GDP per Capita among African Countries over the Period 1950-2008: Highlights of Convergence Clubs

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Abstract

Using intradistribution dynamics and panel unit root tests, this study considers the economic convergence processes of 53 African countries during the period 1950–2008. The stochastic evidence reveals no global convergence among African countries but provides indications of convergence clubs. The poorest countries remained relatively poor, stuck in a poverty trap, whereas countries with the best initial conditions converged. The analysis of structural characteristics reveals that the significant determinants of the constitution of convergence clubs among African countries are openness, foreign direct investment inflows, and the level of development. In a few cases, tests also highlight the production structure and access to the sea as determinants.

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1. Introduction

"Emerging countries recover a specific reality: they are those of the developing countries which practice, in a manner more or less effective, the market economy and reach the international financings"

—de Larosière, 2002[1]

Although they had persistently been engaged in a game of economic catch-up since the end of the 1990s, emerging countries experienced a short pause during 2008–2009, when the large Western countries entered into their worst economic crisis since World War II. In this period growth continued in Asia, the Middle East and North Africa, Africa, and Latin America, such that emerging countries passed through the financial crisis in better shape than they had been previously. Even as these changes have taken place, empirical research continues to focus on convergence between developed and developing countries, without addressing how convergence might function like a process of development. The great differences observed in gross domestic product (GDP) per capita and growth rates across countries justify a more detailed study of convergence though. For example, rates of economic growth have varied widely among developing countries in Africa during the past three decades, featuring periods of rapid growth for certain countries but slow developments for others. Such emerging economies also are critical to international trade. On average, developed countries purchase 60% of total exports by emerging countries (see Table A1, Appendix A). Emerging countries also are signing regional trade agreements, which may encourage growth and thus convergence.

In Africa, most countries belong to some cooperation agreement (e.g., COMESA, SADC, ECOWAS, WAEMU),[2] which aim to reinforce commercial links and encourage greater economic cooperation. These results in turn should lead to homogenized standards of living, which would mean improvements for the least advanced countries, mainly because of their increased access to larger markets. At the present though, African countries are characterized by very divergent economic conditions (see Figure 1), due to factors and natural resource endowments, as well as geographical locations. Progress with respect to exports comes mainly from the sale of commodities and higher manufactured goods prices. For example, four of the five largest African exporters of goods are oil exporters.

[1] Speech at the Symposium HEC-Eurasia Institute by Jacques de Larosière in 2002 (February 6, Paris).

[2] COMESA is the Common Market for Eastern and Southern Africa, SADC is the Southern African Development Community, ECOWAS is the Economic Community of West African States, and WAEMU is the West African Economic and Monetary Union.

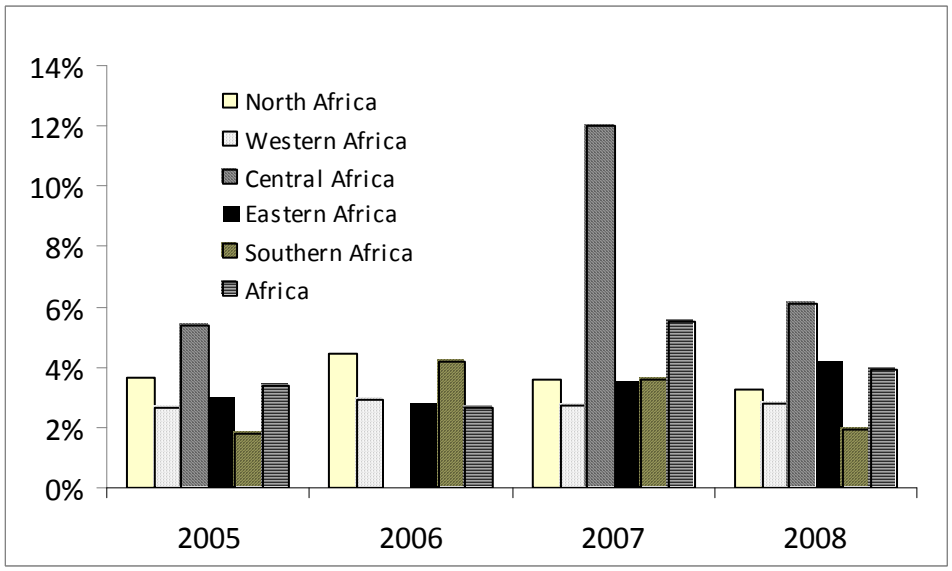

Figure 1: Subregional growth performance, 2005–2008
Source: Madisson (own calculations)

