IS LONG-RUN OUTPUT CONVERGENCE ASSOCIATED WITH INTERNATIONAL COOPERATION? SOME NEW EVIDENCE FOR SELECTED AFRICAN COUNTRIES

MARK J. HOLMES[*]

Waikato University

This study assesses long-run real per capita income convergence among selected African countries. The empirical investigation is based on an alternative approach. Strong convergence is determined on the basis of the first largest principal component, based on income differences with respect to a chosen base country, being stationary. This qualitative outcome of the test is invariant to the choice of base country and, compared to alternative multivariate tests for long-run convergence, this methodology places less demands on limited data sets. Using annual data for the period 1960-2000, strong convergence is confirmed for the Communaute Financiere Africaine and South African Customs Union countries. An amended version of the test is unable to confirm weaker long-run convergence in the case of the Economic Community of West African States countries.

Keywords: Africa, Common Trends, Output Convergence
JEL classification: F4, O0, O5

1. INTRODUCTION

In recent years, economists have keenly debated the issue of whether or not per capita incomes across countries are converging. The neoclassical growth model predicts that countries will converge towards their balanced growth paths where per capita growth is inversely related to the starting level of income per capita. Early studies by Barro (1991), Barro and Sala-I-Martin (1991,1992), Baumol (1986), Sala-I-Martin (1996) and others that consider convergence across countries, US states and European regions, argue that in most instances the annual rate of convergence is roughly 2%. This is confirmed by studies such as Mankiw *et al*. (1992) who investigate conditional convergence that allows for population growth and capital accumulation. More recent

studies have offered mixed evidence on this question. For instance, Quah (1996) questions the 2% convergence rate and argues that convergence will take place within relatively homogenous convergence clubs. McCoskey (2002) suggests that convergence clubs and regional homogeneity is probably unresolved with respect to less developed countries (LDCs) where geographic proximity and cross-national economic interdependence will cause groups of LDCs to grow or falter as one. As noted by Dobson and Ramlogan (2002), little is known about the convergence process among LDCs and the limited range of studies that have considered LDCs have proceeded at a highly aggregated level [Khan and Kumar (1993)] or have focussed on convergence within a particular country [Ferreira (2000), Nagaraj *et al.* (2000), Choi and Li (2000)]. The purpose of this paper is to examine convergence among LDCs where we assess the possibility of convergence clubs within LDCs based on common characteristics regarding international trade and monetary arrangements.

The question of whether trade liberalisation is associated with income convergence is currently unresolved both in terms of theory and evidence.[1] Using annual data on real per capita GDP for a total sample of twenty three LDCs drawn from Africa,[2] this study offers an empirical assessment of whether long-run income convergence among LDCs has been achieved by countries who have participated in a sample of agreements that includes the *Communaute Financiere Africaine* (CFA), *South African Customs Union* (SACU), and *Economic Community of West African States* (ECOWAS).

While this study is motivated by the desire to throw more light on the issue of convergence among LDCs, there are further reasons of interest attached to this study. First, a key contribution is in terms of the methodology employed. The tests for income convergence across African countries are on the basis of whether the first largest principal component (LPC), based on benchmark deviations from base country output, is stationary or not. The use of factor structures to test for unit roots and common trends is reflected in a growing literature that includes Snell (1996), Hall *et al.* (1999), Moon and Perron (2002) and Phillips and Sul (2002). Moreover, unit root testing of the first LPC based on income differentials offers a number of advantages over existing tests for convergence. Unlike the estimation of bivariate equations, the outcome of this test for convergence is not critically dependent on the choice of base country. Also, there are advantages over alternative multivariate common trends methods based on Johansen (1988) and Stock and Watson (1988), which can suffer from low test power on account of data limitations, as well as principal components analyses that search for integration using arbitrary methods to determine the 'significance' of given components.

An alternative way forward might be to investigate convergence using panel data

---

[1] See, for example, Slaughter (2001) and references therein.

[2] The full list of countries includes Benin, Botswana, Burkina Faso, Cameroon, Cape Verde, Central African Republic, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Lesotho, Mali, Mauritania, Namibia, Niger, Nigeria, Republic of Congo, Senegal, Sierra Leone, South Africa and Togo.

unit root and cointegration testing [McCoskey (2002)]. Both these approaches offer enhanced test power and allow for panel heterogeneity but they have the potential to be sensitive to the choice of base country. Also, the pooling nature of the test statistic means that care should be taken in any rejection of the null hypothesis. For example, the IPS panel data unit root test advocated by Im *et al.* (2003) specifies a null hypothesis that that *all* series or income differentials in the panel are non-stationary against an alternative that *at least one* series or differential is stationary. However, rejection of the null might simply be attributable to as few as one differential in the panel rejecting non-stationarity. The same issue might apply to testing for cointegration in panel data sets [see, for example, McCoskey and Kao (1998), Pedroni (1999)]. Any rejection of the null of cointegration (non-cointegration) null may be attributable to the presence of just a single non-cointegrating (cointegrating) relationship from within the panel.

A second reason of interest attached to this study is that the concept of convergence in the context of the groupings we analyse is important. Essentially, this study tests the hypothesis that convergence is a phenomenon where experience as trading partners or geographical location has the potential to bind economies together. Given that these agreements have sought to promote integration as part of their long-term objectives, the absence of convergence would justify the need for proactive policies to promote growth and reduce income inequalities. If the incomes of countries within these groups are converging, then it becomes more difficult to justify regional development policy in terms of economic efficiency [Dobson and Ramlogan (2002)].

