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A Panel Data Approach for Testing Convergence in Real Exchange Rates in The Economic Community of West African States

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Abstract

In this paper, a test for convergence in real exchange rates among the West African countries is conducted using their exchange rate gaps and the normalized exchange rate gaps. The benchmark values are the long-run values of each of the real exchange rates estimated by the method of the pooled mean group estimator. These values are used to obtain the exchange rate gaps and normalized gaps. A test is then conducted for convergence among these real exchange rates gaps and normalized gaps. The result shows that these real exchange rates converge conditionally to a common speed of convergence, an indication that they react the same way to idiosyncratic shocks.

Keywords: Panel cointegration; Idiosyncratic shocks; Fixed effects; Random effects; Individual effects; and Cluster effects.

1. Introduction

Investigating convergence in economic variables like gross domestic product (GDP), interest rate, etc. has been in the literature for some time now. For instance Baumol (1986), Barro and Sala-i-Martin (1995), Bernard and Durlauf (1995) and Haug *et al.* (2000). These papers concentrated on time series and cross-sectional data analysis. Due to the advancement in panel data studies, new tests for convergence emerged (Evans and Karras, 1996; Gaulier *et al.*, 1999; and Fleissig and Strauss, 2001). These tests combine both the time series and cross-sectional analysis (the panel data approach) to test for the convergence hypothesis.

Two main approaches for testing convergence have been proposed in the literature. The first group of study extends the cross-sectional approach to the panel data analysis, the beta (β) and sigma (σ) convergence tests. Proponents of this approach include: Knight et al. (1993) and Islam (1995). The second group use unit root procedures in the analysis of panel data, the stochastic convergence approach and these include: Bernard and Jones (1996), Evans and Karras (1996) and Gaulier *et al.* (1999). Gaulier *et al.* (1999) for instance used Evans and Karras (1996) approach to test for convergence in GDP per capita to the international average with three samples, the World, Organization for Economic Co-operation and Development (OECD) and Europe. They concluded that the World showed no convergence, while OECD had different speeds of convergence and Europe exhibited absolute convergence.

In this paper, a convergence process is assumed to occur if the exchange rate gaps from the benchmark values approach constant values as time approach infinity (Evans and Karras, 1996). If these values tend to zero, the convergence process is absolute otherwise, the convergence is conditional. The paper uses a nested approach similar to Gaulier *et a*l. (1999) but combines two sources of heterogeneity in a panel setting: individual effects and heterogeneous autoregressive parameters. This approach varies from Gaulier *et al.* (1999) because the real exchange rates are used instead of per capita gross domestic product (GDP). The dynamics of the two variables vary, while a simple average GDP may be easy to compute, this may not be applicable to exchange rates. To get round this problem, benchmark values for each currency are obtained. Deviations from this benchmark values are calculated and similar technique applied for each currencies.

To our knowledge, the proposed approach to determining the benchmark of a currency in testing for convergence has not been used in this context of convergence. This value is obtained by the use of the long-run value of the exchange rate from the pooled mean group approach of Pesaran *et al.* (1999). The long-run value is used because that is the equilibrium value at which the exchange rate is expected to return, whenever there is a shock in the system. The benchmark value is used to obtain the exchange rate gap. Furthermore, bootstrapping is used to obtain critical values from different simulation procedures to test the robustness of these results.

2. Theoretical Framework

Investigating stochastic convergence is essential especially in countries wishing to harmonize their currencies towards a monetary union. As mentioned earlier, similar studies of this nature have been conducted in the European Union (EU), Africa and Asia. Some of these studies were carried out by Evans and Karras (1996), Gaulier *et al.* (1999), Haug *et al.* (2000) and Maeso-Fernandez *et al.* (2004), Bankole and Odularu (2009) and recently by Toyoshima and Hamori (2011). Haug *et al*. (2000) investigated convergence in economic variables (interest rate, inflation rate and ratio of deficit to gross domestic product (GDP)) using time series cointegration approach. They found partial convergence of policies among large subsets of European Union countries. In the panel setting, Evans and Karras (1996), Gaulier *et al*. (1999), and Maeso-Fernandez *et al*. (2004) used panel cointegration to investigate convergence in gross domestic product (GDP).

The relationship between urbanization and economic growth in West Africa using panel approach was investigated by Bankole and Odularu (2009). The duo used fixed effect panel regression model approach to observe that, all the variables except one were parsimoniously significant at 10%, while the urbanization variable is significant at 5% level. On the other hand Toyoshima and Hamori (2011) used the panel cointegration of the Fisher hypothesis to show that Fisher's hypothesis is valid for the three countries, the United States, the United Kingdom and Japan.