We explore the process of real convergence on the African continent among 53 African countries (see the Appendix, Table A) during 1950–2008. In so doing, we attempt to answer a key question: To what extent have African countries converged to an identical income level, or to the income level of more developed countries? Therefore, in the next section, we summarize empirical literature on convergence in Africa. In Section 3, we describe the distribution of GDP per capita in African countries according to two approaches: kernel density and dynamics approach. After we analyze the stochastic convergence process between African countries using panel unit root tests, in Section 5 we identify estimated convergence clubs and conditions for their formation. Section 6 concludes.

2. A Brief Literature Review

Principal investigations into the dynamic of economic growth in Africa indicate growth heterogeneity (Easterly and Levine, 1997; Bloom and Sachs, 1998; Collier and Gunning, 1999; Block, 2001; Bertocchi and Canova, 2002), usually explained by the countries' more or less favorable specializations and geographical positions. In contrast, little research has undertaken an analysis of the real convergence among countries in the African zone or between African and more developed countries.

Jones (2002) addresses the properties of convergence, in cross-section and time series, for ECOWAS members between 1960 and 1990 and proposes that these member countries form a club of convergence, with a convergence speed of approximately 1.7%. Barro and Sala-I-Martin (1991) estimate a speed of convergence of 2% in their study of OECD countries. In McCoskey's (2002) approach, convergence consists of six welfare indicators.[3] For 37 countries in sub-Saharan Africa, she applies panel root unit tests and McCoskey and Kao's (1998) test for cointegration but finds no real convergence in the observed sample, though she

[3] The six indicators are public expenses in terms of GDP, capital stock per worker, international trade in terms of GDP, GDP per capita, private and public consumption in terms of GDP, and real per worker GDP.

identifies homogeneous groups among economies that participate in agreements such as the SADC and SACU (Southern African Customs Union). Paap et al. (2005) analyze growth differentials between countries of sub-Saharan Africa and those of Asia and Latin America for 1960–2000. They distinguish three groups of countries that suggest three convergence clubs, none of which reveal a high GDP per capita. Most Eastern and Southern African countries belong to the low growth cluster; Egypt, Mauritius, Malawi, Seychelles, and Zimbabwe can be assigned to the middle growth class; and no countries join the high growth cluster. Carmignani (2006) focuses on economic convergence by COMESA members by analyzing assumptions of real convergence over the period 1960–2002. He concludes that there is no convergence; rather, his data suggest that the gap between the poorest and the richest countries increased, leading to two clubs over time. In his next study, Carmignani (2007) considered 28 regional groupings; convergence toward the group average occurred only among North–North agreements. Regarding the GDP per capita of 43 countries during 1950–1999, Cunado and Pérez de Gracia (2006) investigated the difference of the log of the real per capita African GDP with the African average and U.S. GDP. Some countries converged toward the African average, while others moved toward the U.S. GDP per capita (i.e., Cape Verde, Egypt, Maurice, Seychelles, and Tunisia). Malekela (2007), Mabunda (2009), and Dramani (2010) all assert that the process of real convergence is not obvious in Africa except for members of WAEMU and SADC. Charles et al. (2011), in a study of COMESA, reveal no absolute convergence among member states. They test for convergence clubs by defining different groups according to two criteria: economic development (Human Development Index [HDI]) and economic structure (oil producer, structure of exports). From panel unit root tests, they conclude that convergence clubs exist, according to the HDI criterion[4].