A third reason of interest concerns a motivation for creating a customs or monetary union, namely to facilitate increased trade between member states. In this respect, such a policy might be welfare enhancing. This may also facilitate increased (long-run) integration with respect to a variety of real indicators that include income. The measurement of integration or convergence throws light on the ability of economies to follow individual growth paths. Disintegration or divergence of real income may present member states with a degree of dissatisfaction with the current nature of an agreement because it implies that one or more countries may become progressively poorer in relation to other group members. Integration or convergence, on the other hand, may indicate that, in the long run, member countries have income differentials that are not drifting further apart so there may be reduced scope for such a grievance. Of course, participation in a customs or monetary union might be sub-optimal irrespective of convergence if low-income members can contemplate forging closer relationships with alternative richer countries. In this respect, countries may face a dilemma in terms of trading off integration against growth.

The paper is organised as follows. The following section briefly considers the literature on trade liberalisation and income convergence. The groupings of countries used in this study are then outlined. Section 3 discusses the data and econometric methodology. This leads to a new categorisation of types of real convergence based on the stationarity of the first LPC. Section 4 reports and discusses the results. The evidence suggests that long-run convergence is strongest with respect to the CFA countries. Section 5 concludes.

2.   TRADE CONVERGENCE AND INTERNATIONAL AGREEMENTS

The traditional approach to the convergence debate concerns poor countries catching up with rich ones. In the approaches taken by studies such as Barro (1991), Barro and Sala-I-Martin (1991,1992), Baumol (1986) and Sala-I-Martin (1996), a cross-section of growth rates are regressed on income levels and the estimated coefficient informs on the rate at which poor countries catch up with those richer. Quah (1996) argues that the conventional analyses miss key aspects of growth and convergence. Moreover, it is argued that the key issue is what happens to the cross-sectional distribution of economies, not whether an economy tends towards its own steady state. Quah therefore considers issues of persistence and stratification in the context of convergence clubs forming where the cross-section polarizes into twin peaks of rich and poor. The economic forces that drive this notion of convergence include factors such as capital market imperfections, country size, club formation etc.

Structural and institutional factors are crucial in forming the background against which long-run linkages between countries can exist. As pointed out by Slaughter (2001), many papers on convergence cannot analyse the role of international trade because they assume a 'Solow world' in which countries produce a single aggregate good independently of each other. Moreover, convergence arises from capital stock convergence. However, trade theory that draws on and develops some of the arguments belonging to the factor price equalisation theorem, Heckscher-Ohlin models, Stolper-Samuelson effects or Rybczynski theorem offers an ambiguous prediction as to whether or not trade liberalisation will cause per capita incomes to converge or diverge. The convergence of factor prices via the factor price equilibrium theorem depends on cross-country tastes, technology and endowments. It is argued that trade liberalisation has an ambiguous effect on endowments of labour and capital (see, for example, Findlay (1984)). Trade liberalisation may reduce investment risk particularly in poorer countries (see, for example, Lane (1997)). Divergence may occur through the Stolper-Samuelson effects of liberalisation on capital rentals where Baldwin (1992) argues that dynamic gains from trade will mean that richer countries that are well endowed with capital will experience increased capital rentals. Ventura (1997) argues that free trade may inhibit the onset of diminishing returns to investment where richer countries do not lose their incentive to invest as they would under autarky. Finally, income convergence will be affected by technology flows. Matsuyama (1996) argues that freer trade leads poorer countries to specialise in technologically-stagnant products because they lack the resources to engage in the production of high-technology products.

Empirical evidence on trade and income convergence is also mixed. Ben-David (1993, 1996) and Sachs and Warner (1995) find that international trade causes convergence. Sachs and Warner point to the convergence club of economies linked by international trade. Ben-David (1996) finds that it is the wealthier countries that trade significantly who are characterised by per capita convergence. Ben-David (1993) analyses five episodes of post-1945 trade liberalisation and finds that income

convergence generally shrank after liberalisation started. On the other hand, Bernard and Jones (1996) find that freer trade causes incomes to diverge while Slaughter (2001), using a sample of developed countries and LDCs, finds no strong, systematic link between trade liberalisation and convergence. Indeed, Slaughter suggests that much of the evidence indicates that trade liberalisation diverges incomes among the liberalisers.

In this paper, we consider three international economic and monetary arrangements involving African LDCs and consider whether these arrangements have been associated with income convergence among the participating members. These agreements are as follows.

First, the *Communaute Financiere Africaine* (CFA). The CFA was established in 1948 and comprises two monetary unions between African states whose two CFA currencies have been pegged to the French Franc and, more latterly, the Euro. The two CFA monetary unions are the *West African Economic and Monetary Union* (UEMOA) and *Central Bank of Equatorial Africa* (BEAC). The sample of CFA countries used in this study comprises Benin, Burkina Faso, Cameroon, Central African Republic, Gabon, Ivory Coast, Mali, Niger, Republic of Congo, Senegal and Togo and cuts across both the UEMOA and BEAC.[3] In their study of macroeconomic shocks in the CFA, Fielding and Shields (2001) argue that the groups of CFA countries, for which patterns of output growth responses to output shocks are noted, do not correspond to the two existing monetary unions. This sample of CFA countries corresponds to the sample employed by Elbadawi and Madj (1996) in their study of economic performance among CFA countries.[4] Countries that participate in a monetary union can be expected to forsake scope for autonomous monetary and exchange rate policy. Recently, a growing number of papers have addressed the issue of the impact of having a common currency on trade [see, *inter alia*, Frankel and Rose (2000), Glick and Rose (2001), Persson (2001)]. Most notably, Rose (2000) finds this effect to be positive, highly significant, and extraordinarily large in magnitude: his 'conservative' estimate indicates that countries would triple their bilateral trade by using the same currency. More recently, Levy-Yeyati (2003) finds a link between a common currency and bilateral trade flows is significantly stronger for common currency pairs comprising unilaterally dollarized countries than for members of a multilateral currency union.

