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Exchange Rate Convergence in the East African Monetary Union: An Econometric Investigation

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Abstract
The paper initially revisits the definition of convergence in bivariate sense to cater for gradual changes which occur from one point to another and distinguishes between the different levels of convergence including zero mean, conditional deterministic, stochastic, conditional and unconditional stochastic convergence, and re-categories the conditional stochastic convergence and conditional deterministic as being either static or dynamic depending on whether the constant in the convergence equation increases, remains constant or decreases as the convergence progresses, with dynamic convergence occurring when the constant decreases overtime. This is an expansion of the approach of previous studies that mainly focused on three general types of convergence of stochastic, deterministic and zero mean convergence, described by Halket (2005), mainly based on the entire sample being investigated without capturing the gradual changes that occur from one period to another using a rolling approach. This approach captureS the dynamic nature of the stochastic changes which occur before, during, and after the convergence is attained. After revisiting the above, the study investigated the extent of convergence of the exchange rates for the East African Community using the rolling bivariate cointegration approach, accounting for structural breaks using the Sup LM test. The motivation was that the EAC member countries for several years have been implementing reforms aimed at attaining macroeconomic convergence as a measure to ensure a successful Monetary Union. Whether it has been attained is an empirical question. The results revealed limited convergence of the exchange rates, which has serious negative implications for the success of the EA Monetary Union. This calls for review of the current monetary policies, and macroeconomic policies in general.
Keywords: Convergence, Rolling Bivariate Cointegration, Structural Break LM Test, Exchange Rates, EAC-Integration
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1. Introduction

According to the ECB (2010), for the East African Monetary Union to function smoothly and to economically benefit all the partner states, it must start with a high degree of sustainable monetary and economic convergence, and compatibility among the member states. They should have synchronous economic cycles, experience similar external shocks, have comparable inflation and growth rates, have public financial control, aligned interest rates, a high degree of stability of nominal bilateral exchange rates and possibly similar income levels. This implies that East African Monetary Union should start with the member countries in the single currency area fulfilling and maintaining the macroeconomic targets set for the East African Community (EAC).

Having effective monetary policy is crucial for ensuring that countries attain homogeneity before and after joining a Monetary Union since monetary policy through its effects on money supply can and does affect inflation, unemployment, interest rates and economic growth, among other variables included in the convergence criteria. Convergence of such variables is necessary for effective economic integration. Depending on the exchange rate regime adopted by a given country, the management of the exchange rate market can constitute a major component of the effective monetary policy management. In this vain, achievement and maintenance of stable exchange rates is one of the secondary criteria targeted for the 2007-2010 period.

The EAC by advocating for a stable exchange rate regime are emphasizing the role of exchange rate management in ensuring the effectiveness of monetary policy, particularly as a means to control the money supply in the respective economies. This is essential for convergence, since monetary policy through its effects on money supply affects almost all the other variables included in the convergence criteria either in the short-run and/or long-run. According to ECB (2006), exchange rate targeting refers to a monetary policy strategy aiming for a given, usually stable or even fixed, exchange rate against another currency or group of currencies. This implies that the members of the EAC requiring stable exchange rates is advocating for exchange rate targeting. Three of the EAC member countries (Uganda, Kenya and Tanzania) are currently not targeting a monetary or fixed exchange rate regime but are aiming at stabilizing exchange rates by managing the floating exchange rate regime (managed float). In this scenario, the central banks cannot have a truly independent monetary policy as would happen under a freely floating exchange rate regime. However, since the effectiveness of the other tools of monetary policy are in question, especially in the current era of liberalized economies, the exchange rate targeting becomes a major monetary policy that can be used to ensure that the EAC member countries attain a high degree of sustainable monetary and economic convergence, and compatibility among the member states. The EAC member countries have since 1999 been implementing reforms for ensuring monetary convergence. However, the extent of convergence that has been attained and will be attained in the near future is still in question.

All the monetary policy frameworks in the EAC countries use monetary targeting under a floating exchange rate regime (Anand et al. 2011). Under monetary targeting, an objective target for the inflation rate is set— five percent in Kenya, Uganda and Tanzania in 2011—and the central bank aims to achieve this by using money supply (usually M2 or M3) as the intermediate target, since they have direct control over reserve money, that is used as the operating instrument. The EAC member countries are currently required to aim for annual average inflation rate of not more than 5% as stipulated in Stage II of convergence criteria for the EAC.

Meeting the convergence criteria in the EAC has been elusive, with persistent threats for macroeconomic stability in general, and volatile inflation and exchange rates (Mafusire & Brixiova (2012)). Kuteesa (2012), who reviewed the trends in the macroeconomic variables included in the convergence criteria, noted that the EAC countries generally remain behind the staged numerical indicators. She however, indicated that there were significant achievements in terms of maintenance of market based interest and exchange rates; and currency convertibility are concerned but did not give a clear indication as to whether the exchange rates are stable or converging. Since the ultimate goal of creation of a monetary union would be to harmonise exchange rates, convergence of exchange rates would be a crucial requirement for all countries intending to join the monetary union. It is therefore necessary to determine whether the exchange rates for the EAC countries are converging or not converging, and if not to devise means of ensuring that the East African Monetary Union succeeds when it comes in effect.

The objective of the study is to undertake an empirical investigation of the extent of convergence (divergence) among the member nations of the emerging monetary union of EAC. This study will specifically look at monetary convergence using the exchange rate variable as a target rather than an instrument.

2. East African Intergration Review

Integration in the East African region can be traced back to 1894 and can be divided into four major periods, that is, 1894-1947, 1948 -1966, 1967-1977 and 1984 –to date. The focus of this paper is on the last two periods running from 1967 to-date. In 1967, the quasi federation which had begun in 1948 culminated in the East African Community, referred to as phase 1 hereafter (EAC, Phase 1). This community collapsed in 1977, with the East African Ministers signing a memorandum of understanding in Washington that sealed the collapse of the community. In 1984, three partner states, that is, Uganda, Kenya and Tanzania committed themselves to exploring areas of future cooperation, and signed a communique committing their countries to revive the East African Cooperation in 1991. In 1993, the Permanent Tripartite Commission (PTC) was set up; the first protocol to establish the EAC Secretariat was signed in 1994; while the EAC Treaty was signed on 30 November 1999, forming EAC, Phase 2, among the three African states. The treaty entered into force on 7 July 2000. At their Summit in 2004, the Heads of State of the EAC partner states adopted a Customs Union Protocol. This Protocol entered into force on 1 January 2005 and became fully effective, after a period of progressive implementation, on 1 January 2010. In 2007, Rwanda and Burundi joined the East African Community.

During their 2009 Summit, they adopted a Protocol on the Establishment of the East African Community Common Market (The Common Market Protocol). This Protocol was expected to enter into force on 1 July 2010 and become fully effective, after a period of progressive implementation, by 1 January 2015.

The EAC integration effort was aimed at establishing a monetary union by 2012 and a federation of East African states later (EAC (2007) and Buigut (2009)). As indicated by Anand et al (2011), the East African Monetary Union (EAMU) would replace the five country currencies with a common currency which would be managed by an East African Central Bank (EACB). It is anticipated that the proposed EAMU will offer significant economic benefits to the region, including but not limited to: reduction in transaction costs and risks, increased trade, deeper financial integration, removal of the costs of transacting in different currencies as well as the risk of adverse exchange rate movements for traders and travelers within the region, and increased collective political status in the international arena. Such benefits would outweigh the costs associated with monetary union such as the resulting contagion effects, moral hazard problems, and loss of control over some national policies.

As with other monetary unions, it was anticipated that macro-economic convergence among the partner states in the EAC single currency area must have been achieved by the time the EAMU Protocol is signed. The EAC Monetary Union is currently striving to attain the three key prerequisites for a monetary union including: macroeconomic convergence, financial market integration and legal and institutional convergence. Monetary and fiscal policies harmonization entails the attainment of a set of macro-economic convergence criteria via the removal of all macro-economic disharmonies which may exist among the EAC member states as a result of pursuing macro-economic policies, which may have divergent rather than convergent forces.

The EAC following what has been done for other emerging economic blocks has come up with a macro-economic convergence matrix (Opolot and Luvanda (2009), Lunogelo and Mbilinyi (2009), ECB (2010), Anand et al (2011), Mafusire and Brixiova (2012), and Kuteesa (2012)) aimed at ensuring price stability within the EAC sub-region, strengthening the financial sector, encouraging cross-border activities and providing liberal policy conducive to trade, investment, savings, growth and development.

According to the EAC 2012 Conference proceedings (Davoodi ed. 2012) that took place in Arusha, Tanzania, on February 27–28, 2012, to celebrate the achievements of the EAC in its first decade and look into upcoming challenges in its second decade. At this point, the EAC had succeeded in establishing a customs union and a common market; putting in place ingredients of a comprehensive regional infrastructure; holding discussions on the protocols of a monetary union; intensifying the crucial processes of harmonization of monetary and exchange rate policies, payment and settlement systems, financial sector supervision, fiscal policies, coordination and harmonization of statistics, and regionalization of the financial sector in order to create a single financial market; and achieving macroeconomic stability over the past decade or so.

The four major challenges that the EAC faced included: balancing the prospective benefits of a larger common market against the greater complexity that comes with a more diverse membership; ensuring that all countries benefit from regional integration; advancing the customs union and common market; and determining the appropriate pace for moving beyond a common market to monetary union. The EAC at this point had not yet developed the institutions needed for market integration, with trade dispute still being resolved in national courts; and still had to attract private financing for quality shared infrastructure, to overcoming the political impediments to such financing by increasing the multi-country cooperation thereby reducing the costs of mobilizing funds from the private sector. It was argued that too much attention may have been given to the symbolism of monetary union and common currency, and too little to opportunities for cooperation in creating a shared infrastructure for the community.

The EAC countries were commended for having started the process of developing domestic financial markets and accelerating integration, infrastructural development as well as improving capacity but there was still a lot to be desired. For example in the area of capacity development, more skills such as debt management, legal, accounting, and other capital market professionals were needed. Further, the EAC was still faced with unresolved issues in trems of satisfying the prerequisites to the long-term success of a common currency. They still had to put in place permanent fiscal rules, a multilateral fiscal surveillance regime to oversee the operation of those rules, an enforcement mechanisms, and effective risk sharing mechanisms. They would also have to consider implications of overlapping membership of EAC partner states and other regional blocks.