3. Distributions of Per Capita Incomes

3.1. Kernel density

To describe changes over time in the distribution of income across countries and to highlight the polarization phenomenon, we use kernel density estimates[5] of the relative per capita GDP. We analyze the distribution of relative GDP per capita, that is, the distribution of the ratios between the GDP per capita of each country and the average GDP per capita for Africa overall. We use a kernel distribution, which allows for several modes. In Figure B1 (Appendix B), we depict the estimated density function of the relative GDP per capita for the initial year, as well as 1975, 2000, and 2008. This simple observation indicates bimodal distributions in 1950, 1975, and 2000, and possibly trimodal distributions in 2008.[6] Thus, it

[4] Using a dynamic approach of the distribution of GDP per capita, Rey (2005) concludes to the absence of global convergence among 22 MENA countries, but to the existence of convergence clubs. A similar result is obtained by Deisting (2010) in a study of convergence process between countries of the South Europe and MENA countries.

[5] The kernel estimator is a smoothed version of the histogram used to estimate a probability density function f of a random walk variable X. Given a sample X1, X2, …, Xn of independent and identically distributed observations, the fixed estimator for the density function at point x is $f(x) = \frac{1}{n.h}\sum_{i=1}^{n} K(\frac{x - Xi}{h})$, where h is the bandwidth (smoothing parameter) and K is the kernel function. We use a Gaussian kernel function.

[6] The third mode would include Equatorial Guinea and Mauritius.

implies the potential existence of convergence clubs, which we try to highlight through a dynamic approach.

3.2. Dynamic approach

We see the distribution of GDP per capita for a given dates but cannot explain dynamics in the distribution during the period. Therefore, we estimate intradistributional mobility using stochastic kernels and transition probability matrices. We are interested in the stochastic kernel, in its continuous version. In addition, we normalize the per capita GDP observations for each economy to the average level of per capita GDP among the 53 countries. Then the dynamics of the cross-regional income distribution (F) can be modeled as an AR(k) process:

$$F_{t+k} = T(F_t), \tag{3}$$

where T denotes the operator mapping period's t distribution into the period's t + k distribution. Because the transition probabilities resulting from the Markov matrix can be distorted by an inappropriate discretization (i.e., choice of states), we retain the stochastic kernel approach, which is a continuous equivalent of the transition probability matrix. Hyndman et al. (1996) propose two methods to represent the conditional density: stacked and high-density region (HDR) plots (see also Basile 2010; Peron and Rey 2011).

Stacked plots depict the stochastic kernel as a three-dimensional, stacked, conditional density plot in which multiple conditional densities appear side-by-side. For any point x on the period t axis, observations in a direction parallel to the t + s time axis trace a conditional probability density. The graph shows how the cross-sectional income distribution at time t evolves by time t + s. A 45-degree diagonal in the graph indicates persistence properties.

The HDR plot instead reflects the smaller region in the sample space that contains a given probability. The 50% (darker shaded), 90%, and 99% (lighter shaded) HDR plots can be computed using the density estimate.

In Figure C1 (Appendix C), we depict the kernel density estimated for a 10-year relevant transition period (s = 10),[7] though mobility can be limited to shorter transition periods (e.g., 1 or 5 years). The stacked density plot (Figure C1a) reveals a probability mass along the main diagonal for the poorest countries, with some apparent deviations with higher relative incomes. The HDR plot (Figure C1b) shows persistence among countries with relative incomes between 0.1 and 3 times the average per capita income, insofar as the mass of the probability is concentrated around the diagonal. Conversely, we observe multimodality for the GDP per capita greater than 3 times the average; that is, we find some evidence for a convergence process among higher incomes.

The stochastic convergence approach applied to countries overall and then to subgroups of countries should enable us to discriminate among the absence of convergence, global convergence, and convergence clubs. However, it remains difficult to identify the convergence clubs exactly. Therefore, after our initial analysis to test for global convergence, we conduct a subsequent analysis to tease out the existence of clubs.