Second, the *South African Customs Union* (SACU). This was established in 1969 with the aim of achieving free interchange of goods between member countries. For this purpose, SACU has employed common external tariffs and excise tariffs. The sample of SACU countries used in this study comprises Botswana, Lesotho, Namibia and South Africa.

---

[3] From this sample of countries, all countries are members of the UEMOA except Cameroon, Central African Republic and Gabon who are members of the BEAC.

[4] In this study, Elbadawi and Madj compare economic performance among CFA and other sub-Saharan countries and find that the latter group have generally performed better with respect to growth upto the 1970s.

Third, the *Economic Community of West African States* (ECOWAS) whose sample comprises Benin, Burkina Faso, Cape Verde, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone and Togo. ECOWAS was established in 1975 with the aim of promoting integration in all fields of economic activity. However, there has been slowness in suppressing customs duties and equivalent taxes, establishing a common external tariff, and harmonizing government policy.

3.   DATA AND METHODOLOGY

This study employs data for annual per capita real GDP (US$) for each of the sample of countries for study periods of upto 1960-2000.[5] All data are obtained from the Penn World Tables version 6.1. The exclusion of certain countries from some of the groups is driven by data availability over the full study period. The largest principal component (LPC) methodology requires sets of countries that are characterized by equal numbers of time series observations but some countries have very limited time series.[6] Attempting to employ the LPC methodology on such limited time series would seriously compromise the power of test making it much less likely that the null hypothesis concerning non-convergence can be rejected.

Using this data, this study employs a two-stage testing procedure for income convergence. The first stage draws on a technique, developed by Snell (1996), Hall *et al.* (1999), Moon and Perron (2002) and Phillips and Sul (2002), which is an extension of the principal components methodology, based on testing for the stationarity of the first LPC of benchmark deviations from base country output for each group in turn. This test can confirm long-run convergence where all series move in tandem over the long-run. This can be described as *strong convergence*. The second stage applies if stage one finds against strong convergence. Principal components are computed for each group where per capita incomes are expressed in levels rather than differences from base country and the number of common shared trends are calculated. This second stage searches for evidence of a single common shared trend driving the output series. This would confirm weak convergence because, unlike stage one, homogeneity between the countries has been relaxed.

With regard to the first stage of the convergence test, suppose $n+1$ countries constitute the sample of a given group. The benchmark deviations are defined as

$$(y_i - y_G)_t = u_{it}, \tag{1}$$

where y_{it} and y_{Gt} respectively denote the natural logarithm of the real per capita income of country i and the chosen base-country, and $i = 1, 2, ..., n$. Let X_t be an $(n \times 1)$ vector of random variables, namely the u_{it}'s for each of the n countries, which may be integrated up to order one. The principal components technique addresses the question of how much interdependence there is in the n variables contained in X_t. We can construct n linearly independent principal components which collectively explain all of the variation in X_t where each component is itself a linear combination of the u_{it}'s.[7] Since I(1) variables have infinite variances, whereas stationary, I(0), variables have constant variances, it follows that the first LPC, which explains the largest share of the variation in X_t, is the most likely to be I(1) and so corresponds to the notion of a common trend [Stock and Watson (1988)]. However, if the first LPC is I(0) then all the remaining principal components will also be stationary and there are no common trends which suggests that the u_{it}'s contained in X_t are themselves stationary. This will confirm real convergence with the base-country across the sample of n benchmark deviations.

More formally, following Stock and Watson (1988) we can argue that each element of X_t may be written as a linear combination of $k \leq n$ independent common trends which are I(1), and $(n - k)$ stationary components which correspond to the set of $(n - k)$ cointegrating vectors among the u_{it}'s. The k vector of common trends and $(n - k) \times 1$ vector of stationary components may respectively be written as

$$\tau_t = \alpha' X_t, \tag{2}$$

$$\xi_t = \beta' X_t, \tag{3}$$

where α is an $(n \times k)$ matrix of full column rank, β is an $n \times (n - k)$ matrix that forms the $(n - k)$ cointegrating vectors, $\alpha' \alpha = I$ and $\alpha' \beta = 0$. If there are k common trends, it can be shown that the k LPCs of X_t may be written as

$$\tau_t^* = X_t^{*'} \alpha^*, \tag{4}$$

where X_t^* is a vector of observations on the u_{it}'s in mean deviation form, α^*

---

[7] See, for example, Child (1970).

represents the k eigenvectors corresponding to the largest eigenvalues of X_t and is defined as αR where R is an arbitrary, orthogonal $(k \mathrm{x} k)$ matrix of full rank. This relationship guarantees that under the null hypothesis of k common trends, each of the k LPC's will be I(1). Similarly, for the $(n-k)$ remaining principal components, it can be shown that

$$\xi_t^* = X_t^{*\,'} \beta^* , \tag{5}$$

where β^* corresponds to the $(n-k)$ eigenvectors that provide the $(n-k)$ smallest principal components and is defined as βS where S is an arbitrary orthogonal $(n-k)\mathrm{x}(n-k)$ matrix.

The first LPC will be I(1) provided there is at least one common trend among the u_{it}'s contained in X_t. We can therefore test the null hypothesis that the first LPC is non-stationary against the alternative hypothesis that the first LPC is I(0). Rejection of the null means that all principal components are stationary and so there are no common trends among the u_{it}'s contained in X_t. This confirms convergence with respect to the base-country across the sample. To test the stationarity of the first LPC we can use the familiar Augmented Dickey-Fuller (ADF) test based on

$$\Delta z_{1t} = \rho z_{1t-1} + \sum_{i=1}^{p} \gamma \Delta z_{1t-i} + e_t , \tag{6}$$

where the first LPC is calculated as $z_1 = \alpha_1^* X_t^*$ using α_1^* as the first column of α^*, and e_t is a white noise error term. If we find that z_1 is trend stationary only, this will not confirm convergence because for at least one series in the sample, the difference from base country is growing over time. This would imply the presence of at least two common shared trends among the X_t's.