In panel data analysis, ignoring cluster effects could distort the inference in the cointegration analysis. The omission of this effect may inflate the standard errors in a cointegration relationship (Wooldridge, 2002; Gobillon, 2004; Baltagi, 2006; Baum et al., 2010). As discussed in Baum et al. (2010) and Cameron and Miller (2010), the estimation of variance-covariance matrix without controlling for clustering could lead to understated standard errors and overstated statistical significance. In other words, ignoring error correlations within group or clusters, may lead to misspecification or erroneous statistical inference. As suggested by Cameron and Miller (2010), estimation of panel data in this research is carried out using the cluster specific model of Cameron and Trivedi (2005).

In testing convergence in the time series, stochastic trends are necessary to formulate statistical hypothesis. In a similar manner, panel unit root tests provide the basic hypothesis for testing stochastic convergence in the panel setting. The definition of stochastic convergence used in this instance is a version of Bernard and Durlauf (1995), Evans and Karras (1996) and Gaulier *et al*. (1999). In this instance the exchange rate y_{it} of country i is said to converge stochastically to a benchmark value $\bar{y}_i$ if $\lim \Pr\{|y_{it} - \bar{y}_i| \geq \varepsilon\} = 0$, which is also a necessary and sufficient condition for stochastic convergence (Hogg and Craig, 1995), where $\bar{y}_i$ is the benchmark value for country i and ε is any small positive real number. In other words, there is stochastic convergence in exchange rates, if the exchange rate gaps from the benchmark values approach stationary values, as time approach infinity.

The stochastic convergence test amounts to testing whether the data generating process $y_{it} - \bar{y}_i$ contains a unit root. To apply the stochastic convergence, panel unit root and the pooled group mean (PMGE) models are used. The panel unit root tests considered in this study is the test by Im, Pesaran and Shin (2003) while the PMGE model of Pesaran *et al.* (1999) is used to obtain the long-run values which serve as benchmark values. The Im et al. (2003) panel unit root test is chosen because of its superior size and power properties, in addition to its allowance for heterogeneity of cross-sectional units within the panel. The framework for testing for convergence is therefore based on this panel unit root which is an extension of the Augmented Dickey-Fuller unit root test to the panel data (Said and Dickey, 1984).

3. Materials and Methods

The data for this paper are collected from the International Monetary Fund through their website: *http://www.imfstatistics.org/imf/activate.asp?*. The data consists of annual observations from 1980 – 2006. The variables used are: real exchange rate (rer), net foreign asset (nfa), real interest rate differential (rir), openness (op), price (pr), real gross domestic product per capita (rgdpc), terms of trade (tot), and fiscal balance (fb). These variables are selected based on the behavioral equilibrium exchange rate (BEER) of Clark and MacDonald (1999) and MacDonald (2002). Their approach seeks explicitly, economic relations between macroeconomic fundamentals and exchange rates. These fundamentals are selected based on the balance of payment theory and uncovered interest parity. Two stage cluster sampling technique is used to draw up homogeneous variables. The first stage involves selecting countries with per capita income of \$1000-\$3000 according to United Nations 2010 report. In the second stage, five countries Cote D'Ivoire (cv), The Gambia (gm), Ghana (gh), Nigeria (ng), and Sierra Leone (sl) are selected. These are countries within the same per capita bracket.

3.1 The Pooled-Mean Group Estimator (PMGE)

The methodology adopted for test of convergence in this study is the stochastic convergence approach similar to Evans and Karras (1996) and Gaulier et al. (1999). The benchmark values for the real exchange rates are first obtained using the panel autoregressive distributed lag (ARDL) as proposed by Pesaran et al. (1999). The pooled mean group estimator (PMGE) procedure allows the short-run coefficients and error variances to differ across the group, but constrains the long-run coefficients to be identical in an error correction framework. The panel ARDL model of order (p_i, q_i) is given by the following equation

$$\Delta y_{it} = \phi_i y_{it-1} + \beta_i' x_{it} + \sum_{j=1}^{p_i-1} \lambda_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q_i-1} \delta_{ij}' \Delta x_{i,t-j} + \alpha_i + \varepsilon_{it} \quad (1)$$

where y_{it} is the dependent variable, x_{it} is vector of explanatory variables, α_i are country specific intercepts and λ_{ij} and δ_{ij} are the country specific coefficients of the short-term dynamics, ε_{it} the white noise error term. The long-run coefficients $\phi_i = \phi$ (are defined to be the same across countries). If ϕ_i <0, there is a long-run relationship between y_{it} and x_{it} defined by $y_{it} = -(\beta_i' / \phi_i) x_{it} + \eta_{it}$. The maximum likelihood procedure based on the concentrated likelihood function is used to estimate the panel pooled mean group (PMG) model. A Gauss-Newton algorithm is then used to maximize the likelihood function. The PMG regression equation (1) can be estimated with individual specific ϕ_i which are then averaged over N to obtain a pooled-mean group estimator (PMGE).