[7] To calculate the plots, we used the R package *hdrcde.*

4. Convergence Clubs in Africa

4.1. Stochastic Convergence and Panel Unit Root Tests

Consider an equilibrium relationship among incomes for a specified period. According to Bernard and Durlauf (1996), convergence means that the output difference between two economies, over a fixed time interval between *t* and *t + k*, tends to narrow. We also consider the output difference between the output of country *i* and the output of a reference country or a sample average, which serves as the benchmark. We follow Evans and Karras (1996) and write the convergence condition as:

$$\lim_{k\to\infty} E_t(y_{i,t+k} - y^*_{t+k}) = \mu_i . \tag{4}$$

In the convergence relationship that we analyze, y^* also could represent a sample average that contains country *i* or the GDP of either a reference country or a group of countries. In the first case, y^* gets replaced by the sample average $\bar{y}_t = N^{-1}\sum_{i=1}^{N} y_{i,t}$. In the second case, y^* equals the real per capita income of benchmark countries, defined as the world, the United States, Europe of 12, West Asia, or Latin America. It also is possible that we might observe dynamics in GDP per capita that differ depending on whether we consider African countries only or the comparison of African countries with other zones with which Africa has economic relationships. In this framework, convergence implies that $(y_{i,t} - y^*_t)$ is I(0) stationary. We achieve absolute convergence when $\mu_i = 0$ for all *i* and conditional convergence if $\mu_i \neq 0$ for some *i*. When $y_{i,t} - y^*_t$ is nonstationary for all *i*, the economies diverge.

To test for stochastic convergence, we adopt a panel unit root procedure. The tests without fixed individual effects reveal the presence of absolute convergence, whereas the versions with fixed individual effects can test for conditional convergence. For conditional convergence, we retain two categories of tests with fixed individual effects. The first assumes independent cross-sectional errors, whereas the second accounts for cross-sectional dependence in errors. Because African countries have strong economic linkages, it may be useful to apply all these tests[8].

4.2. Global Convergence

Table D1 (Appendix D) presents the panel unit root tests results for absolute convergence, without fixed individual effects. In all cases, regardless of which countries serve as the benchmark, we cannot reject the null hypothesis of a unit root, so there is no absolute convergence among African countries or between African countries and other economic zones. The results of the unit root tests with fixed individual effects to test conditional convergence appear in Tables D2 and D3. When we assume that the cross-sectional units are independent of each other (Table D2), the stationary hypothesis (Hadri's test) is rejected. Globally, this conclusion is confirmed in the tests of the null hypothesis of the unit root, with two exceptions. For Europe and Asia, using Levin et al.'s test, stationary/conditional convergence could be accepted. To confirm this conclusion, we next assume that the cross-

[8]These tests use Matlab software and codes developed by Hurlin (see http://www.univ-orleans.fr/deg/masters/ESA/CH/churlin_E.htm). The references of various articles describing these tests can be found in Peron and Rey (2011).

sectional units are dependent; the results in Table D3 confirm that there is no convergence among African countries. In addition, the findings reinforce the prediction of conditional convergence between African countries and Europe of 12; the null hypothesis is rejected for three tests out of four. With Choi's test, we discern conditional convergence with Asian countries, but other tests do not confirm this assertion. The convergence between African countries and the world, observed in one case, may be interpreted as the consequence of previous observations.

The absence of convergence among African countries together with the conditional convergence of African countries with Europe or even Asia reveal different dynamics among countries. Perhaps some countries have benefited from economic relationships (trade, technology transfers) with developed countries and in turn create convergence clubs, such that African countries with the greatest per capita incomes and growth paths constitute a separate group. These richest countries might have benefited more others (i.e., the poorest) from globalization.