This notion of convergence can be seen in the context of the Bernard and Durlauf (1995) definition of convergence in a stochastic environment where the long-run forecasts of the benchmark deviations tend to zero as the forecast horizon tends to infinity. If each y is I(1), then each $(y_i - y_G)_t = u_{it}$ is a stationary process where each y_{it} and y_{Gt} is cointegrated with a cointegrating vector [1, -1]. The LPC methodology is testing whether or not income differentials are drifting further apart over time. This notion of convergence is less rigid than Bernard and Durlauf who suggest that (the forecast of) income differentials tend towards zero in the long-run. Indeed, in this respect, one can say that *stability* rather than *convergence* of real per capita incomes is the issue in the current study because the long-run income differentials may be characterized by a non-zero long-run equilibrium value.

An alternative way forward is to test for a single common trend among a series of I(1) variables ($y_{1t}, y_{2t}, ..., y_{nt}, y_{Gt}$) where convergence is confirmed through the presence of n cointegrating vectors among the $n+1$ countries. The advantage of examining the stationarity of the first LPC is that, unlike the Johansen (1988) maximum likelihood procedure (and the Stock and Watson (1988) common trend framework), it does not require the estimation of a complete vector autoregression system (VAR).[8] The size and power of this test is not affected by the VAR being constrained to an unreasonably low order on account of data limitations. This method also avoids the need for an entire sequence of tests for the stationarity of a multivariate system. As indicated by Snell (1996), even if each test in the sequence had a reasonable chance of rejecting the false null, the procedure as a whole is likely to have low power. Another important issue is whether the choice of base country affects the outcome of the test. This methodology employed in this paper is based on a multivariate test for convergence that is not critically dependent upon the choice of base country. In one scenario we may find that the first LPC constructed from the n income differentials is stationary thereby suggesting that all $n+1$ countries in the sample share the same common stochastic trend. It will not matter which country is used as base because the first LPC will still be stationary. If the first LPC is non-stationary, then there are at least two common stochastic trends among the sample of $n+1$ countries with a maximum of n countries sharing the same trend. In this case, it is impossible to change to base country so that the first LPC is stationary.

A further advantage of this methodology is over previous studies that have employed principal components as a means of assessing integration. In earlier studies of financial integration [see, *inter alia*, Logue *et al.* (1976), White and Woodbury (1980) and Nellis (1982)] *increased* financial integration occurs if interest rate covariation is captured by fewer 'significant' principal components. Integration is confirmed if there is one 'significant' principal component explaining the variation of interest rates in the sample. In this context, 'significance' is determined on the basis of an arbitrary rule whereby a principal component is 'significant' it has an eigenvalue of greater than one.

The second stage of the test is applied if one is unable to reject the null that the first LPC based on differences with respect to base country is non-stationary. So far, under the LPC test, income differentials are constructed among the lines of $\left(y_i - \beta_i y_G\right)_t$ where $\beta_i = 1 \, \forall i$. Since the differentials are computed as $\left(y_i - y_G\right)_t$, this means that homogeneity has been imposed, i.e., $\beta_i = 1 \, \forall i$, before the test is conducted. *Strong convergence*, which is based on homogeneity, is therefore confirmed if the first LPC is stationary. Non-stationarity of the first LPC may occur because $\beta_i \neq 1$ in at least one case. Even if y_i and y_G are cointegrated, it may now be more appropriate to think of

---

[8] See, for example, Mills and Holmes (1999) who employ these methods to examine common trends among European output series during the Bretton Woods and Exchange Rate Mechanism eras.

the long-run cointegrating relationship not being written as $y_{it} = y_{Gt} + u_{it}$ but rather as $y_{it} = \beta_i y_{Gt} + u_{it}$ instead. In the latter case, homogeneity has not been imposed and it is *weak convergence* that is being tested for where the variables used to construct the principal components are $y_1, \ldots, y_n, y_G$ instead of $(y_i - y_G) = u_i$ for $i = 1, \ldots, n$. Moreover, it is possible that the series are driven by a single common shared trend but without the homogeneity that strong long-run convergence implies. To address this, principal components are computed for the $n+1$ countries expressed in levels rather than differences with respect to base country. If the first and second LPCs are respectively non-stationary and stationary, this will suggest there are n cointegrating vectors present and therefore one $((n+1) - n = 1)$ common shared trend. We can describe this as *weak convergence* because the first stage of the test described previously did not support convergence based on homogeneity, yet the second stage of the test found that the countries are nonetheless sharing the same long-run trend.[9] We may find that the third LPC is the first principal component that is stationary. In this case, we have $n-1$ cointegrating vectors present and this implies the presence of two $((n+1) - (n-1) = 2)$ common trends among the $n+1$ countries. This is yet weaker of evidence of convergence. In the extreme, we may find that none of the principal components are stationary. This implies that there are no cointegrating vectors and therefore $n+1$ common trends and the sample of $n+1$ countries. This would be consistent with zero long-run convergence or complete divergence.

Before proceeding to the results discussion, it is important to highlight some caveats associated with this methodology. The advantages over existing methods of testing for long-run convergence have been discussed, however the downside of this methodology concerns a standard criticism of principal component estimation and indeed of common stochastic trends. They are linear combinations of economic variables and so the economic interpretation of a given component can be problematic. Also, testing the null of non-stationarity of the first LPC leaves one vulnerable to the standard criticisms concerning the low power attached to unit root tests making it difficult to reject the null of non-stationarity. A final caveat concerns a situation where there exist two or more common trends under the null hypothesis. The ADF unit root test is conducted on the series with the largest sum of squares. However, if we take Equation (6), the simple Dickey-Fuller statistic is asymptotically proportional to $\sum z_{t-1} e_t / \left(\sum z_{t-1}^2 \right)^{0.5}$. It is possible that the size of the test under such a null may actually be less than 5%.