3.2 Test for Convergence in Real Exchange Rates

The test for convergence in real exchange rates is a modified version of the test by Evans and Karras (1996), Gaulier *et al.* (1999) and Maeso-Fernandez *et al.* (2004). We therefore consider N countries each with their currencies. These currencies are at equilibrium if and only if their real exchange rate gaps $(y_{it} - \bar{y}_i)$ converge stochastically to a constant equilibrium value.

$$\lim_{p \to \infty} E_i (y_{it+p} - \bar{y}_i) = \mu_i \quad (2)$$

where $\bar{y}_i$ is the empirical long-term equilibrium value of the exchange rate. The dollar is used as a numeraire (since a country's exchange rate is defined by dividing its international price of the currency by that of US dollar). In other words, the real exchange rates converge stochastically if deviations from their equilibrium values approach individual constant value as time approaches infinity. The convergence process is classified as absolute or conditional on the basis of individual effect μ_i.

(i) If μ_i = 0 for all i = 1, …, N, the convergence is absolute that is the real exchange rate converges in level to the equilibrium value.

(ii) If $\mu_i \neq 0$ for some i the convergence process is said to be conditional (See Evans and Karras, 1996; and Gaulier *et al.*, 1999).

The data generating process for the test of convergence hypothesis is

$$\lambda_i(L)(y_{it} - \bar{y}_i) = \alpha_i + \varepsilon_{it} \quad (3)$$

where α_i are individual effects which control the cross-sectional differences. Because of structural disparities between the economies in West Africa the fixed effect regression estimators are used similar to Gaulier *et al.* (1999) to control for unobservable timeless specific characteristics. Allowing for flexibility in the speed of convergence, the following Im *et al.* (2003) functional form similar to the Said and Dickey (1984) test, is used as a general linear process

$$\Delta(y_{it} - \bar{y}_i) = \alpha_i + \rho_i (y_{it-1} - \bar{y}_i) + \sum_{j=1}^{p_i} \gamma_{ij} \Delta(y_{it-j} - \bar{y}_i) + \varepsilon_{it} \quad (4)$$

where $\rho_i < 0$ for $i = 1, \ldots, N$, while it is zero if they diverge. The roots of the polynomial $\sum_{j=1}^{p} \gamma_{ij} L^j$ are outside the unit circle. The lag length is selected to eliminate residual autocorrelation. To this end, the lag length is selected using the Modified Akaike Information Criteria (MAIC) to fit the dynamic structure well without imposing any constraint (see Ng and Perron, 2001).

Unlike the panel unit root test by Im *et al.* (2003), the test for convergence in this instance is performed in four stages as follows: The first three stages of the test, examine convergence of real exchange rates cross differences against divergence and the last stage characterizes convergence process as absolute or conditional.

In the first stage, equation (4) is estimated by ordinary least squares (OLS). The standard errors obtained from the estimated equation, are collected for each country. These standard errors are used to generate the normalized series

$$\hat{z}_{it} = \frac{y_{it} - \overline{y}_i}{\sigma_i} \quad (i = 1, \ldots, N).$$

where $\hat{\sigma}_i$ is the estimated standard errors and $\hat{z}_{it}$ is the normalized series of the country i.
In the second stage the normalized series is used to obtain the model

$$\Delta \hat{z}_{it} = \hat{\eta}_i + \rho z_{it-1} + \sum_{j=1}^{p_i} \gamma_{ij} \Delta \hat{z}_{it-j} + u_{it} \quad (5)$$

where $\eta_i = \dfrac{\alpha_i}{\hat{\sigma}_i}$ are cluster-specific (country-specific) intercepts and $\sum_{j=1}^{p_i} \gamma_{ij} \Delta \hat{z}_{it-j}$ are the lagged difference dependent variables included to eliminate serial correlation in the error term. ρ_i is the coefficient of the lagged dependent variable which determines the degree of persistence and $u_{it} = \dfrac{\varepsilon_{it}}{\hat{\sigma}_i}$ are the estimated residuals.