4.3. Convergence Clubs

Although no absolute convergence of African economies is observable, it is possible that we might verify local convergence properties, such as occurs in convergence clubs. A small number of steady states exist, and each country has a tendency to converge to one of them. According to Azariadis and Drazen (1990) and Galor (1996), two theoretical conditions are necessary for clubs (i.e., multiple equilibriums) to emerge. First, a club comprises a group of countries with similar initial conditions. Generally differences in factor endowments across countries explain the emergence of multiple equilibrium. In empirical analyses, labor forces, human capital, GDP per capita, and capital stock per capita often are included as the initial conditions (Bartkowska and Riedl 2012). We consider real per capita GDP at the beginning of the period (1950) and another country-specific factor, namely, access to the sea. Second, countries in convergence clubs must have similar structural characteristics. Therefore, we consider HDI (as of 2009), the openness rate (a proxy for trade policy), the ratio of foreign direct investments (FDI) inflows[9] in terms of GDP, and the structure of production. The last factor also reflects initial conditions, insofar as the production of raw materials depends on natural resource endowments. Table E1, in the Appendix E, lists the different groups defined by these criteria.

To test for the existence of clubs, we first test for absolute convergence using unit root tests without individual effects. Then, if we find no absolute convergence, we test for conditional convergence using unit root tests with individual effects. These tests feature the difference between each GDP per capita (log) and the average GDP per capita of the group. In Table 1 we provide the results of these convergence tests for three groups defined by the initial GDP condition, namely, the poorest countries with a GDP per capita below US$600, intermediate countries with a GDP per capita of US$600–900, and the richest countries with an income more than US$900. For the poorest and richest groups, we find no convergence. Conversely, we find support for the conditional convergence hypothesis for the intermediate countries, in line with our observations of the HDR plots (Figure C1), which highlight a convergence process for countries with a GDP per capita more than three times the average.

[9] Ratio of FDI nets inflows in U.S. dollars/GDP in U.S. dollars, averaged across 1990–2008.

Table 1: Convergence clubs and initial conditions

	Poorest countries GDP1950<600	Intermediate countries 600<GDP1950<900	Richest countries GDP1950>900
	No Individual Effects: Absolute Convergence		
LLC	7.1346	-0.5732	1.9659
	(1.00)	(0.28)	(0.97)
	Individual Effects: Conditional Convergence		
LLC	8.7272	-1.8833**	1.8682
	(1.00)	(0.02)	(0.96)
IPS	11.6017	-0.1729	3.6750
	(1.00)	(0.43)	(0.99)
Cross-sections	18	17	19

Notes: The *p*-values are in parenthesis. LLC= Levin, Lin & Chu. IPS= Im, Pesaran & Shin.
*Significant at the 10% level. **Significant at the 5% level.

Table 2 contains the results of the absolute convergence tests for groups defined by their structural characteristics. We obtain positive results (reject the null hypothesis) in four cases. Absolute convergence occurs for groups with the highest HDI (>0.6) and lowest HDI (<0.4), as well as for the group with the lowest openness rate and the group with a ratio of FDI inflows greater than 2%.

In the absence of absolute convergence, we test for conditional convergence by considering individual effects in the unit root panel tests; we provide the results in Table 3. With Choi's test, we identify a convergence process in two cases: for countries with an openness rate between 50% and 90% and for the group with an FDI ratio below 2%. Other tests indicate conditional convergence for the group of oil and mineral producers. Eight of these countries belong to the group with higher HDI. Finally, one test (Bai and Ng) suggests convergence among countries with sea access.

These results confirm the existence of convergence clubs. By considering the initial conditions, as exemplified by the GDP per capita in 1950, we can conclude that there is a club of middle-income countries, but not of richest countries or of poorest countries. This result, apparently paradoxical, reflects the changes, both economic and political, that take place over the study period. For a country to initiate a catching-up process, it must benefit from foreign capital inflows, to compensate for its insufficient savings. But capital flows only if firms trust political institutions, which requires a sufficient degree of democracy and economic freedom (Easterly, 2006). A quick survey confirms that some countries in a relatively favorable position in 1950 experienced a sharp deterioration in their situation, especially following serious political crises, such as in the Ivory Coast, Liberia, Mozambique, and Somalia. These representatives joined other countries that already were sorely underdeveloped to form the