---

[9] If first LPC is stationary, this will imply that all real per capita incomes within the sample are stationary, there are no common trends among the $n+1$ countries and therefore long-run convergence cannot be detected.

4.   RESULTS

Table 1A reports some summary statistics for the countries and groupings used in this study. The CFA sample of countries been characterized by low income and negative growth over the 1960-2000 study period. There is, however, some degree of stability where the standard deviations with respect to income and growth are relatively modest. By contrast, the ECOWAS sample of countries are characterized by a better growth performance while the SACU sample of countries features the highest average real per capita GDP, the highest growth rate but with the greatest volatility of income and growth over the 1969-2000 study period.[10]

Table 1.   Summary Statistics and Unit Root Tests on Per Capita Income

Table 1A.   Summary Statistics

	Real Per Capita Income		Growth	
	Mean	Standard Deviation	Mean	Standard Deviation
ECOWAS (1975-2000)	1932.062	7.940	0.272	2.912
SACU (1969-2000)	4402.787	10.790	2.020	3.658
CFA (1960-2000)	1362.477	2.221	-0.026	1.860

Notes: Data are based on Constant Price Real GDP per capita (based on Laspeyres) in US dollars taken from the Penn World Tables. These are income and annual growth in income (%) averages for the ECOWAS, SACU and CFA groupings used in this study. In the case of the income series, the standard deviation is expressed as a percentage of the mean value. The abbreviations used for the groupings are *Communaute Financiere Africaine* (CFA), *South African Customs Union* (SACU) and *Economic Community of West African States* (ECOWAS).

In the search for long-run relationships among the real per capita incomes, we require that the series are non-stationary. Table 1B reports ADF unit root tests for all the countries. At the 5% significance level, the null of non-stationarity is rejected in the cases of Burkina Faso, Gabon, Gambia, Ghana, Guinea-Bissau, Nigeria, Republic of Congo and Senegal. These countries are therefore excluded from the long-run analysis. In the case of the CFA and ECOWAS sample of countries, there exist a number of cases where real per capita GDP is stationary. As a result of this, it is important to qualify the notion of convergence that this study is considering. On the one hand, the LPC methodology enables us to identify the possibility that a sample of non-stationary time series might share a single common trend and therefore be regarded as cointegrated and characterized by long-run output convergence. Such series will not drift further apart over time.

---

[10] It should be pointed out that when these calculations were made across a common time period of 1975-2000, the rankings with respect to the income and growth averages were unaffected.

Table 1B.   Unit Root Tests

Country	ADF (no trend)	ADF (trend)	Period	Group
Benin	-2.084	-2.192	1960-2000	CFA
Benin	-0.968	-2.383	1975-2000	ECOWAS
Botswana	-1.807	-1.473	1969-2000	SACU
Burkina Faso	-0.421	-4.422***	1960-2000	CFA
Burkina Faso	-1.921	-3.639**	1975-2000	ECOWAS
Cameroon	-1.709	-1.846	1960-2000	CFA
Cape Verde	-1.321	-1.602	1975-2000	ECOWAS
Central African Republic	-0.127	-2.461	1960-2000	CFA
Gabon	-4.089***	-2.978	1960-2000	CFA
Gambia	-3.299**	-2.890	1975-2000	ECOWAS
Ghana	-2.659	-3.689**	1975-2000	ECOWAS
Guinea	0.267	-1.020	1975-2000	ECOWAS
Guinea-Bissau	-2.938**	-3.536**	1975-2000	ECOWAS
Ivory Coast	-1.723	-1.697	1960-2000	CFA
Ivory Coast	-1.484	-3.231	1975-2000	ECOWAS
Lesotho	-1.784	-2.147	1969-2000	SACU
Mali	-2.306	-2.210	1960-2000	CFA
Mali	-1.478	-1.435	1975-2000	ECOWAS
Mauritania	-0.944	-1.273	1975-2000	ECOWAS
Namibia	-2.190	-3.133	1969-2000	SACU
Niger	-0.978	-2.498	1960-2000	CFA
Niger	-1.207	-1.937	1975-2000	ECOWAS
Nigeria	-1.363	-3.512**	1975-2000	ECOWAS
Republic of Congo	-3.309**	-2.219	1960-2000	CFA
Senegal	-3.103**	-3.361*	1960-2000	CFA
Senegal	-2.950**	-2.319	1975-2000	ECOWAS
Sierra Leone	0.050	-1.261	1975-2000	ECOWAS
South Africa	-2.763*	-2.442	1969-2000	SACU
Togo	-1.845	-2.386	1960-2000	CFA
Togo	-0.730	-2.036	1975-2000	ECOWAS

Notes: These are Augmented Dickey Fuller (ADF) unit root tests on the natural logarithm of real per capita GDP (US dollars). In all cases the lag length of the ADF regression was selected on the basis of the Akaike Information Criteria (AIC). Annual data are employed for the indicated study periods. ***, ** and * indicate rejection of the null of non-stationarity at the 1, 5 and 10% levels of significance respectively in the ADF tests.

On the other hand, the subgroup of stationary series will not drift further apart from each other but they will not be cointegrated with the larger group of non-stationary series. Indeed, the combination of stationary and non-stationary series precludes the possibility of strong convergence with respect to *all* countries in each of these groupings. This leaves open the possibility that convergence clubs may be present in the case of the CFA and ECOWAS countries. By contrast, the SACU sample of countries appears to only include non-stationary series. Therefore, there is the possibility that the LPC test might support strong convergence among the SACU countries.