It was also noted that the formation of the EAMU would face complexities since EAC countries have different initial conditions, such as policy effectiveness, dissimilar depth of financial markets, varying fiscal dominance, the nature of the current exchange regime, diverse monetary policy and monetary policy instruments. As a result, the EAC would have to face the challenge of sequencing monetary policy harmonization, harmonization of monetary policy instruments, such as different reserve requirements and lending facilities, which requires a rich framework that is capable of steering policymakers to ask the right questions and make the relevant decisions.

Kuteesa (2012) has argued that fast tracking the East African Monetary Union (EAMU) to the 2015 deadline faces great risk since countries are still struggling with fulfilling current criteria which tighten over time. She indicated that meeting the stated criteria is currently flawed with many challenges, signaling the need for new strategy setting and criteria overhaul. As reported in the EAC legislative Assembly (EAC 2013), the EAC was reviewing and negotiating the targets for the macroeconomic convergence criteria on the following indicators: inflation, fiscal deficit, debt to gross domestic product (GDP) ratio and reserve over imports.

According to the EAC legislative Assembly (EAC Legislative Assembly 2013) which took place from 26 May to 7th June 2013, the process of creating the EAMU would entail: (i) preparation, adoption, ratification, and implementation of legal instruments such as a Monetary Union Protocol, inclusive of the bills for new institutions such as an East African Central Bank; (ii) establishment of the operational and regulatory framework necessary for the smooth functioning of a monetary union; (iii) attainment and sustaining a level of macroeconomic convergence that allows countries participating in monetary union to reap the benefits thereof; and (iv) change-over from national currencies to a single currency, which must be properly anchored in society and particularly in the financial market, which will be instrumental to the success of the change-over.

The Monetary Union Protocol was finally signed at the Speke Resort Munyonyo in Kampala on 30 November 2013 during the 15 Summit by the five EAC member country presidents. This marked the logical culmination of the EAC integration efforts. It provides the framework for unlocking the promise of integration. The EAMU, it is anticipated will be established within 10 years. Through this Union, the member countries will synchronize their monetary, fiscal, and exchange policies, establish a central bank, support regional trade within the bloc with its common currency arrangement, reduce the transaction costs associated with using different currencies in the EAC, reduce currency volatility, minimize currency fluctuations, and increase intra-EAC trade and investment. This Monetary Union, is therefore expected to create macro-economic stability and discipline; and reduce the cost of doing business down through the East African payment system.

It was expected that the single customs territory would become a reality in January 2014; and that East

African identity cards, work permits and a single tourist visa would be due in 2014. It was also noted that internationally recognized passports were in the pipeline. The ratification of the EAMU, the third pillar of integration was set for July 2014. This would pave a way for the use of a common currency. The EAMU would eventually spread to include South Sudan and Somalia if they are admitted. South Sudan was finally admitted on March 02, 2016 but Somalia has not yet been admitted.

3. Theoretical and Empirical Literature Review

Musa (2009) indicated that studies on monetary union emphasize a high degree of convergence among the countries as a prerequisite for monetary integration. Two forms of convergence can be identified (Opolot and Luvanda (2009) and Bernard and Durlauf (1995)). First, convergence occurs if the long-run forecasts of a given variable in a given set of countries are equal at some fixed time period, t. Testing for convergence in this case would be equivalent to testing whether the differences in the long-run forecasts of the variable tend to zero as the forecast horizon (K) tends to infinity. Second, convergence may occur if the long-run forecasts of the variables in question are proportional at a fixed time period, t, implying that the variables in question have a common trend but there may be stochastic trends affecting the variable which may differ across countries.

Research on convergence has indeed proceeded in many directions using many different definitions and methodologies reviewed by Islam (2003). However, most researchers, such as Kocenda (2001), Brada and Kutan (2001), Brada and Kutan (2002), Brada et al. (2002), Opolot and Luvanda (2009), among others, who have investigated the convergence of macroeconomic variables for the emerging custom unions, have adopted a static approach thereby not taking into account the dynamic nature of the convergence coefficients. Such studies investigate the necessary condition of requiring the parameters to take on specific values at a point in time, leaving out the sufficient condition of the same parameters to be converging to certain levels over time, or even attaining a certain level at a given point in time following a period of adjustment. They ignore the gradual nature of the changes in the stochastic properties from the period of no cointegration, plausibly the case before integration, to that of cointegration after some convergence has been attained.

Using cointegration tests based on the entire period has a major shortcoming of assumimg that the cointegration vector is constant. In reality, the long-run relationship between the underlying variables may change implying a shift in the cointegration vector. This may be due to several factors, for example, technological progress, economic crises, changes in peoples' behaviour, policy or regime alteration, and organizational or institutional developments. Brada et al (2002) argued that the condition of having achieved convergence is quite different from that of achieving convergency. During the adjustment from the state of an un-cointegrated state to that of convergence, the parameters or stochastic properties of the system are changing. As a consequence, using the conventional cointegration tests over the entire period would bias the test towards rejecting cointegration and thus convergence.

Brada et al (2002), following Hansen and Johansen (1999) and Rangvid and Sorensen (2000), used the technique of rolling cointegration to overcome the shortcoming. According to them, tests for structural breaks in the model are likely to reject the hypothesis of a structural break since the changes are gradual. The rolling horizon approach takes into account the possibility of the data series being more integrated during some parts of the sample period, less so during others and/or not at all. It can also be used to test for cointegration during the earlier parts of the transition without biasing those later parts. It is therefore necessary to use a rolling procedure that can be used to track these gradual changes.

4. Methodological Framework

This study will apply a rolling bivariate cointegration/convergence tests to determine whether the macoreconomic policies in EAC are converging using the nominal exchange rate variable. The study will also test for constancy of parameters/cointegration using structural regime models and the $Sup-LM$ tests used by Andrews (1993), Andrews (2003), Hansen (1992), Hansen (1990), Quintos and Phillips (1993), Gregory and Hansen (1996), Olusegun, Oluwatosin and Abimbola (2012). Using the Sup LM test will overcome the short-coming of failing to detect cointegration if it exists in the presence of a structural break using ADF and Phillips-Perron tests.

4.1 Nature of Convergence

The study attempts to determine whether in a bi-variate setting, the exchange rate variable exhibits zero mean (ZMC), conditional deterministic convergence (CDC), conditional stochastic convergence (CSC), unconditional stochastic convergence (USC), or no long-run convergence (NC) at a point for a given period and over time as integration in the community progresses. In order to capture the changes overtime, CSC and CDC for the bivariate case, are further categorised as being static or dynamic depending on whether the constant in the convergence equation increases, remains constant or decreases from one sub-sample to the next one. A dynamic situation is achieved if the constant decreases over time.

Halket (2005) using the $I(1)$ versus $I(0)$ framework sketches three general types of convergence which have been used by different researchers (Carlino and Mills (1993), Bernard and Durauf (1996), and Li and Papell (1999)) including stochastic, deterministic and zero-mean convergency. Stochastic and deterministic convergence can be broken down into the corresponding unconditional and conditional convergence depending on the value of the constant in the respective equations.

Given two series, Y_i and Y_j which are $I(1)$, stochastic convergence (Carlino and Mills (1993)) or equivalently, catching up convergence (Bernard and Durauf (1996)), would occur if δ in equation (1) gets smaller as the difference between the two series $(Y_i - Y_j)$ tends to get smaller over time. This implies that for stochastic convergence to occur, δ must take on values of zero and above and must be declining overtime to towards zero. A negative value of δ would imply that the countries are deterministically diverging.

$$Y_i - Y_j = c + \delta t + u_{ij}, \quad u_{ij} \sim I(0) \tag{1}$$

Conditional stochastic convergence would occur if stochastic convergence exists and the value of the constant ***c*** is significantly different from zero, otherwise unconditional stochastic convergence occurs if stochastic convergence exists but the value of c is not significantly different from zero. Deterministic convergence (Li and Papell (1999)) would occur if

$$Y_i - Y_j = c + u_{ij}, \quad u_{ij} \sim I(0) \tag{2}$$

Equation 2 would be equivalent to equation (1) in the special event that the value of δ is not significantly different from zero, thus deterministic convergence is a special case of stochastic convergence. Deterministic convergence implies stochastic convergence but not vice versa. Two forms of deterministic convergence have been identified: conditional deterministic convergence**,** which occurs if the value of the constant c is significantly different from zero; and unconditional deterministic convergence**,** occurring if the value of the constant c is not significantly different from zero in the presence of deterministic convergence. For both stochastic and deterministic convergence, conditional convergence occurs if the absolute value of c in equations 1 and 2 is greater than zero.

Zero mean convergence would occur if Y_i and Y_j unconditionaly or absolutely converge or converge to a zero mean, that is,

$$Y_i - Y_j = u_{ij}, \quad u_{ij} \sim I(0) \tag{3}$$

Equation 3 is equivalent to equation 1 if and only if the absolute values of c and δ are not significantly different from zero. Zero mean convergence therefore implies unconditional deterministic convergence thus stochastic convergence but the reverse is not true.

Stochastic convergence therefore takes on four distinct forms: conditional stochastic convergence (both c and δ is positive and significantly different from zero), unconditional stochastic convergence (c not significantly different from zero, δ is positive and significantly different from zero), conditional deterministic convergence (c significantly different from zero, δ not significantly different from zero), and unconditional deterministic convergence or zero-mean convergence, also viewed as unconditionally converging to a mean of zero (both c and δ not significantly different from zero).

Lack of stochastic convergence is the situation where δ takes on a negative value. In this case, lack of stochastic convergence would imply deterministic divergence. Deterministic divergence takes on two forms: conditional deterministic divergence– CDD (c is significantly different from zero and δ is negative and significantly different from zero) and unconditional deterministic divergence- UDD (c is not significantly different from zero and δ is negative and significantly different from zero).

Overall, convergence proceeds from a situation of no convergence (NC) to static conditional stochastic convergence ($SCSC$), followed by dynamic conditional stochastic convergence ($DCSC$), then unconditional stochastic convergence (UST), followed by static conditional deterministic convergence ($SCDC$), then dynamic conditional deterministic convergence $DCDC$, and finally zero mean convergence (ZMC).