Table 2: Convergence clubs 1950–2008 and structural characteristics (independent panel unit root tests)

Criterion	Access to sea		Economic structure		Economic development (HDI)			Openness			Nets inflows FDI/GDP	
Groups	Access	Non Access	Oil & Mineral	Agric.	< 0.4	Interm.	> 0.6	< 50%	Interm.	>90 %	< 2%	> 2%
No Individual Effects: Absolute Convergence												
LLC	3.426	1.357	2.809	1.329	-2.791**	2.772	-2.661**	-2.162**	-0.152	3.192	2.516	-1.529*
	(0.99)	(0.91)	(0.99)	(0.90)	(0.002)	(0.99)	(0.003)	(0.00)	(0.43)	(0.99)	(0.99)	(0.06)
Individual Effects: Conditional Convergence												
LLC	4.296	0.577	2.568	2.369		7.063			0.914	4.387	1.470	
	(1.00)	(0.71)	(0.99)	(0.99)		(1.00)			(0.81)	(1.00)	(0.92)	
IPS	6.315	3.245	4.718	4.553		8.457			2.356	6.082	2.293	
	(1.00)	(0.99)	(1.00)	(1.00)		(1.00)			(0.99)	(1.00)	(0.98)	
Observations	2360	767	1357	1770		1534			1534	767	1711	

Notes: The probabilities for the Fisher tests are computed using an asymptotic chi-square distribution. All other tests assume asymptotic normality. The individual effects are exogenous variables. We use balanced observations for each test. ADF = augmented Dickey–Fuller test, and PP = Philipps-Perron. LLC= Levin, Lin & Chu. IPS= Im, Pesaran & Shin. The *p*-values are in parenthesis.

*Significant at the 10% level. **Significant at the 5% level.

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Table 3: Convergence clubs 1950–2008 and structural characteristics (dependent panel unit root tests with individual effects)

	Criterion	Access to sea		Economic structure		Economic development (HDI)			Openness			Nets inflows FDI/GDP	
	Groups	Yes	No	Oil & Mineral	Agri.	< 0.4	Int.	> 0.6	< 50%	Int.	>90 %	< 2%	> 2%
Null: Unit root Statistic													
Choi (a)	*Pm*	0.434	0.212	2.294**	0.972		-0.051			2.711**	-1.440	3.413**	
		(0.33)	(0.41)	(0.01)	(0.16)		(0.52)			(0.003)	(0.92)	(0.0003)	
	Z	1.227	0.757	-0.777	0.499		0.049			-1.718**	1.602	-1.450*	
		(0.89)	(0.77)	(0.21)	(0.69)		(0.51)			(0.04)	(0.94)	(0.07)	
	L^*	1.473	1.108	-1.049	0.891		0.005			-1.915**	1.546	-1.683**	
		(0.92)	(0.86)	(0.14)	(0.81)		(0.50)			(0.02)	(0.93)	(0.04)	
Moon & Perron (b)	t_a^*	0.768	1.364	0.215	1.135		0.025			0.205	1.130	0.873	
		(0.77)	(0.91)	(0.58)	(0.87)		(0.50)			(0.58)	(0.87)	(0.80)	
	t_b^*	4.780	6.319	1.998	5.095		0.133			1.160	8.866	4.876	
		(1.00)	(1.00)	(0.97)	(1.00)		(0.55)			(0.87)	(1.00)	(1.00)	
Bai & Ng (c)	*PCe_Choi*	1.192*	-1.228	1.311*	-1.025		-0.782			-0.603	-1.878	-0.757	
		(0.11)	(0.89)	(0.09)	(0.84)		(0.78)			(0.72)	(0.96)	(0.77)	
	PCe_MW	95.08*	17.14	47.12*	48.76		38.49			45.85	12.45	49.83	
		(0.11)	(0.90)	(0.10)	(0.85)		(0.77)			(0.71)	(0.98)	(0.76)	
Pesaran (d)	*CIPS*	-1.615	-1.500	-1.281	-1.613		-0.818			-0.902	-1.206	-1.849	
	p=1	(0.76)	(0.89)	(0.97)	(0.76)		(0.99)			(0.99)	(0.98)	(0.38)	
	p=2	-1.616	-1.376	-1.443	-1.529		-0.754			-0.945	-1.312	-1.687	
		(0.76)	(0.92)	(0.90)	(0.86)		(0.99)			(0.99)	(0.95)	(0.65)	
	p=3	-1.756	-1.397	-1.441	-1.599		-0.796			-1.01	-1.493	-1.734	
		(0.53)	(0.90)	(0.90)	(0.77)		(0.99)			(0.99)	(0.83)	(0.56)	