Similar to the Im et al. (2003), $\rho_i = \rho = 0$ is tested against $\rho_i < 0$. The test is conducted by constraining ρ to be common to all countries, since interest is on convergence of real exchange rates. Individual effects η_i, are however, allowed to vary across countries.
In the third stage, student t-statistic (t_ρ associated with ρ) is computed and compared with the critical values usually obtained by bootstrapping. If $t_{\hat{\rho}}$ is greater than the critical value for a particular level, the null hypothesis of $\rho_i = \rho = 0 \ (\forall i)$ is rejected in favor of the alternative $\rho_i < 0 \ (\forall i)$. This then implies that there is convergence among the real exchange rates. We then proceed to classify the convergence as absolute or conditional convergence.

3.3 Testing for Common Speed of Convergence

This test is conducted to determine whether it takes the same time for all the countries' exchange rates to converge to their steady states. Recall that in the convergence test of equation (5), heterogeneity is introduced through the fixed effects equation. The test for heterogeneity is also given in this section.
Two tests are therefore conducted in line with Gaulier *et al.* (1999) and Fleissig and Strauss (2001). The first test is the Hausman-type test based on the differences between the pooled mean group estimators ($\hat{\rho}_{PMG}$) and the between regression estimator with the fixed effects ($\hat{\rho}_{FE}$) of the parameter ρ. The proposed statistic is defined as

$$H_{\hat{\rho}} = \frac{(\hat{\rho}_{PMG} - \rho_{FE})^2}{\hat{\sigma}_{PMG} V} \quad (6)$$

with $\hat{\sigma}_{PMG} = \dfrac{1}{N} \sum_{i=1}^{N} \sigma_{\varepsilon_i}^2$ and $\hat{V} = \dfrac{1}{N^2} \sum_{i=1}^{N} (X_i' \Gamma_T X_i)^{-1} - \left(\sum_{i=1}^{N} X_i' \Gamma_T X_i \right)^{-1}$

where $X_i' = \left[\left(y_{i,0} - \overline{y}_0 \right), \ldots, \left(y_{i,T-1} - \overline{y}_{T-1} \right) \right]$, and Γ_T is a dummy operator used to eliminate individual effects in the fixed effect regression, N is the cross-section dimension and T is the time dimension. As demonstrated by Gaulier *et al.* (1999), the null hypothesis shows that the statistic H_ρ is asymptotically chi-square (χ^2(1)) distributed for T sufficiently large.
The second test is an F-test for homogeneity of variance, that is the null hypothesis $\rho_i = \rho_j$, for all i and j, $i \neq j$. The statistic is defined as

$$F_{\hat{\rho}} = \frac{\left(SSR_{FE} - \sum_{i=1}^{N} SSR_{PMG} \right)}{\sum_{i=1}^{N} SSR_{PMG}} \left(\frac{N(T-1)-k}{(N-1)} \right) \quad (7)$$

where SSR_{FE} is the residual sum of squares for the fixed effects model and SSR_{PMG} is the residual sum of squares for the pooled mean group model. Under the null hypothesis, $F_{\hat{\rho}}$ follows a $F\left[N-1, N(T-1)-k\right]$, where k is the number of regressors.

4. Results and Discussion

The PMGE was carried out in two stages. In the first stage all the variables were used to obtain the results for the long-run values of the real exchange rates. The results of the first stage long-run cointegration parameters using the PMGE are given in Table 1. The results show that the variables nfa, rir, op, pr and tot account for most of the fluctuation in the rer which tallies with Pattichis *et al.* (2007) results. For instance op depreciates rer in developing countries as suggested in the literature by Pattichis *et al.* (2007) and Roudet *et al.* (2007). The variables rgdpc and fb were eliminated in the second stage as literature suggest they do not contribute substantially to the exchange rate (see Roudet et al. 2007; Awogbemi & Taiwo, 2012).

Table 1: First stage estimation results of PMGE.

Variables (Dep. var rer)	PMGE	t-stat
nfa	0.012	5.55
rir	-0.001	0.32
op	-0.687	3.53
pr	1.517	6.07
rgdpc	0.592	0.34
tot	0.105	1.16
fb	0.603	1.11

The second stage estimation results are reported at Table 2. The results are consistent with the literature as the fluctuation in rer in developing countries can be explained by these variables.

Table 2: Second stage estimation results of PMGE.