The definitions of convergence and divergence above require that the values of c and δ be monitored overtime to capture the dynamic nature of the stochastic changes which occur before, during, and after the efforts geared towards integration have been put in place

4.2 Testing for Stationarity

In order to test for cointegration/convergence, it is necessary to determine the time series properties of the variables in question. This involves determining whether each of the series in question is stationary (no unit root) or non-stationary (unit root exists). If non-stationary, it is also important to determine the order of integration. The usual Dickey Fuller test (DF) (Dickey and Fuller (1979)), Augmented Dickey Fuller Test (ADF) (Banik and Yoonus

(2009); the Phillips-Perron Test (Phillips and Perron (1988)) stationarity tests were applied. The PP test was implemented together with the DF/ADF test since it overcomes the shortcomings inherent in the DF and ADF tests (See Phillips (1987), Perron (1988), and Phillips and Perron (1988)). The Akaike Information criterion (AIC), and /or the Schwartz Bayes Information Criterion (Schwartz BIC) (developed by Akaike (1974) and Schwarz (1978, respectively)) were used to identify the appropriate number of lags.

4.3 Rolling Bivariate Convergence Tests

The difference ($Y_i - Y_j = \Delta Y_{ij}$) between two EAC member countries i and j, was computed for different pairs of the countries, yielding ten sets of difference series which were used for the analysis for the entire period from 1960 to 2011 and the 19 sub-samples, each of 34 observations before adjustments, to perform the rolling bivariate convergence test.

For each of the 20 samples, ΔY_{ij} was tested for stationarity using the ADF and PP tests to determine whether zero mean convergence (ZMC) or absolute convergence or unconditional convergence (or converging to zero mean) existed. A stationary ΔY_{ij} would imply ZMC. For the non-stationary ΔY_{ij} equation 4 was estimated.

$$Y_i - Y_j = c + \delta t + u_{ij} \tag{4}$$

The next step was to determine whether the necessary and/or the sufficient condition for Conditional Stochastic convergence was satisfied, breaking the results into static conditional stochastic convergence $(SCSC)$, dynamic conditional stochastic convergence, and deterministic convergence (DC). Let the necessary condition for convergence be defined as having $u_{ij} \sim I(0)$ from equation 4, and the sufficient condition for condition stochastic convergence be a declining δ in absolute terms as $Y_i - Y_j$ gets smaller overtime.

$SCSC$ would be indicated if the necessary condition was satisfied but the sufficient one was not, and both the constant and the coefficient of the trend were significantly different from zero; $DCSC$ if both the necessary and sufficient conditions were satisfied while both the constant and the coefficient of the trend were significantly different from zero; $SCDC$, if the necessary condition was satisfied, but the sufficient one not, with the constant significantly different from zero but the coefficient of the trend not significantly different from zero; and $DCDC$, if both the necessary and sufficient conditions are satisfied with the constant significantly different from zero but the coefficient of the trend not significantly different from zero.

4.4 Rolling Bivariate Cointergration Tests

Several researchers including Kocenda (2001), Brada and Kutan (2001), Brada et. al. (2002), Opolot and Luvanda (2009), Buigut (2011) and Brada and Kutan (2002), among others have used cointegration to test for convergence. Cointegration is used to refer to a linear combination of non-stationary variables which have a stationary relationship in the long-run (Banik and Yoonus (2009)). Cointegration is tested for only those series which are integrated of order one ($I(1)$) or above. It is important to note that most economic series are integrated of order 1 or $I(1)$.

Testing for cointegration involves two basic steps. The first step involves testing the data series for stationarity, while the second step involves testing for cointegration or presence of a long-term stationary relationship among the permanent components of the series included in the primary convergence criteria. The rolling cointegration involved applying the two basic steps to the entire sample and the 19 different sub-samples. It is expected that parameter instability exists during the adjustment process from a period no convergence to complete convergence, implying that dynamic adjustments alter the long-run parameters during the process of adjusting towards convergence or divergence.

4.5. Testing for Cointegration in Presence of Structural Breaks

4.5.1 Testing for structural breaks

The tests described in this section will be used to determine whether the ADF test and Phillips-Perron tests used in the bivariate analysis falsely failed to reject the null of no cointegration due to a structural break for the entire sample using a model that allows for structural breaks. Several researchers including Hansen (1990), Hansen and Seo (2000), Andrews (1993), Calvori et al (2014), Breitung and Eickmeier (2011) and others have tested structural breaks using either the null of the Engle-Granger Cointegration (Engle and Granger (1987), Hansen (1992, 1990), Quintos and Phillips (1993), among others) or the null of no cointegration with power against the various structural change regimes (Gregory and Hansen 1996).

Given the observed data Y_t whereby $Y_t = (Y_{1t}, Y_{2t})$ and is real-valued and Y_{2t} is an m-vector, five possible models can be identified, including the standard model of cointegration with no structural change and four structural change single equation models described by Gregory and Hansen (1996) and Olusegun, Oluwatosin and Abimbola (2012). Model 1, the standard model of cointegration (SMC) is presented in equation 5.

$$Y_{1t} = \mu + \alpha^T Y_{2t} + e_t \quad t = 1,..., n \tag{5}$$

where Y_{2t} is $I(1)$, e_t is $I(0)$ while μ and the $\alpha^T s$ are the 'long-run cointegration parameters' described by Engle and Granger (1987). With no structural break, these parameters are time invariant, but may not be for very long-time periods, and are not in the presence of structural changes. The usual model described by Engel and Granger (1987) is a useful model for 'long-run equilibrium' in the case of time-invariant cointegration parameters, however, as argued by Gregory and Hansen (1996), cointegration may hold over some long period of time, and then shifts to a new 'long-run' relationship. This timing of the shift may be known or unknown. Depending on the situation, there may even be more than one shift. The structural change(s) would be reflected in changes in the intercept μ and/or the slope α.

A dummy variable D_{1t} is used to incorporate the structural changes in the standard cointegration model to obtain the structural change cointegration alternatives. The dummy variable takes on either a value of zero for time periods before the structural break and one for those after the break, that is: $D_{1t} = 0$ if $\{t \le \{[n\tau]\}\}$ otherwise $D_{1t} = 1$ if $\{t \succ \{[n\tau]\}\}$, where the unknown parameter τ ϵ (0, 1) denotes the (relative) timing of the change point, and $[]$ denotes integer part. There structural alternatives can be obtained from the general model in equation 6.

$$Y_{1t} = \mu_1 + \mu_2 D_{tr} + \beta_1 t + \beta_2 t D_{tr} + \alpha_1^T Y_{2t} + \alpha_2^T Y_{2t} D_{tr} + e_t \ t = 1,..., n \tag{6}$$

where μ_1 is the slope before the shift, μ_2 is the change in the intercept at the time of the shift, t is time trend, α_1 is the cointegrating slope coefficient before the regime shift, α_2 is the change in the slope coefficient after the shift, β_1 is the slope of the trend before the structural break and δ β_2 is the change in the slope of the trend after the structural break. The level shift (C-model 2) is obtained if β_1, β_2, and α_2 are set to zero; the level shift with trend (C/T-model 3) is obtained if β_2 and α_2 are set to zero; the regime shift (C/S-model 4) is obtained when β_1 and β_2 are set to zero, while the regime shift with a trend (C/S/T- model 5) is obtained if all the parameters are non-zero.

Gregory and Hansen (1996) and Nwaobi (2011)) used the Phillips-Perron $Z_\alpha(\tau)$) and $Z_t(\tau)$; as well as Augmented Dickey- Fuller, $ADF\ (\tau)$ to test for parameter instability while others such as Kodongo and Ojah (2014) and Calvori et al (2014) used the $Sup-LM$ test of Andrews (1993). Hansen (1990) and Zeileis (2005) outline the general theories for testing for parameter instability in econometric models based on the above models. Hansen (2012) provides an excellent overview of the different tests.

4.5.2 Testing the Null of Cointegration using the $Sup-LM$ Test

For this paper, the main objective for the structural break test is to determine whether the standard model of cointegration is a suitable model for the exchange rate series. The standard cointegration model with the associated stability of equilibrium long-run parameter (Model 1) is tested against the structural alternative of Model 5 which incorporates the different structural breaks involving the constant, trend and slope variables using the $Sup-LM$ test of Andrews (1993).

The null hypothesis for the $Sup-LM$ test is that there are no structural shifts, implying parameter stability (cointegration/constant parameters). This is tested against the alternative of a single structural break (no cointegration/parameters variability) at some unknown point in time. Rejection of the null implies that the standard model of cointegration including its implicit assumptions of the cointegrating relationship is rejected by the data, signaling re-evaluation of the cointegration status using an alternative model.

According to Kodongo and Ojah (2014), the $Sup-LM$ statistic is computed as the largest of LM statistics computed at 5% increments between 15% and 85% of the sample. This requires estimation of the cointegration test statistic using the selected structural alternative for each possible regime shift τ ϵ T and the largest value across all possible break points is selected as the $Sup-LM$ statistic. The value of T should be small enough to enable the computation of the relevant statistics. The set T can be any compact sub-set of $(0,1)$ where 1 corresponds to total sample space. According to literature, $T = (.15,.85)$ is a reasonable space. This T contains an uncountable number of points, but only the step functions on T are considered, implying jumps only on the points $\{\frac{i}{n}, i\ integer\}$. The test statistic is normally computed for each break point in the interval T_1 ϵ $[.15n,.85n]$, corresponding to the 5% point jump or increments within the interval for a sample of size n.

Alternatively, the interval T must cover the period during which certain reforms or policies were implemented.

For the purpose of this paper and cointegration for EAC, it is expected that the EAC initiated its major political and institutional changes during the 1990s and thereafter. For this reason the interval $T_1 \in [.65n, .85n]$, was considered. Rejection of the null of constant parameter would signal regime shifts following the political/institutional reforms. The LM statistic, ($LM(\tau)$), corresponding to each possible regime shift $\tau \in T$ is the "$LM - like$" statistic referred to as the "point-wise LM statistic" was used to test the null hypothesis of no serial correlation ($H_0 = \rho = 0$) for residuals corresponding to the multiple regression model estimated using OLS procedures, against the alternative of serially correlated errors ($H_1 = \rho \neq 0$). If $\rho = 0$, the errors e_{1t} are white noise (they are independent and have all the same variance and mean 0). The largest point-wise $LM(\tau)$ statistic estimated is the $Sup\ LM$ test statistic, that is, $Sup\, LM = Sup_{\tau \in T}\, LM(\tau)$. The calculated $Sup - LM$ statistic is evaluated against critical values in Table 1 of Andrews (2003).

4.6 Data for Testing for Convergence in the East African Community (EAC)

The study used the the Official exchange rate (LCU per US $, period average) compiled by the World Bank (World Bank 2012). It refers to the exchange rate determined by national authorities or to the rate determined in the legally sanctioned exchange market. It is calculated as an annual average based on monthly averages (local currency units relative to the U.S. dollar).