The first stage of the convergence test is to take each of the three groupings and express per capita income with respect to a chosen base country. The choice of base countries are Togo for the CFA and ECOWAS countries and South Africa for the SACU countries. For the CFA and SACU groupings, the null of non-stationarity of the first LPC is rejected at the 5% significance level. For these countries, there is strong evidence that movements in per capita incomes converge in the long-run. Given that the sample of CFA countries includes members of both monetary unions, this result is consistent with Fielding and Shields (2001) who argue that the response of output growth to output shocks does not depend on which monetary union a country is drawn from. The null of non-stationarity is also rejected in the case of the SACU group of countries. However, in this instance the non-stationary null can only be rejected if a time trend is included in the ADF regression. This suggests that at least two of the income levels within the SACU grouping are drifting apart over time and so there are at least two common trends among the income series. These findings may be compared with McCoskey (2002). Using per capita income data for study periods of upto 1989/90, McCoskey examines pairwise income differentials and applies panel data cointegration techniques finding little evidence to support convergence across Africa including the grouping based on SACU countries. Unlike McCoskey, this study finds in favour of long-run convergence with respect to the CFA countries.

In further reflecting on the results obtained in the current study, one might bear in mind that SACU is the oldest Customs Union in the world. Its aim is to maintain the free interchange of goods between member countries and provides for a common external tariff and a common excise tariff to this common customs area. SACU coupled with the Multilateral Monetary Area is regarded as the tightest integration arrangement in Southern Africa [Mistry (2000)].

The CFA is characterized by a single currency and only one devaluation has occurred during the history of the currency peg from CFA50 to CFA100 = FF1 in January 1994. Prior to the mid 1980s, the atmosphere of currency convertibility, relative monetary discipline and the depreciation of the French Franc, helped create a steady and positive economic performance for the CFA Franc zone. However, difficulties arose in the second half of the 1980s where the CFA-franc-zone countries have been through repeated financial crises, leading to the implementation of a series of structural adjustment programmes. During this period, the comparative growth performance of CFA members in the 1970s eroded relative to non-CFA countries. Elbadawi and Majd

(1996) attribute this to the direct effects of zone participation and, hence, the fixed parity of the exchange rate. Following laxity in the implementation of further zone monetary and fiscal discipline, the French Franc appreciated against the US dollar in the face of a deteriorating terms of trade for the CFA zone. Zone members followed conventional rules for monetary cooperation, budgetary discipline and the mobility of capital but this was not sufficient to bring about the necessary adjustment in response to exogenous shocks. These concerns are underlined by the decision in 1994 to devalue the CFA Franc. Despite these events, we are still able to find some evidence of long-run convergence. The devaluation of the CFA meant the end of the CFA franc's status as a strong currency offering opportunities to reduce the competitiveness gap with non-franc-zone countries. This can be considered as a turning point (which began at the end of the 1980s) towards the integration of the West African real economy.

Table 2.   Stationarity of the First LPC Based on Differences

Group	Period	n	ADF (no trend)	ADF (trend)	Base County
CFA	1960-2000	6	-3.351**	-3.331*	Togo
SACU	1969-2000	3	-1.851	-3.615**	South Africa
ECOWAS	1975-2000	8	-0.018	-1.792	Togo

Notes: These are ADF unit root tests on the first largest principal component (LPC) based on n real per capita income differences with respect to the designated base country. In all cases, the lag length of the ADF regression is determined using the AIC. ***, ** and * indicate rejection of the null of non-stationarity at the 1, 5 and 10% levels of significance respectively in the ADF tests.

Table 3.   Stationarity of the LPCs Based on Real Per Capita Income Levels

Group	Period	$n+1$	LPC	ADF (no trend)	ADF (trend)	k
ECOWAS	1975-2000	9	4	-3.311**	-3.630**	3

Notes: The information in this table is based on $n+1$ real per capita income levels (not differences with respect to some designated base country) for each group. The column LPC indicates which LPC is the first that is identified as being stationary. The following two columns report the ADF unit root tests reported for this principal component. In all cases, the lag length of the ADF regression is determined using the AIC. ***, ** and * indicate rejection of the null of non-stationarity at the 1, 5 and 10% levels of significance respectively in the ADF tests. The column on the right hand side indicates the number of common shared trends present for each group. In the case of the ECOWAS sample, the fourth LPC is the first principal component that is stationary. This suggests there are six cointegrating vectors and therefore three single common trends among the nine ECOWAS countries used in this stage of the investigation.

In the case of the ECOWAS countries, the first LPC is found to be non-stationary. The implications here are that strong convergence with homogeneity is rejected and we are therefore unable to conclude that the movement in ECOWAS LDC per capita

income levels are characterised as being converged in the long-run with a coefficient of unity. This second stage of the convergence test applies to the ECOWAS group for whom the first LPC was non-stationary. This second test is based on the search for a single common trend among the series in levels form rather than differences with respect to base country. The results reported in Table 3 suggest that the remaining ECOWAS group is characterised by three common shared trends driving per capita income and so we are unable to conclude that even weak long-run convergence is present.

This result reflects the lack of success in promoting greater integration among its member countries. ECOWAS was conceived as a means towards economic integration and development intended to lead to the eventual establishment of an economic union in West Africa, enhancing economic stability and enhancing relations between member states. ECOWAS put regional markets at the center of a comprehensive development strategy advocating the lowering of trade barriers; implementing mechanisms and measures designed to facilitate trade (including means of payment); establishing African production companies with sectoral allocations for different countries; and creating an African common market [OECD (2000)]. This ambitious arrangement has failed to live upto its objectives where intra-regional trade in 2000 was only 7% of total trade [Mistry (2000)].