Variables (Dep. var rer)	PMGE	t-stat
nfa	-0.0085	4.57
rir	0.004	1.73
op	-0.541	-3.87
pr	1.110	16.98
tot	0.092	1.33

4.1 Results of test for convergence

The results of the OLS estimate of the exchange rate gap for individual countries are given in Table 3. As can be seen in the table, all the coefficients are negative for all the countries as postulated. However, all the series are non stationary as the test statistic is greater than the critical value at 5% in each case.

Table 3: OLS Estimate of the Exchange Rate Gap for Individual Countries.

Var.	ρ_{cv}	ρ_{gm}	ρ_{gh}	ρ_{ng}	ρ_{sl}
Coeff.	-0.0181	-0.0252	-0.0789	-0.0575	-0.1065
Std. error	0.0123	0.0183	0.028	0.0310	0.0523
Lag length	3	0	2	1	4
t-stat	-1.466	-1.375	-2.823	-1.854	-2.035

Critical value of the test at 5% = -2.8887

In the next step we proceed to estimate the normalized exchange rate gaps. The estimated results of the normalized exchange rate gap are reported in Table 4. Since the absolute value of $t_{\hat{\rho}}$ is greater than the critical value, we reject the null hypothesis and conclude that convergence in real exchange rates has occurred. The test results in Table 5 are based on the p-values. The Lagrange Multiplier test for serial correlation shows that there is no serial correlation in the errors. The Jarque-Bera test for normality of the residuals also shows normality of the residuals. The result of the autoregressive conditional heteroscedasticity (ARCH) test shows that first order ARCH is rejected.

Table 4: OLS Estimate of the Normalized Exchange Rate Gap.

Dep var $\Delta\hat{z}_{it}$	Coefficient	Standard error	t-stat
$z_{i,t-1}$	-0.072	0.017	-4.22
$\Delta z_{i,t-1}$	0.0707	0.0438	1.62
$\Delta z_{i,t-2}$	-0.0297	0.0439	-2.68
$cons$	-0.1101	0.0509	-2.16

Critical values at 5% obtained by bootstrap of t_{ρ} is -3.0834, $t_{\hat{\eta}}$ is -1.599 and $R^2 = 0.79$.

Table 5: Misspecification Tests.

		Test stat	p-value
Serial Corr	LM-type	2.9491	0.0124
Resid Corr	Ljung-Box (LB)-type	13.5862	0.0252
ARCH	M-ARCH	1.6660	0.0423
Normality	Lutkepohl(1993)	14.9097	0.0113

The first column in Table 6 reports the Hausman's statistic. This statistic is used for the comparison of fixed versus random effects in panel data models. The result shows that the fixed effects model is not rejected which is an indication that the model is correctly specified. The second column in Table 6 gives the calculated F-value for the common speed of convergence among these real exchange rates. From the table it is observed that the null hypothesis of homogeneity (common speed of convergence) is not rejected for these countries at 10% level of significance while it is rejected at 1% and 5% levels (see critical values at 1%, 5% and 10% from columns three to five). This is an indication that there is conditional convergence with a common speed of convergence for these countries.

Table 6: Test for a Common Speed of C

Sample	$H_{\hat{\rho}}$	$F_{\hat{\rho}}$	$F^s_{1\%}$	$F^s_{5\%}$	$F^s_{10\%}$
5 countries	1.07	1.68	3.32	2.37	1.94

The conclusion we draw from the convergence tests is that even though the convergence is conditional, homogeneity is not rejected for the sampled countries. This is not far from reality, because all the sampled countries lie within the group of developing countries. They are therefore expected to react the same way to idiosyncratic shocks (see Ng, 2002). This result compares favorably with Bankole and Odularu (2009) who found that economic performance in West Africa can be enhanced through sound urban development policies which support openness in economic policies.

5. Summary and Conclusion

This paper provides a simple test for convergence in real exchange rates among a group of countries in West Africa. The long-run cointegration parameters are obtained using the PMGE and these are used to compute the exchange rate gaps and the normalized exchange rate gaps for these currencies. Test for convergence in real exchange rates for these countries are conducted using these values. The result shows that all the currencies converge conditionally to their equilibrium values. This is an indication that these countries respond the same way to random shock in the system.

The study therefore shows that real exchange rates of currencies in West Africa are influenced by changes in their fundamental determinants like price, openness, fiscal balance, etc. Also all the currencies converge conditionally, an indication that the countries react the same way to idiosyncratic shocks. This is a clear indication that these countries can form a sustainable monetary union (Ng, 2002). The sustainability is assured by the fact that the currencies of these countries react the same way to any shocks in the system.

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