5. Analytical Results

5.1 Stationarity Tests

The Phillips-Perron (PP) and the Augumented Dickey-Fuller (ADF) tests revealed that the official exchange rate series for all the five countries were integrated of order one $I(1)$ for the 1960-2011 for Kenya, Burundi, Tanzania and Uganda but 1960-2010 for Rwanda. For the PP tests, the data was de-trended using the Spectral Generalised Least Squares approach. Examination of the plots of the data for all countries revealed a quadratic trend in the level and stationarity for the first differences, confirming that all the series were integration of one order.

5.2 Bivariate Cointegration/Convergence Results

Table 5.1 presents a summary of the rolling bivariate cointegration results. The detailed results are presented in Appendix Tables 1 to 3. These results show that over the period, Kenya achieved minimal or no convergence with other members of the EAC. Kenya achieved no convergence for the entire sample for Rwanda, Uganda and Burundi; only CSC with Tanzania; and unconditional stochastic convergence, USC and dynamic convergence for one sub-sample with Rwanda and two sub-samples with Uganda. There were several periods of $SCSC$ but these were interrupted with periods of no convergence. Uganda/Burundi had either $SCSC$ for all the sub-samples except for the 13th up to 17th sub-sample where $DCSC$ existed; Uganda/Rwanda had $SCSC$ for all but the 8th sub-sample where no convergence existed and the last sub-sample where $DCSC$ was achieved while Uganda/Tanzania had $SCSC$ for all the sub-samples except the 14th up to 18th sub-samples where $DCSC$ pertained. Tanzania/Burundi begun with a situation of no convergence for the first three sub-samples, thereafter had intermittent situations of $SCSC$ and $DCSC$ until the last sub-sample where ZMC was attained. ZMC was also attained for the entire sample, implying that the two exchange rate series had achieved convergence by the end of the period but this was not true for the entire period.

Tanzania/Rwanda initially had no convergence, but attained $SCSC$ for the third and fourth sub-sample, reverted back to no convergence for three sub-samples and then $SCSC$ until the last sub-sample where ZMC was attained. Rwanda/Burundi begun with no convergence, moved to ZMC for the 3rd up to the 5th sub-sample but thereafter experienced diverging forces leading to $SCSC$ for several sub-samples and ultimately no convergence for the 10th and 11th sub-samples. Thereafter there were intermittent situations of no convergence and $SCSC$ until the 17th sub-sample which advanced to $DCSC$ for the last sub-sample.

The results show that four years after signing the EAC treaty, the macroeconomic policies implemented did not lead to convergence of the exchange rates in Kenya and Tanzania. Some convergence between Uganda and Kenya was indicated shortly after signing the EAC treaty between the two countries in 1999 but this was short-lived. It seems that Burundi joining the EAC in 2007 did not necessarily lead to macroeconomic policies that could lead to convergence of the exchange rate policies in Kenya and Burundi. Kenya and Rwanda have experienced the least convergence compared to other countries in the EAC. Rwanda joining the EAC in 2007 seems to have delivered some results in the form of $SCSC$ with Kenya but this was short-lived with diverging forces leading to no convergence.

Uganda and Burundi have for the most part had exchange rates that have been conditionally converging at a point in time, dynamic convergence begun before Burundi joined the EAC in 2007 but dynamic-diverging forces were in effect at the end of the study period. Uganda and Tanzania joined the EAC in 1999, however, they have not attained ZMC at all. The results show that the forces of exchange rate convergence for Rwanda and Tanzania begun before Rwanda joined the EAC in 2007. Although slow in coming, joining the EAC seems to have reinforced the forces leading to convergence of the exchange rates over time for these two countries.

Most of the cases of no convergence were characterised with conditional deterministic divergent forces (CDD) with a few cases unconditional deterministic convergence (UDD)for Kenya and Rwanda and Kenya and Burundi as high-lighted in the tables.

Table 5.1: Bivariate Convergency Tests using Equation 1

Period	**Description of Country**									
	***i* = KEN**				**i = UGA**			**i = TZA**		**i = RWA**
	Country j				**Country j**			**Country j**		**Country j**
	BDI	**RWA**	**TZA**	**UGA**	**BDI**	**RWA**	**TZA**	**BDI**	**RWA**	**BDI**
1960-2011	NC	NC	**CSC***	NC	CSC*	CSC*	CSC*	**ZMC**	**ZMC**	**ZMC**
1960-1993	NC	**CSC***	**CSC***	CSC*^{A}	NC	**CSC*^{A}**	**CSC*^{A}**	NC	NC	NC
1961-1994	CSC* δ↑	CSC** δ↓	NC	CSC* δ↑	**CSC*^{A}** δ↑	**CSC*^{A}** δ↑	CSC* δ↑	NC	NC	CSC* δ↑
1962-1995	**CSC*^{A}** δ↑	NC	**CSC*^{A}** δ↑	**CSC*^{A}** δ↑	**CSC*^{A}** δ↑	**CSC*^{A}** δ↑	CSC* δ↑	NC	**CSC*^{A}** δ↑	**ZMC**
1963-1996	CSC* δ↑	CSC* δ↑	CSC* δ↑	CSC* δ↑	**CSC*^{A}** δ↑	CSC* δ↑	CSC* δ↑	**CSC*^{A}** δ↑	**CSC*^{A}** δ↑	**ZMC**
1964-1997	**USC*** δ↑	CSC* δ↑	CSC* δ↑	CSC* δ↑	CSC* δ↑	CSC* δ↑	CSC* δ↑	**CSC*^{A}** δ↑	NC	**ZMC^{A}** **CSC*^{P}**
1965-1998	NC	NC	CSC* δ↑	NC	CSC* δ↑	**CSC*^{P}** δ↑	CSC* δ↑	**CSC*^{A}** δ↑	NC	CSC* δ↑
1966-1999	NC	NC	CSC* δ↑	NC	CSC* δ↑	**CSC*^{A}** δ↑	CSC* δ↑	**CSC*^{A}** δ↑	NC	CSC* δ↑
1967-2000	CSC* δ↑	NC	NC	CSC** δ↓	CSC* δ↑	NC	**CSC*^{P}** δ↑	CSC** δ↓	**CSC*^{A}** δ↑	**CSC*^{A}** δ↑
1968-2001	**CSC*^{A}** δ↑	NC	NC	**CSC*^{A}**	CSC* δ↑	CSC* δ↑	**CSC*^{P}** δ↑	CSC** δ↓	**CSC*^{A}** δ↑	**CSC*^{A}** δ↑
1969-2002	**CSC*^{A}** δ↑	NC	NC	**CSC*^{A}**	CSC* δ↑	CSC* δ↑	CSC* δ↑	CSC** δ↓	**CSC*^{A}** δ↑	NC
1970-2003	NC	NC	NC	**CSC*^{A}** δ↑	CSC* δ↑	CSC* δ↑	CSC* δ↑	**CSC**^{A}** δ↓	**CSC*^{A}** δ↑	NC
1971-2004	**CSC*^{A}** δ↑	NC	**CSC*^{A}** δ↑	CSC* δ↑	CSC* δ↑	CSC* δ↑	CSC* δ↑	**CSC**^{A}** δ↓	CSC* δ↑	**CSC**** δ↑
1972-2005	**CSC*^{A}** δ↑	NC	**CSC*^{A}** δ↑	CSC* δ↑	CSC** δ↓	CSC* δ↑	CSC* δ↑	CSC** δ↓	CSC* δ↑	NC
1973-2006	**CSC*^{A}** δ↑	NC	NC	CSC* δ↑	CSC* δ↑	CSC* δ↑	CSC** δ↓	CSC* δ↑	**CSC*^{A}** δ↓	CSC* δ↑
1974-2007	**CSC*^{A}** δ↑	NC	NC	CSC* δ↑	CSC** δ↓	CSC* δ↑	CSC** δ↓	CSC* δ↑	CSC* δ↑	**CSC*^{A}** δ↑
1975-2008	**CSC*^{A}** δ↑	**CSC*^{A}** δ↑	**CSC*^{A}** δ↑	CSC* δ↑	**CSC**^{A}** δ↓	CSC* δ↑	CSC** δ↓	CSC** δ↓	CSC* δ↑	NC
1976-2009	**CSC*^{A}** δ↑	CSC* δ↑	**CSC*^{P}** δ↑	CSC* δ↑	CSC** δ↓	CSC* δ↑	CSC** δ↓	CSC** δ↓	CSC* δ↑	**CSC*^{A}** δ↑
1977-2010	NC	NC	**CSC*^{P}** δ↑	CSC* δ↑	CSC* δ↑	CSC* δ↑	CSC** δ↓	CSC* δ↑	CSC* δ↑	CSC* δ↑
1978-2011	CSC* δ ↑	NC	CSC** δ ↓	CSC* δ↑	CSC* δ↑	CSC** δ↓	CSC* δ↑	**ZMC**	**ZMC**	CSC** δ↓

Explanatory notes for Table 5.1a and 5.1b: *1. The necessary condition for convergence is defined as having $u_{ij} \sim I(0)$ from equation 1, the sufficient condition for condition stochastic convergence be declining δ in absolute terms as $Y_i - Y_j$ gets smaller overtime. 2. The change in δ is not defined for the first sub-sample. 3. A single asterics (*) implies satisfaction of the necessary condition as defined above while a double asterics implies satisfaction of both the necessary and sufficient conditions. 4. In cases of mixed results, stationarity was assumed as long as one of the tests indicated stationarity. A superscript A implies that the ADF test was significant but the PP test was not while superscript P implies the opposite. 5. The change in δ for the first sub-sample (1960-1993) is not defined. 6. NC implies no convergence, other symbols remain as defined earlier. BDI, KEN, RWA, TZA and UGA stand for Burundi, Kenya, Rwanda, Tanzania, and Uganda, respectively.*

5.3 Tests for Cointegration/Parameter Stability Using the Sup LM Test

The Sup LM test results in Table 5.2 show that the null of cointegration or (constancy of parameters) for the entire sample, was rejected in favor of the alternative of no cointegration or parameter variability for all the possible pairs