A decrease in trade within ECOWAS can be attributed to a variety of factors that includes a combination of unwieldy procedures and the multiplicity of organizations for regional integration with the same objectives; the diversion of preferential tariffs into distribution channels; and the lack of domestic competitiveness of the products eligible for a regional cooperation tax.[11] The development of regional trade was also hindered by strong protection for national businesses and an increasing complexity, uncertainty and instability of national tax and customs rules. These factors served to adversely affect growth, convergence and economic integration within ECOWAS while wider problems were present with respect to political instability and a lack of good governance that plagued many member countries. The substantial external debt of individual states remains one of the region's greatest challenges.

In the case of the CFA and ECOWAS sample of countries, there exist a number of cases reported in Table 1B where real per capita GDP is stationary. In terms of the impact on the results, the assessment on convergence among SACU countries is unaffected because all series are confirmed as being non-stationary. In the case of the CFA countries, this study identifies strong convergence among the majority of sample members whose real per capita GDP series are non-stationarity. However, we also note that four CFA countries- Burkina Faso, Gabon, Republic of Congo and Senegal- are stationary series and therefore do not drift further apart from each other over time. We therefore conclude that the CFA countries are characterized by the presence of two

---

[11] The free movement of factors will be difficult to achieve in West Africa without an alignment of customs and tax standards.

convergence clubs. It should be noted that the sample of stationary CFA time series cuts across both the West African Economic and Monetary Union (UEMOA)- Burkina Faso and Senegal- and the Central Bank of Equatorial Africa (BEAC)- Gabon and Senegal. In the case of the ECOWAS countries, there are five members for whom real per capita GDP is stationary- Burkina Faso, Gambia, Ghana, Guinea-Bissau and Nigeria. These countries do not drift further apart from each other over time as well. However, the results concerning the remaining majority of non-stationary ECOWAS time series is indicative of the absence of long-run convergence.

5. CONCLUSION

This paper has tested for economic convergence among less developed countries- a relatively unexplored area- using groupings based on key agreements concerning trade liberalisation and monetary cooperation. For this purpose, convergence is addressed in an alternative way through the application of principal components and cointegration analysis. This multivariate technique has advantages over existing methods because less demand is placed on limited data sets and the qualitative outcome of the test is invariant to the choice of base country. There is mixed evidence that convergence is most likely to be found within convergence clubs based on monetary or trade agreements. We find that strong long-run convergence is confirmed for the *Communaute Financiere Africaine* and *South African Customs Union* countries in Africa. Evidence in favour of convergence is strongest in the former case. However, long-run convergence is absent from the *Economic Community of West African States* grouping. The implications of these findings are fourfold. First, on the basis of the results here, monetary union among African countries appears to be more effective at promoting long-run convergence in output movements than trade agreements. Second, it is not necessarily the case that convergence is restricted to smaller groups of LDCs. Third, the presence of both stationary and non-stationary series means that we can actually identify convergence clubs *within* these groupings. Moreover, the notion of strong convergence applied to the *Communaute Financiere Africaine* countries does not apply to those countries that were initially found to be stationary. These latter countries were excluded from the long-run analysis. Fourth, those groupings that exhibit little or no evidence of convergence may require additional regional development policies aimed at facilitating closer integration among member states. Bearing in mind the findings from this study, several avenues for future research are brought to light. Researchers may reflect on why some international agreements on increased cooperation are more conducive towards convergence than others. Future research may also reflect on alternative measures of long-run convergence perhaps utilising panel data techniques that are able to assess the presence of long-run convergence using data that have a limited time-series dimension.

REFERENCES

Baldwin, R.E. (1992), "Measurable Dynamic Gains from Trade," *Journal of Political Economy*, Vol. 100, 162-74.

Barro, R.J. (1991), "Economic Growth in a Cross Section of Countries," *Quarterly Journal of Economics*, Vol. 106, 407-43.

Barro, R.J., and X. Sala-I-Martin (1991), "Convergence across States and Regions," *Brookings Papers on Economic Activity*, No. 1, 107-82.

_____ (1992), "Convergence," *Journal of Political Economy*, Vol. 100, 223-51.

Baumol, W.J. (1986), "Productivity, Growth, Convergence and Welfare: What the Long-run Data Show," *American Economic Review*, Vol. 76, 1072-85.

Ben-David, D. (1993), "Equalising Exchange Rate: Trade Liberalisation and Income Convergence," *Quarterly Journal of Economics*, Vol. 108, 653-679.

_____ (1996), "Trade and Convergence among Countries," *Journal of International Economics*, Vol. 40, 279-98.

Bernard, A.B., and S.N. Durlauf (1995), "Convergence in international output," *Journal of Applied Econometrics*, Vol. 10 No. 1, 97-108.

Bernard, A.B., and C.I. Jones (1996), "Comparing apples to oranges: Productivity convergence and measurement across industries and countries," *American Economic Review*, Vol. 86 No. 5, 1216-38.

Child, D. (1970), *The Essentials of Factor Analysis*, Holt, Reinhart and Winston, New York.

Choi, H., and H. Li (2000), "Economic Development and Growth in China," *Journal of International Trade and Economic Development*, Vol. 9, 37-54.

Dobson, S., and C. Ramlogan (2002), "Economic Growth and Convergence in Latin America," *Journal of Development Studies*, Vol. 38, 83-104.

Elbadawi, I., and N. Madj (1996), "Adjustment and Economic Performance Under a Fixed Exchange Rate: A Comparative Analysis of the CFA Zone," *World Development*, Vol. 24, 939-951.

Ferreira A. (2000), "Convergence in Brazil: Recent Trends and Long-run Prospects," *Applied Economics*, Vol. 32, 79-90.

