reform.

Ekanayake,E.M.(1999) "Export and Economic Growth in Asian Developing Countries: Cointegration and Error-Correction Models," *Journal of Economic Development*, 24(2):43-56.

Fousekis, P. and Shortle, S. J. (1995). "Investment Demand When Economic Depreciation is Stochastic," *American Journal of Agricultural Economics*, 77(4), 990-1000.

Ghura, D. (1997). "Private Investment and Endogenous Growth: Evidence from Cameroon," *IMF Working Paper* 97/165.

Ghura, D., and T. Hadjimichael (1996). "Growth in Sub-Saharan Africa," *Staff Papers International Monetary Fund,* 43, September.

Greene, H. W. (2012). *Econometric Analysis*, 7th edition, Prentice Hall, Upper Saddle River, New Jersey 07458.

Hernandez-Cata, E. (2000). "Raising Growth and Investment in Sub-Saharan Africa: What Can be Done?" *Policy Discussion Paper: PDP/00/4,* International Monetary Fund, Washington, D .C.

Johnston, J. (1984). *Econometric Methods*, New York: McGraw-Hill.

Jayachandran, G. and Seilan, A. (2010) "A Causal Relationship Between Trade, Foreign Direct Investment and Economic Growth in India" *International Research Journal of Finance and Economics*, issue 42.

Kormendi, R. and Meguire, P. (1985). "Macroeconomic Determinants of Growth: Cross-Country Evidence," *Journal of Monetary Economics* 16, pp 141-163.

Khan, M.S. and C.M. Reinhart (1990). "Private Investment and Economic Growth in Developing Countries," *World Development, 18* (1), 19-27.

Lewis, A. (1970). *Theory of Economic Growth*, George Allen and Unwin Limited, London.

Mehrara, M. and Firouzjaee, B. A. (2011). "Granger Causality Relationship between Export Growth and GDP Growth in Developing Countries: Panel Cointegration Approach," *International Journal of Humanities and Social Science*,1 (16): 223-231.

Ndikumana, L. (2000). "Financial Determinants of Domestic Investment in Sub-Saharan Africa," *World Development, 28* (2), 381-400.

Ocaya Bruno-Logumale (2013). Simplified Practical Econometrics, Department of Statistical Methods & Actuarial Science, CoBAMS, Makerere University. Unpublished Manuscript.

Ramesh, J. (2011). "Causal Relationship between Saving, Investment and Economic Growth for India, What does the Relation Imply?" *Reserve Bank of India Occasional Papers* 32 (1), 2011.

Schmidt-Hebber, K., Serven, L. and Solimano, A. (1996). "Saving and Investment: Paradigms, Puzzles, Policies," *The World Bank Research Observer,* 11(1):87-117.

Wijeweera, A., Villano, R. and Dollery, B. (2010). "Economic Growth and FDI Inflows: A Stochastic Frontier Analysis," *The Journal of Developing Areas,* 43(2): 143-158.

World Bank (2012). *World Development Indicators Report*. The World Bank, Washington, DC.