(a) Lag selection in the augmented Dickey–Fuller/generalized least squares (ADF-GLS) test is determined using the Bayesian information criterion.
(b) t_a^* and t_b^* tests are computed using a quadratic spectral kernel.
(c) *PCe_Choi* is a pooled test standardized statistic on idiosyncratic components (N[0,1] under H0). *PCe_MW* is a pooled tests statistic on idiosyncratic components (χ^2 at 2N degrees of freedom under H0).
(d) The *CIPS* test is the mean of individual cross-sectional ADF statistics. The truncated statistics (*CIPS**) are not reported because they are always equal to the nontruncated ones. *p* denotes the nearest integer of the mean of the individual lag lengths in ADF tests.
Notes: The *p*-values are in parenthesis. *Significant at the 10% level. **Significant at the 5% level.

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club of “poor countries” with a low HDI (< 0.4). Conversely, among the 10 nations that make up the club of “rich countries,” with a high HDI (> 0.6), eight countries belong to the group with the best initial conditions in 1950 and a GDP per capita of greater than $900. None of the poorest countries in 1950 (GDP per capita < $600) belongs to the club of most developed countries 60 years later.

Prior literature also emphasizes the role of structural factors in convergence processes. In particular, economic openness constitutes a key driver of the catching-up process. The results we achieved confirmed these hypotheses, in that we observed clubs conditioned by the openness rate, measured by the trade/GDP ratio and FDI inflows/GDP ratio. Thus, countries with low exposure to exchange and those with an intermediate openness rate constitute two separate clubs. Note that the club of the least open (<50%) is predominantly composed of countries that originally belonged to the group of poorest countries or the group of middle-income countries. We therefore consider that a low openness rate contributes to maintain the country in a poverty trap. In contrast, countries with high openness rates achieve differentiated economic performance and are not a club. A high degree of openness can help them catch up, but it is insufficient if other conditions are not met.

In a complementary way, we highlight the role of capital inflows (FDI) for two clubs, one with a FDI/GDP ratio greater than 2% and another whose ratio is less than 2%. With the exceptions of the Seychelles and Mauritius, the countries that received the least FDI comprise the initially poorest countries or countries whose political situation deteriorated sharply (Algeria, Madagascar, Somalia, Sierra Leone, Ivory Coast). In addition, eight of the most closed countries join this club (Benin, Burkina Faso, Burundi, Cameroon, Central Africa Republic, Comoros, Sierra Leone, Somalia).

In summary, countries that were initially poor or that became poorer as a result of serious political events become caught in a poverty trap, due to both low openness and a lack of FDI inflows. Conversely, countries initially favored have become the core representatives of the most developed countries. This phenomenon is reinforced by a greater economic openness. Finally, though the statistical estimates are less conclusive, except in Seychelles and Mauritius, countries with a high HDI belong to the club of countries producing raw materials. It is therefore not surprising that these countries appear more open and attract more FDI, both from developed countries and, since the 2000s, from major emerging countries.