Table 5.2: Parameter Stability Test: $SUP \quad LM$ Test Results

Dep. Var.	Ind. Var.	Break Period	ρ	Critical Value for 1% [a]	$SUP \quad LM$ Test Statistic	Conclusion
Burundi	Kenya	2008	1	11.341	46.6297***[b]	Parameter Variability
Kenya	Rwanda	1998	3	17.204	31.825***	Parameter Variability
Kenya	Tanzania	2008	1	11.341	35.069***	Parameter Variability
Kenya	Uganda	2008	1	11.341	16.733***	Parameter Variability
Uganda	Burundi	2008	2	14.678	45.0402***	Parameter Variability
Uganda	Rwanda	2008	2	14.678	42.8022***	Parameter Variability
Uganda	Tanzania	1995	4	19.54	38.6663***	Parameter Variability
Tanzania	Burundi	2006	5	21.781	41.1745***	Parameter Variability
Tanzania	Rwanda	1995	1	11.341	35.2164***	Parameter Variability
Rwanda	Burundi	2008	2	14.678	28.3906***	Parameter Variability

*[a)] The Critical values were computed using τ (0.65, 0.95) with a value of $\lambda = 10.2307$ computed as recommended by Andrew 1993, page 839 where $\lambda = \pi_2(1-\pi_1)/(\pi_1(1-\pi_2))$. The specific critical values for this value of λ were obtained by interpolation since it is not directly tabulated. [b)] The ***signifies rejection of the null of cointegration/constancy of parameter at the 1% level of significance. Critical values for 5% and 10% for $\lambda = 10.2307$ can be obtained from the author by request.*

of the five member countries of the EAC. This does not imply that the best model was model 5 but that the regression coefficient estimates rather than converge uniformly in different parts of the sample space to the cointegrating relationship, they converge to random variables which take on different values for different samples; and that the standard model of cointegration ((constancy of parameters) for the entire sample is rejected in favour of the alternative formulations of parameter variability. This justifies the rolling cointegration analysis. The rolling cointegration analysis was undertaken using a variation of Model 3, since the coefficients of C and T vary for the different sub-samples. For the structural break models, re-evaluation of the cointegration was done using the point-wise LM test statistics and Model 5 in particular. The results are presented in Table 5.3.

The point-wise LM statistics computed at 5% increments between τ = 0.65 and τ = 0.95% for 7 structural break points rejected the null of no serial correlation (no unit root) with a probability of zero for 66 out of 70 scenarios, implying significance at the 1% level; and at the 5% level of significance for 3 out of the70 cases as presented in Table 5.3. For the 69 cases, these results indicate that the structural break alternatives are superior to the standard cointegration model, implying parameter variability. This approach is thus complementary to the rolling cointegration analysis, which assumes that parameter variability over time.

The null hypothesis of no serial correlation, thus the null of cointegration/constancy of parameters was not rejected for the case of Kenya and Uganda for the model with the 1993 structural break point. This implies that there was a structural break in 1993 and that cointegration was achieved after the structural break. This implied the existence of cointegration with a C/T regime shift since all the parameters except the slope change variable in the estimated model were significant at the 1% level of significance. The slope shift coefficient was only significant at the 12.02% level of significance. This would imply that the long-run cointegration parameters must have shifted at least one time during the period of analysis.

Table 5.3: Point-Wise LM Tests for the Null Hypothesis of No Unit Root in Regime Shift Models

Dep. Var.	Ind. Var.	LM Test rejection of null of no unit root for the different structural break periods at the 1% (***), 5% (**) and 10% (*)						
BDI	KEN	1993***	1995***	1998**	2001***	2003***	2006***	2008***
KEN	RWA	1993***	1995***	1998***	2001***	2003***	2006***	2008***
KEN	TAN	1993***	1995***	1998***	2001**	2003**	2006***	2008***
KEN	UGA	1993[NS]	1995***	1998***	2001***	2003***	2006***	2008***
UGA	BUR	1993***	1995***	1998***	2001***	2003***	2006***	2008***
UGA	RWA	1993***	1995***	1998***	2001***	2003***	2006***	2008***
UGA	TAN	1993***	1995***	1998***	2001***	2003***	2006***	2008***
TAN	BUR	1993***	1995***	1998***	2001***	2003***	2006***	2008***
TAN	RWA	1993***	1995***	1998***	2001***	2003***	2006***	2008***
RWA	BUR	1993***	1995***	1998***	2001***	2003***	2006***	2008***

BDI, KEN, RWA, TZA and UGA stand for Burundi, Kenya, Rwanda, Tanzania, and Uganda, respectively.

The standard cointegration model for the entire sample did not capture the cointegration relationship possibly due to the major structural break that may have occurred in 1993. The fact that the null of no serial correlation is, however, rejected for all break points after the 1993 break point, implies that there was no major structural break after 1993, implying parameter stability thereafter. However, this is contrary to the parameter variability- established using rolling cointegration analysis but confirms what has been sighted in literature that tests for structural breaks may pick the major structural breaks but may fail to capture the gradual changes that occur over time, even between structural breaks during the process of adjustment, which the rolling cointegration captures. It is important to note that the effect of most of the reforms is gradual and it can only be captured overtime. Also, since the timing of the shifts is in most cases unknown, the rolling cointegration analysis is a good framework for monitoring the adjustment process and should be used in combination with structural break models which signal the major structural breaks.

6. Conclusion and Recommendations

6.1 Conclusions

Overall, Kenya, Rwanda and Burundi seem to show up more often as lacking convergence, with Uganda and Tanzania having some degree of convergence for all samples. Kenya and Tanzania have also had several instances of non-convergence with each other. There were isolated situations of Zero Mean Convergence but there was no situation where such convergence was attained for all the sub-samples and was attained for only three entire samples (Tanzania/Burundi, Tanzania/Rwanda and Rwanda/Burundi). Conditional deterministic divergence was also detected for most of the situations of no convergence. These results are supported by the $Sup-LM$ test for cointegration/parameter stability which revealed the fact that parameters were not stable for the period of analysis. Lack of complete convergence of the exchange rates for all the pairs of the EAC member countries implies that the macroeconomic reforms implemented to date have not yet harmonized the macroeconomic environment in the EAC with crucial implications for the success of the EAMU.

6.2 Recommendations

The EAC should undertake an extensive study of the factors influencing the exchange rates in the member countries, high-lighting the role of the different factors in the different economies and devise means/reforms for harmonising these factors in a manner that ensures that the exchange rates are stabilized and converging over time. These measures include but are not limited to: (i) designing mechanisms for harmonising the exchange rate regimes which currently differ; (ii) devising mechanisms/rules for efficiently and effectively managing aid inflows which requires countries to balance the risks of inflation, appreciation, and increases in interest rates and thorough review of the current liquidity management policies; (iii) investigating the extent of fiscal dominance which according to Anand et al (2011), Baldini and Ribeiro (2008), and Crowe and Meade's (2007), is an outstanding characteristic of EAC member countries, both from a legal and a practical point of view; to establish the effect of such dominance on the effectiveness of monetary policy and on attainance of the convergence criteria in particular; and devising means of reducing fiscal dominance both legally and in practice thereby providing the precursor for harmonizing the monetary policy/instruments in the EAC; (iv) evaluating the effectiveness of the macroeconomic reforms implemented to date and revisiting the macroeconomic policies, particularly the fiscal policy frameworks currently in place by crafting prudent and coordinated fiscal policy thereby ensuring business cycle synchronization; and (v) harmonizing the financial markets systems and their operations, which have differing levels of development.

For, empirical studies investigating stability of long-run cointegration/convergence relationships, it is recommended that they endeavor to capture the gradual changes which occur over time in addition to the major changes that are traditionally captured by the structural break tests. Capturing the gradual changes can be used to capture the impact of certain events on the equilibrium relationship, which may be obscured by empirical investigations that focus on the entire data set only. This would reveal the changes which occur before, during the adjustment period and up to the end of the adjustment, or even after the adjustment, depending on the data availability and whether complete adjustment has occurred. This can signal investigation of other factors in the environment which may have affected the adjustment process at different points in time.

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Appendix: Detailed Rolling Bi-variate Cointegration and Convergence Results

Table 1. Detailed Bivariate Convergency Tests Results, using equation 1: Country i = Kenya