Fielding, D., and K. Shields (2001), "Modelling Macroeconomic Shocks in the CFA Franc Zone," *Journal of Development Economics*, Vol. 66, 199-223.

Findlay, R. (1984), "Growth and Development in Trade Models," in Jones, R.W. and Kenen, P.B. (eds.), *Handbook of International Economics*, Vol. 3, Elsevier, Amsterdam.

Frankel, J., and A. Rose (2000), "Estimating the effect of currency unions on trade and output," NBER Working Paper No. 7857, NBER, Cambridge Ma.

Glick R., and A. Rose (2001), "Does a Currency Union Affect Trade? The Time Series Evidence," NBER Working Paper No. 8936.

Hall, S., S. Lavarova, and G. Urga (1999), "A Principal Components Analysis of Common Stochastic Trends in Heterogeneous Panel Data: Some Monte Carlo

Evidence," *Oxford Bulletin of Economics and Statistics*, 61, 749-67.

Im, K., M.H. Pesaran, and Y. Shin (2003), "Testing for Unit Roots in Heterogeneous Panels," *Journal of Econometrics*, Vol. 115, 53-74.

Johansen, S. (1988), "Statistical analysis of cointegrating vectors," *Journal of Economic Dynamics and Control*, Vol. 12 No. 1, 231-54.

Khan, M.S., and M.S. Kumar (1993), "Public and Private Investment and the Convergence of Per Capita Incomes in Developing Countries," IMF Working Paper, WP/93/51.

Lane, P.R. (1997), "International Trade and Economic Convergence," mimeograph, January.

Levy-Yeyati, E., and F. Sturzenegger (2003), "On the Impact of a Common Currency and Bilateral Trade," *Economic Letters*, Vol. 79, 125-29.

Logue, D.E., M.A. Salant, and R.J. Sweeney (1976), "International integration of financial markets: Survey, synthesis and results," in Stem, C., Makin, J. and Logue, D. (eds), *Eurocurrencies and the International Monetary System*, American Enterprise Institute, Washington D.C, 91-138.

Mankiw, N., D. Romer, and D.N. Weil (1992), "A Contribution to the Empirics of Economic Growth," *Quarterly Journal of Economics*, Vol. 107, 407-37.

Matsuyama, K. (1996), "Why are there Rich and Poor Countries? Symmetry-breaking in the World Economy," *Journal of the Japanese and International Economies*, Vol. 10, 419-39.

McCoskey, S. (2002), "Convergence in sub-Saharan Africa: A non-stationary panel data approach," *Applied Economics*, 34, 819-29.

McCoskey, S., and C. Kao (1998), "A residual based test of the null of cointegration in panel data," *Econometric Reviews*, 17, 57-84.

Mills, T., and M.J. Holmes (1999), "Common trends and cycles in European industrial production: exchange rate regimes and economic convergence," *Manchester School*, Vol. 67 No. 4, 557-87.

Mistry, P. (2000), "Africa's Record of Regional Co-operation and Integration," *African Affairs*, 99, 553-73.

Moon, H.R., and B. Perron (2002), "Testing for a Unit Root in Panels with Dynamic Factors," mimeo.

Nagaraj, R., A. Varoudakis, and M.A. Veganzones (2000), "Long-run Growth Trends and Convergence across Indian States," *Journal of International Development*, Vol. 12, 45-70.

Nellis, J.G. (1982), "A principal components analysis of financial integration under fixed and floating exchange rate regimes," *Applied Economics*, Vol. 14 No. 4, 339-54.

OECD, (2000), "Regional Integration in West Africa: Options and Risks," OECD mimeograph.

Pedroni, P. (1999), "Critical values for cointegration tests in heterogeneous panels with multiple regressors," Economics Working Paper, Indiana University, *Oxford Bulletin*

of Economics and Statistics, Special Issue, 653-70.

Persson, T. (2001), "Currency Unions and Trade: How Large is the Treatment Effect?" *Economic Policy*, Vol. 33, 433-48.

Phillips, P.C.B., and D. Sul (2002), "Dynamic Panel Testing and Homogeneous Testing Under Cross-Section Dependence," Cowles Foundation Discussion Paper 1362.

Quah, D. (1996), "Twin peaks: growth and convergence in models of distributional dynamics," *Economic Journal*, Vol. 106 No. 437, 1019-36.

Rose, A. (2000), "One money, one market? The effects of common currencies in international trade," *Economic Policy*, Vol. 30, 7-45.

Sachs J., and A. Warner (1995), "Economic Reform and the Process of Global Integration," *Brookings Papers on Economic Activity*, Vol. 1, 1-118.

Sala-I-Martin, X. (1996), "The classical approach to convergence analysis," *Economic Journal*, Vol. 106 No. 437, 1019-36.

Slaughter, M. (2001), "Trade liberalisation and per capita income convergence: A difference-in-difference analysis," *Journal of International Economics*, 55, 203-28.

Snell, A. (1996), "A test of purchasing power parity based on the largest principal component of real exchange rates of the main OECD economies," *Economics Letters,* Vol. 51 No. 2, 225-31.

Stock, J.H., and M.W. Watson (1988), "Testing for common trends," *Journal of the American Statistical Association*, Vol. 83 No. 404, 1097-107.

Ventura, J. (1997), "Growth and Interdependence," *Quarterly Journal of Economics*, Vol. 112, 57-84.

White, B.B., and J.T. Woodbury (1980), "Exchange rate systems and international capital market integration," *Journal of Money, Credit and Banking*, Vol. 12 No. 2, 175-84.

Mailing Address: Department of Economics, Waikato University, Private Bag 3105, Hamilton, New Zealand. E-mail: holmesmj@waikato.ac.nz