Period	Burundi		Rwanda		Tanzania		Uganda	
Country i	Constant	Trend	Constant	Trend	Constant	Trend	Constant	Trend
Kenya **(1960-2011)**	236.23 (0.0003)[a] $u_{ij} \sim I(1)^{**ADF}$ $u_{ij} \sim I(1)^{***PP}$ no conv.	-21.04 (0.000)	96.526 (0.0524) $u_{ij} \sim I(2)^{*}$ **both ADF and PP**	-11.11 (0.000)	331.61 (0.000) $u_{ij} \sim I(0)^{*}$ conver. **both ADF and PP**	-24.55 (0.000)	613.037 (0.000) $u_{ij} \sim I(1)^{***}$ no conv. **both ADF and PP**	-46.15 (0.000)
1960-1993 **(s=34 before sample adjustments)**	-36.046 (0.000) $u_{ij} \sim I(1)^{**}$ $u_{ij} \sim I(1)^{***PP}$	-3.075 (0.000)	62.653 (0.0000) $u_{ij} \sim I(0)^{*}$ L1 $u_{ij} \sim I(0)^{**PP}$	-0.727 (0.021)	60.054 (0.0132) $u_{ij} \sim I(0)^{*}$ L3 (implies 3 lags in adf test) $u_{ij} \sim I(0)^{*}$ ppboarder line	-5.523 (0.000)	197.57 (0.028) $u_{ij} \sim I(0)^{*ADF}$ L0 $u_{ij} \sim I(1)^{**PP}$	-17.11 (0.003)
1961-1994	-32.186 (0.0001) $u_{ij} \sim I(0)^{***ADF}$ $u_{ij} \sim I(1)^{***PP}$	-3.362 (0.000)	-65.507 (0.0000) $u_{ij} \sim I(0)^{***ADF}$ $u_{ij} \sim I(0)^{**PP}$	-0.6 (0.048)	87.512 (0.0072) $u_{ij} \sim I(2)^{***}$ **both ADF and PP**	-7.4294 (0.000)	253.166 (0.0111) $u_{ij} \sim I(0)^{**}$ L2 $u_{ij} \sim I(1)^{**PP}$	-20.67 (0.000)
1962-1995	-28.549 (0.0015) $u_{ij} \sim I(0)^{***}$ $u_{ij} \sim I(1)^{***PP}$	-3.611 (0.000)	-60.17522 (0.000) $u_{ij} \sim I(1)^{**ADF}$ $u_{ij} \sim I(2)^{*PP}$	-1.096 (0.023)	120.887 (0.0033) $u_{ij} \sim I(0)^{***ADF}$ L2 $u_{ij} \sim I(2)^{***PP}$	-9.549 (0.000)	309.932 (0.0041) $u_{ij} \sim I(0)^{**}$ L1 $u_{ij} \sim I(1)^{***PP}$	-23.915 (0.000)
1963-1996	-21.892 (0.0394) $u_{ij} \sim I(0)^{***}$ **both ADF and PP**	-4.050 (0.000)	-52.02271 (0.0010) $u_{ij} \sim I(0)^{***}$ **both ADF and PP**	-1.737 (0.0097)	155.189 (0.0011) $u_{ij} \sim I(0)^{***ADF}$ $u_{ij} \sim I(0)^{**PP}$	-11.507 (0.000)	372.683 (0.0014) $u_{ij} \sim I(0)^{**ADF}$ L3 $u_{ij} \sim I(0)^{**PP}$	-27.239 (0.000)
1964-1997	-11.897 (0.3786) $u_{ij} \sim I(0)^{***}$ **both ADF and PP**	-4.67 (0.000)	-44.493 (0.0145) $u_{ij} \sim I(0)^{***}$ **both ADF and PP**	-2.28 (0.0037	192.3821 (0.0003) $u_{ij} \sim I(0)^{***ADF}$ $u_{ij} \sim I(0)^{**PP}$	-13.459 (0.000)	438.33 (0.0004) $u_{ij} \sim I(0)^{**ADF}$ L3 $u_{ij} \sim I(0)^{***PP}$	-30.436 (0.000)
1965-1998	5.494 (0.7802) $u_{ij} \sim I(2)^{**}$ **both ADF and PP**	-5.685 (0.0000)	-36.483 (0.0743) $u_{ij} \sim I(1)^{**}$ **both ADF and PP**	-2.808 (0.0015)	233.953 (0.0001) $u_{ij} \sim I(0)^{***ADF}$ $u_{ij} \sim I(0)^{*PP}$	-15.50 (0.000)	-34.103 (0.0001) $u_{ij} \sim I(1)^{***}$ L1 **both ADF and PP**	516.352 (0.000)
1966-1999[d]	37.200 (0.1947) $u_{ij} \sim I(2)^{**}$ **both ADF and PP**	-7.313 (0.0000)	-27.87883 (0.2186) $u_{ij} \sim I(1)^{***}$ **both ADF and PP**	-3.331 (0.0000)	281.5088 (0.000) $u_{ij} \sim I(0)^{***ADF}$ $u_{ij} \sim I(0)^{*PP}$	-17.71 (0.000)	-38.438 (0.0000) $u_{ij} \sim I(1)^{***}$ L1 **both ADF and PP**	611.410 (0.000)
1967- 2000	83.785 (0.0477) $u_{ij} \sim I(0)^{***}$ **L0 both ADF and PP**	-9.594 (0.000)	-9.168800 (0.7218) $I(1)^{***}$ **both ADF and PP**	-4.238 (0.000)	333.1195 (0.000) $I(1)^{**}$ **both ADF and PP**	-19.96 (0.000)	722.02 (0.000) $u_{ij} \sim I(0)^{***}$ **L0 both ADF and PP**	-43.275 (0.000)
1968-2001	141.1745 (0.0128) $u_{ij} \sim I(0)^{***}$ **L0 both ADF and PP**	-12.24 (0.000)	16.66 (0.5761) $I(1)^{***}$ **both ADF and PP**	-5.398 (0.000)	390.893 (0.0000) $I(1)^{***}$ **both ADF and PP**	-22.36 (0.000)	840.816 (0.000) $u_{ij} \sim I(0)^{*ADF}$ L1 $u_{ij} \sim I(1)^{***PP}$	-48.179 (0.000)
1969-2002	208.866 (0.0035) $u_{ij} \sim I(0)^{**ADF}$ L2 $u_{ij} \sim I(1)^{*PP}$	-15.19 (0.000)	45.96319 (0.1774) $I(1)^{***}$ **both ADF and PP**	-6.637 (0.000)	456.389 (0.000) $I(1)^{***}$ **both ADF and PP**	-24.98 (0.000)	960.128 (0.0000) $u_{ij} \sim I(0)^{**ADF}$ L1 $u_{ij} \sim I(1)^{***PP}$	-52.779 (0.000)
1970-2003	292.869 (0.0010) $u_{ij} \sim I(2)^{***}$ **both ADF and PP**	-18.68 (0.000)	82.304 (0.0388) $I(1)^{***}$ L1 **both ADF and PP**	-8.112 (0.000)	527.805 $u_{ij} \sim I(1)^{*}$ **both ADF and PP**	-27.69 (0.000)	1092.597 (0.0000) $u_{ij} \sim I(0)^{**ADF}$ L1 $I(1)^{***PP}$	-57.703 (0.000)
1971-2004	377.5098 (0.0003) $u_{ij} \sim I(0)^{**ADF}$ L2 $u_{ij} \sim I(1)^{**PP}$	-21.97 (0.000)	122.5605 (0.0072) $u_{ij} \sim I(1)^{***}$ **both ADF and PP**	-9.658 (0.000)	601.7236 (0.0000) $u_{ij} \sim I(0)^{*ADF}$ L1 $u_{ij} \sim I(1)^{**PP}$	-30.358 (0.000)	1200.509 (0.0000) $u_{ij} \sim I(0)^{**ADF}$ L1 $u_{ij} \sim I(0)^{*PP}$	-61.259 (0.000)

1972-2005	458.3622 (0.0001) u_{ij} ~I(0)**ADF L1 u_{ij}~I(1)**PP	-24.89 (0.000)	160.29 (0.0012) u_{ij} ~I(1)***ADF L0 u_{ij}~I(1)***PP **both ADF and PP**	-10.998 (0.000)	677.0224 (0.0000) u_{ij} ~I(0)**ADF L1 u_{ij} ~I(1)**PP	-32.94 (0.000)	1296.758 (0.000) u_{ij} ~I(0)**ADF L1 u_{ij} ~I(0)**PP	-64.152 (0.000)
1973-2006	530.2763 (0.0000) u_{ij} ~I(0)***ADF L2 u_{ij} ~I(1)*PP	-27.28 (0.000)	195.272 (0.0002) u_{ij} ~I(1)*** **both ADF (L0) and PP**	-12.17 (0.000)	763.374 (0.0000) u_{ij} ~I(1)*** **both ADF (L0) and PP**	-35.82 (0.000)	1389.582 (0.0000) u_{ij} ~I(0)**ADF L1 u_{ij} ~I(0)**PP	-66.796 (0.000)
1974-2007	604.577 (0.0000) u_{ij} ~ I(0)***ADF u_{ij} ~ I(1)***PP	-29.65 (0.000)	227.1991 (0.0000) u_{ij} ~ I(1)*** u_{ij} ~ I(1)***PP **both ADF and PP**	-13.17 (0.000)	843.878 (0.000) u_{ij} ~ I(1)*** **both ADF and PP**	-38.34 (0.000)	1457.361 (0.000) u_{ij} ~ I(0)*** L1 u_{ij} ~ I(0)**PP	-68.38 (0.000)
1975-2008	687.703 (0.0000) u_{ij} ~ I(0)***ADF u_{ij} ~ I(1)***PP	-32.24 (0.000)	258.686 (0.0000) u_{ij} ~ I(0)*ADF L1 u_{ij} ~ I(1)***PP	-14.09 (0.000)	910.920 (0.0000) u_{ij} ~ I(0)*ADF L1 u_{ij} ~ I(1)***PP	-40.24 (0.000)	1511.109 (0.0000) u_{ij} ~ I(0)***ADF L1 u_{ij} ~ I(0)**PP	-69.43 (0.000)
1976-2009	770.332 (0.0000) u_{ij} ~ I(0)***ADF u_{ij} ~ I(1)***PP	-34.69 (0.000)	289.66 (0.0000) u_{ij} ~ I(0)*ADF L1 u_{ij} ~ I(0)*PP	-14.95 (0.000)	986.394 (0.000) u_{ij} ~ I(1)*ADF u_{ij} ~ I(0)**pp	-42.39 (0.000)	1592.05 (0.000) u_{ij} ~ I(0)**ADF u_{ij} ~ I(0)**PP	-71.495 ((0.000)
1977-2010	847.662 (0.000) u_{ij} ~ I(1)*** **both ADF and PP**	-36.84 (0.000)	320.739 (0.000) u_{ij} ~ I(1)*** **both ADF and PP**	-15.77 (0.000)	1065.63 (0.000) u_{ij} ~I(1)*** L0 u_{ij} ~ I(0)*pp	-44.59 (0.0000)	1677.219 (0.0000) u_{ij} ~I(0)*** L1 **ADF** u_{ij} ~ I(0)**pp	-73.687 (0.000)
1978-2011	921.593 (0.000) u_{ij} ~I(0)** L1 **ADF** u_{ij} ~ I(0)*pp	-38.79 (0.000)	495.242 (0.0001) u_{ij} ~ I(2)* **both ADF and PP**	-21.4 (0.0000)	1012.41 (0.0000) u_{ij} ~I(0)** **both ADF and PP**	-42.256 (0.000)	1794.141 (0.0000) u_{ij} ~I(0)*** L1 **ADF** u_{ij} ~ I(0)**pp	-76.929 (0.000)

[a] Figures in parenthesis are probabilities.

Notes to Appendix Tables: *The optimal number of lags for the ADF test were determined using the Akaike and Shwatz Criteria. All samples from 1961-2006 were tested for zero mean convergence using both the PP and Dickey Fuller tests and not Adf (no lags in the test). In case of any autocorrelation in the errors, the PP test would cater for the short-coming. Mixed results are probably due to the problem of the ADF failing to detect situations where the coefficient is close to 1 but not quite 1, in the situations where the PP indicates stationarity while the ADF test indicates non-stationarity. In cases of mixed results, stationarity was assumed as long as one of the tests indicated stationarity. The ADF test results were preferred to the PP* test results *in case of mixed results based on the two tests. For zero mean convergence, the value of the constant and trend coefficients are equal to zero as defined in the main text.*

Table 2. Detailed Bivariate Convergency Tests Results using Equation 1: Country i = Uganda

Period	Burundi		Rwanda		Tanzania	
Country *i*	Constant	Trend	Constant	Trend	Constant	Trend
Uganda **1960-2011**	-376.80 (0.000) $u_{ij} \sim I(0)^{**}$ ADF $u_{ij} \sim I(0)^{**}$ PP	25.11 (0.000)	-516.51 (0.000) $u_{ij} \sim I(0)^{*}$ almost ** ADF $u_{ij} \sim I(0)^{**}$ PP	35.038 (0.000)	-281.43 (0.0002) $u_{ij} \sim I(0)^{*}$ ADF $u_{ij} \sim I(0)^{*}$ PP	21.608 (0.000)
1960-1993 **(s=33)**	-233.61 (0.0067) $u_{ij} \sim I(1)^{***}$ ADF $u_{ij} \sim I(1)^{**}$ PP	14.035 (0.0014)	-260.22 (0.0047) $u_{ij} \sim I(0)^{**}$ ADF **L2** $u_{ij} \sim I(1)^{**}$ PP	16.383 (0.0006)	-137.514 (0.0395) $u_{ij} \sim I(0)^{**}$ ADF **L1** $u_{ij} \sim I(1)^{***}$ PP	11.588 (0.001)
1961-1994	-285.352 (0.0027) $u_{ij} \sim I(0)^{*}$ ADF **L2** $u_{ij} \sim I(1)^{**}$ PP	17.308 (0.0002)	-318.67 (0.0018) $u_{ij} \sim I(0)^{**}$ ADF **L2** $u_{ij} \sim I(1)^{**}$ PP	20.07 (0.0001)	-165.654 (0.0196) $u_{ij} \sim I(0)^{*}$ ADF **L2** $u_{ij} \sim I(0)^{*}$ PP	13.241 (0.0003)
1962-1995	-338.48 (0.0010) $u_{ij} \sim I(0)^{**}$ ADF **L3** $u_{ij} \sim I(1)^{***}$ PP	20.304 (0.000)	-370.11 (0.0007) $u_{ij} \sim I(0)^{***}$ ADF **L1** $u_{ij} \sim I(1)^{**}$ PP	22.82	-189.045 (0.0107) $u_{ij} \sim I(0)^{**}$ ADF **L3** $u_{ij} \sim I(0)^{**}$ PP	14.367 (0.0001)
1963-1996	-394.575 (0.0003) $u_{ij} \sim I(0)^{*}$ ADF **L4** $u_{ij} \sim I(1)^{***}$ PP	23.189 (0.000)	-424.705 (0.0002) $u_{ij} \sim I(0)^{*}$ ADF **L3** $u_{ij} \sim I(0)^{*}$ PP	25.5029 (0.0000)	-217.4937 (0.0051) $u_{ij} \sim I(0)^{*}$ ADF **L4** $u_{ij} \sim I(0)^{**}$ PP	15.732 (0.000)
1964-1997	-450.2225 (0.0001) $u_{ij} \sim I(0)^{**}$ ADF **L3** $u_{ij} \sim I(0)^{*}$ PP	25.766 (0.0000)	-482.818 (0.0001) $u_{ij} \sim I(0)^{**}$ ADF **L3** $u_{ij} \sim I(0)^{*}$ PP	28.156 (0.0000)	-245.9433 (0.0024) $u_{ij} \sim I(0)^{***}$ ADF **L3** $u_{ij} \sim I(0)^{**}$ PP	16.977 (0.000)
1965-1998	-510.8588 (0.0000) $u_{ij} \sim I(0)^{**}$ ADF **L3** $u_{ij} \sim I(0)^{*}$ PP	28.417 (0.0000)	-552.835 (0.0000) $u_{ij} \sim I(1)^{***}$ ADF **L2** $u_{ij} \sim I(0)^{*}$ PP	31.295(0.0000)	-282.40 (0.0009) $u_{ij} \sim I(0)^{**}$ ADF **L5** $u_{ij} \sim I(0)^{**}$ PP	18.605 (0.0000)
1966-1999	-574.210 (0.0000) $u_{ij} \sim I(0)^{**}$ ADF **L3** $u_{ij} \sim I(0)^{*}$ PP	31.125 (0.0000)	-639.2893 (0.0000) $u_{ij} \sim I(0)^{***}$ ADF **L1** $u_{ij} \sim I(1)^{***}$ PP	35.108 (0.0000)	-329.902 (0.0003) $u_{ij} \sim I(0)^{**}$ ADF **L5** $u_{ij} \sim I(0)^{**}$ PP	20.732 (0.0000)
1967- 2000	-638.235 (0.0000) $u_{ij} \sim I(0)^{**}$ ADF **L3** $u_{ij} \sim I(0)^{*}$ PP	33.682 (0.0000)	-731.188 (0.0000) $u_{ij} \sim I(1)^{***}$ ADF **L1** $u_{ij} \sim I(1)^{***}$ PP	39.037 (0.0000)	-388.900 (0.0001) $u_{ij} \sim I(1)^{***}$ ADF **L1** $u_{ij} \sim I(0)^{*}$ PP	23.316 (0.0000)
1968-2001	-699.641 (0.0000) $u_{ij} \sim I(0)^{**}$ ADF **L3** $u_{ij} \sim I(0)^{*}$ PP	35.937 (0.0000)	-824.156 (0.0000) $u_{ij} \sim I(0)^{*}$ ADF **L2** $u_{ij} \sim I(0)^{*}$ PP	42.781 (0.000)	-449.923 (0.0000) $u_{ij} \sim I(1)^{***}$ ADF **L1** $u_{ij} \sim I(0)^{**}$ PP	25.817 (0.0000)
1969-2002	-751.262 (0.0000) $u_{ij} \sim I(0)^{***}$ ADF **L1** $u_{ij} \sim I(0)^{**}$ PP	37.588 (0.0000)	-914.165 (0.0000) $u_{ij} \sim I(0)^{*}$ ADF **L2** $u_{ij} \sim I(0)^{*}$ PP	46.142 (0.0000)	-503.739 (0.0000) $u_{ij} \sim I(0)^{*}$ ADF **L4** $u_{ij} \sim I(0)^{**}$ PP	27.803 (0.0000)
1970-2003	-799.728 (0.0000) $u_{ij} \sim I(0)^{***}$ ADF **L1** $u_{ij} \sim I(0)^{**}$ PP	39.019 (0.0000)	-1010.292 (0.0000) $u_{ij} \sim I(0)^{*}$ ADF **L2** $u_{ij} \sim I(0)^{*}$ PP	49.591 (0.0000)	-564.792 (0.0000) $u_{ij} \sim I(0)^{***}$ ADF **L1** $u_{ij} \sim I(0)^{**}$ PP	30.010 (0.0000)
1971-2004	-822.999 (0.0000) $u_{ij} \sim I(0)^{***}$ ADF **L1** $u_{ij} \sim I(0)^{**}$ PP	39.289 (0.0000)	-1077.948 (0.0000) $u_{ij} \sim I(0)^{***}$ ADF **L1** $u_{ij} \sim I(0)^{**}$ PP	51.601 (0.000)	-598.785 (0.0000) $u_{ij} \sim I(0)^{***}$ ADF **L1** $u_{ij} \sim I(0)^{**}$ PP	30.901 (0.0000)
1972-2005	-838.396 (0.0000) $u_{ij} \sim I(0)^{***}$ ADF **L1** $u_{ij} \sim I(0)^{*}$ PP	39.263 (0.0000)	-1136.468 (0.0000) $u_{ij} \sim I(0)^{***}$ ADF **L1** $u_{ij} \sim I(0)^{**}$ PP	53.154 (0.0000)	-619.736 (0.0000) $u_{ij} \sim I(0)^{***}$ ADF **L1** $u_{ij} \sim I(0)^{**}$ PP	31.220 (0.0000)
1973-2006	-859.305 (0.0000) $u_{ij} \sim I(0)^{***}$ ADF **L1** $u_{ij} \sim I(0)^{**}$ PP	39.520 (0.0000)	-1194.309 (0.0000) $u_{ij} \sim I(0)^{***}$ ADF **L1** $u_{ij} \sim I(0)^{**}$ PP	54.630 (0.0000)	-626.208 (0.0000) $u_{ij} \sim I(0)^{***}$ ADF **L1** $u_{ij} \sim I(0)^{**}$ PP	30.975 (0.0000)
1974-2007	-852.78 (0.000) $u_{ij} \sim I(0)^{**}$ ADF L1 $u_{ij} \sim I(0)^{***}$ PP	38.732 (0.000)	-1230.16 (0.000) $u_{ij} \sim I(0)^{***}$ ADF L1 $u_{ij} \sim I(0)^{**}$ PP	55.211 (0.000)	-613.4834 (0.000) $u_{ij} \sim I(0)^{***}$ ADF L1 $u_{ij} \sim I(0)^{**}$ PP	30.041 (0.000)

1975-2008	-823.4 (0.000) $u_{ij} \sim I(0)^{*}$ L1 $u_{ij} \sim I(1)^{***PP}$	37.191 (0.000)	-1252.42 (0.0000) $u_{ij} \sim I(0)^{***}$ L1 $u_{ij} \sim I(0)^{**PP}$	55.343(0.000)	-600.1 (0.000) $u_{ij} \sim I(0)^{***}$ L1 $u_{ij} \sim I(0)^{**PP}$	29.18 (0.000)
1976-2009	-821.717 (0.000) $u_{ij} \sim I(0)^{***ADF}$ $u_{ij} \sim I(0)^{*PP}$	36.803 (0.000)	-1302.4 (0.000) $u_{ij} \sim I(0)^{***\ ADF}$ L1 $u_{ij} \sim I(0)^{**PP}$	56.548 (0.000)	-605.655 (0.000) $u_{ij} \sim I(0)^{***\ ADF}$ L1 $u_{ij} \sim I(0)^{**PP}$	29.11 (0.000)
1977-2010	-829.5564 (0.0000) $u_{ij} \sim I(0)^{**\ ADF}$ L1 $u_{ij} \sim I(0)^{*P}$	36.8438(0.0000)	-1356.480 (0.0000) $u_{ij} \sim I(0)^{***ADF}$ L1 $u_{ij} \sim I(0)^{**pp}$	57.918 (0.0000)	-611.587 (0.0000) $u_{ij} \sim I(0)^{***\ ADF}$ L1 $u_{ij} \sim I(0)^{**pp}$	29.10 (0.0000)
1978-2011	-872.548 (0.0000) $u_{ij} \sim I(0)^{*\ ADF}$ L0 $u_{ij} \sim I(0)^{**pp}$	38.137 (0.0000)	-1298.899 (0.0000) $u_{ij} \sim I(0)^{**\ ADF}$ L1 $u_{ij} \sim I(0)^{*pp}$	55.532 (0.0000)	-781.731 (0.0000) $u_{ij} \sim I(0)^{***\ ADF}$ L2 $u_{ij} \sim I(0)^{**pp}$	34.673 (0.0000)

[a)] Figures in parenthesis are probabilities. Explanatory Notes: See notes on Appendix Table 1.

Table 3. Bivariate Convergency Tests using Equation 1: Country i = Tanzania for Columns 2 and 3, Country i = Rwanda for the Last Column

Period	Country *i* =Tanzania				Country *i* = Rwanda	
	Country *j* =Burundi		Country *j* = Rwanda		Country *j* = Burundi	
	Constant	Trend	Constant	Trend	Constant	Trend
1960-2011	Y_i-Y_j = u_{ij} stationary* $u_{ij} \sim I(0)^{*}$ implies ZMC **Both ADF and PP**		Y_i-Y_j = u_{ij} stationary $u_{ij} \sim I(0)^{**}$ **Both ADF and PP**		Y_i-Y_j = u_{ij} stationary* $u_{ij} \sim I(0)^{*\ ADF}$ $u_{ij} \sim I(0)^{**PP}$	
1960-1993 (sample=33)	-96.100 (0.000) $u_{ij} \sim I(2)^{***\ ADF}$ **L0** $u_{ij} \sim I(2)^{***PP}$	2.447 (0.0096)	-122.71 (0.000) $u_{ij} \sim I(2)^{***\ ADF}$ **L0** $u_{ij} \sim I(2)^{***PP}$	4.796 (0.0004)	26.607 (0.0025) $u_{ij} \sim I(1)^{***\ ADF}$ **L0** $u_{ij} \sim I(1)^{***PP}$	-2.348 (0.000)
1961-1994	-122.71 (0.000) $u_{ij} \sim I(2)^{***}$ **L0** $u_{ij} \sim I(2)^{***PP}$	4.067 (0.0014)	-153.0194 (0.0000) $u_{ij} \sim I(2)^{***}$ **L0** $u_{ij} \sim I(2)^{***PP}$	6.829 (0.0001)	33.322 (0.0008) $u_{ij} \sim I(0)^{***}$ L0 **Both ADF and PP**	-2.762 (0.000)
1962-1995	-149.4367 (0.0000) $u_{ij} \sim I(2)^{***\ ADF}$ $u_{ij} \sim I(2)^{***PP}$	5.939 (0.0002)	-181.062 (0.000) $u_{ij} \sim I(0)^{*\ ADF}$ L1 $u_{ij} \sim I(1)^{***PP}$	8.453 (0.000)	Y_i-Y_j = u_{ij} stationary* $u_{ij} \sim I(0)^{*}$ **Both ADF and PP**	
1963-1996	-177.0809 (0.000) $u_{ij} \sim I(0)^{***\ ADF}$ L0 $u_{ij} \sim I(1)^{***PP}$	7.4567 (0.0000)	-207.21 (0.0000) $u_{ij} \sim I(0)^{*\ ADF}$ L1 $u_{ij} \sim I(1)^{***PP}$	9.770 (0.0000)	Y_i-Y_j = u_{ij} stationary $u_{ij} \sim I(0)^{*}$ **Both ADF and PP**	
1964-1997	-204.279 (0.0000) $u_{ij} \sim I(0)^{**\ ADF}$ **L1** $u_{ij} \sim I(1)^{***PP}$	8.789 (0.000)	-236.875 (0.0000) $u_{ij} \sim I(1)^{***\ ADF}$ **Both ADF and PP**	11.179 (0.0000)	Y_i-Y_j = u_{ij} stationary* $u_{ij} \sim I(0)^{*ADF}$ Y_i-Y_j = u_{ij} non-stationary 32.59578 (0.0105) $u_{ij} \sim I(0)^{***\ ADF}$ **L0** $u_{ij} \sim I(0)^{***\ PP}$	-2.39 (0.0000)
1965-1998	-228.4589 (0.0000) $u_{ij} \sim I(0)^{**\ ADF}$ **L1** $u_{ij} \sim I(1)^{**PP}$	9.8125 (0.000)	-270.435 (0.0000) $u_{ij} \sim I(0)^{*\ ADF}$ **L1** $u_{ij} \sim I(1)^{***PP}$	12.690 (0.0000)	41.97637 (0.0037) $u_{ij} \sim I(0)^{***}$ **L0** **Both ADF and PP**	-2.877663 (0.0000)
1966-1999[d]	-244.309 (0.0000) $u_{ij} \sim I(0)^{***\ ADF}$ $u_{ij} \sim I(0)^{*PP}$	10.393	-309.3876 (0.0000) $u_{ij} \sim I(1)^{***}$ **Both ADF and PP**	14.376 (0.0000)	65.079 (0.0007) $u_{ij} \sim I(0)^{***ADF}$ **L1** $u_{ij} \sim I(0)^{**PP}$	-3.983 (0.0000)
1967- 2000	-249.334 (0.0000) $u_{ij} \sim I(0)^{**ADF}$ **L1** $u_{ij} \sim I(0)^{*PP}$	10.366 (0.0000)	-342.288 (0.0000) $u_{ij} \sim I(0)^{**\ ADF}$ **L1** $u_{ij} \sim I(1)^{***PP}$	15.721 (0.0000)	92.954 (0.0007) $u_{ij} \sim I(0)^{**\ ADF}$ **L1** $u_{ij} \sim I(1)^{**PP}$	-5.355 (0.0000)
1968-2001	-249.719 (0.0000) $u_{ij} \sim I(0)^{**ADF}$ **L1** $u_{ij} \sim I(0)^{*PP}$	10.120 (0.0000)	-374.233 (0.0000) $u_{ij} \sim I(0)^{**\ ADF}$ **L1** $u_{ij} \sim I(1)^{***PP}$	16.964 (0.0000)	124.515 (0.0006) $u_{ij} \sim I(0)^{**\ ADF}$ **L1** $u_{ij} \sim I(1)^{***PP}$	-6.844
1969-2002	-247.523 (0.0000) $u_{ij} \sim I(0)^{***ADF}$ **L2** $u_{ij} \sim I(0)^{***\ PP}$	9.785 (0.0000)	-410.426 (0.0000) $u_{ij} \sim I(0)^{*\ ADF}$ **L1** $u_{ij} \sim I(1)^{***PP}$	18.338 (0.000)	162.9028 (0.0003) $u_{ij} \sim I(1)^{***}$ **Both ADF and PP**	-8.553693 (0.0000)
1970-2003	-234.936 (0.0000) $u_{ij} \sim I(0)^{*\ ADF}$ **L1** $u_{ij} \sim I(1)^{***PP}$	9.010 (0.000)	-445.500 (0.0000) $u_{ij} \sim I(0)^{*\ ADF}$ **L1** $u_{ij} \sim I(1)^{***PP}$	19.582 (0.0000)	210.5645 (0.0002) $u_{ij} \sim I(1)^{***}$ L0 **Both ADF and PP**	-10.572 (0.0000)
1971-2004	-224.2138 (0.0002) $u_{ij} \sim I(0)^{***\ ADF}$ **L2** $u_{ij} \sim I(1)^{***PP}$	8.388 (0.0000)	-479.16 (0.0000) $u_{ij} \sim I(0)^{**ADF}$ **L1** $u_{ij} \sim I(0)^{*\ PP}$	20.700 (0.0000)	254.9493 (0.0001) $u_{ij} \sim I(0)^{*\ ADF}$ $u_{ij} \sim I(1)$***PP	-12.312 (0.0000)

1972-2005	-218.660 (0.0004) u_{ij} ~I(0)**^{ADF} **L1** u_{ij} ~I(0)*^{PP}	8.043 (0.0001)	-516.733 (0.0000) u_{ij} ~I(0)**^{ADF} **L1** u_{ij} ~I(0)*^{PP}	21.933 (0.0000)	298.073 (0.0000) u_{ij} ~ I(1)***^{ADF} L0 u_{ij} ~ I(1)***PP	-13.890 (0.0000)
1973-2006	-233.097 (0.0003) u_{ij} ~I(0)***^{ADF} **L1** u_{ij} ~I(0)**^{PP}	8.545 (0.0000)	-568.101 (0.0000) u_{ij} ~ I(0)*^{ADF} **L1** u_{ij} ~ I(1)***^{PP}	8.545 (0.0000)	335.0040 (0.000) u_{ij} ~I(0)**^{ADF} **L1** u_{ij} ~ I(0)*^{PP}	-15.110 (0.000)
1974-2007	-239.3004 (0.0000) u_{ij} ~ I(0)**^{ADF} L1 u_{ij} ~I(0)**^{PP}	8.692 (0.0000)	-616.6784 (0.0000) u_{ij} ~ I(0)**^{ADF} L0 u_{ij} ~I(0)**^{PP}	25.170 (0.000)	377.3780 (0.000) u_{ij} ~ I(0)*^{ADF} **L1** u_{ij} ~ I(1)***PP	-16.478 (0.000)
1975-2008	-223.2170 (0.0012) u_{ij} ~ I(0)** L1 u_{ij} ~I(0)*^{PP}	8.004 (0.0001)	-652.23 (0.000) u_{ij} ~ I(0)*** L1 u_{ij} ~I(0)**^{PP}	26.155 (0.000)	429.0174 (0.000) u_{ij} ~ I(1)***^{ADF} u_{ij} ~ I(1)***PP	-18.152 (0.0000)
1976-2009	-216.06 (0.0023) u_{ij} ~ I(0)** L1 u_{ij} ~I(0)*^{PP}	7.69 (0.0002)	-696.736 (0.000) u_{ij} ~ I(0)*** u_{ij} ~I(0)**^{PP}	27.438 (0.0000)	480.67 (0.000) u_{ij} ~ I(0)* u_{ij} ~ I(1)***PP	-19.745 (0.000)
1977-2010	-217.97 (0.0000) u_{ij} ~ I(0)** L1 **Both ADFand PP**	7.744 (0.0000)	-744.893 (0.0000) u_{ij} ~ I(0)** L0 **Both ADF and PP**	28.818 (0.0000)	526.9235 (0.0000) u_{ij} ~ I(0)**^{ADF} L1 u_{ij} ~ I(0)*^{PP}	-21.074 (0.0000)
1978-2011	Y_i-Y_j = u_{ij} stationary* u_{ij} ~ I(0)* **Both ADFand PP**		Y_i-Y_j = u_{ij} stationary* u_{ij} ~ I(0)* **Both ADFand PP**		426.351 (0.0011) u_{ij} ~ I(0)**^{ADF} L1 , u_{ij} ~ I(0)*^{PP}	-17.395 (0.000)

[a] Figures in parenthesis are probabilities. Explanatory Notes: See notes on Appendix Table 1.