5. Conclusion

This study confirms disparity in the dynamics of growth processes for African countries. Over the long term, we show that there was no global convergence among 53 African countries. Conversely, the poorest countries remained relatively poor, stuck in a poverty trap, while countries with the best initial conditions converged. With regard to the structural characteristics, we find that significant determinants explain the constitution of convergence clubs among African countries, namely, openness, FDI inflows, and the level of development, as approximated by HDI. In a few cases, some tests also highlight the production structure and access to the sea.

In other words, the more a country is closed to international trade, the less it receives FDI, and the lower its level of development (e.g., education, health) will be, such that it is more likely to stay poor. Natural resource endowments are not sufficient to support a regular growth process that would enable the country to catch up to more developed nations.

Our conclusions thus confirm, in line with prior empirical studies, that there is no absolute convergence among African countries. We also show that the constitution of clubs can be explained effectively by HDI and openness, coherent with the conclusions of Charles et al (2011) for the HDI variable among COMESA countries and with Peron and Rey (2011) for openness among Indian Ocean countries.

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Appendix A: Destination of exports

Table A1: Destination of exports (percentage of total) in 2007

Exporters	Importers				
	Developed countries			Emerging countries	Others
	Total	USA	Euro area		
China	73.4	24	17.4	15.3	11.3
India	51.1	14.3	15.9	22.1	26.8
South-East Asia	52.1	13.3	10.7	37.3	10.6
Latin America	66.3	43.4	12	19.2	14.5
MENA	82	15.2	38.5	8.4	9.6
Africa	73	17	39	22	5
Emerging countries	65.1	22.3	18.3	18.7	16.2
World	67.4	14.3	29.9	18.4	14.2

Source: WTO

Appendix B: Kernel density

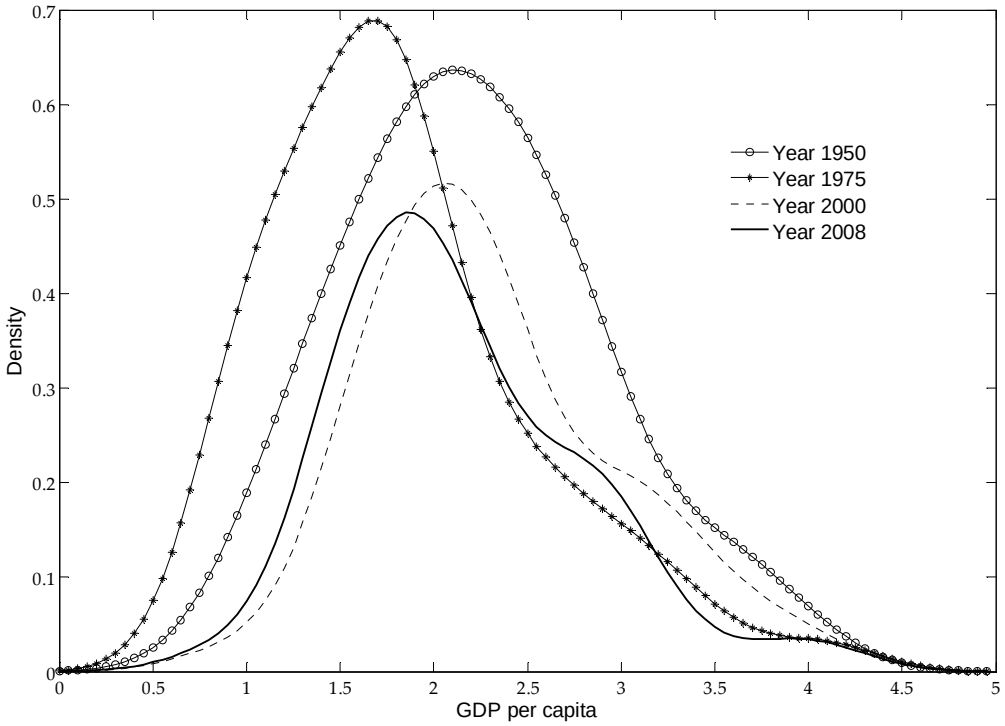


Figure B1: Kernel density of relative income per capita

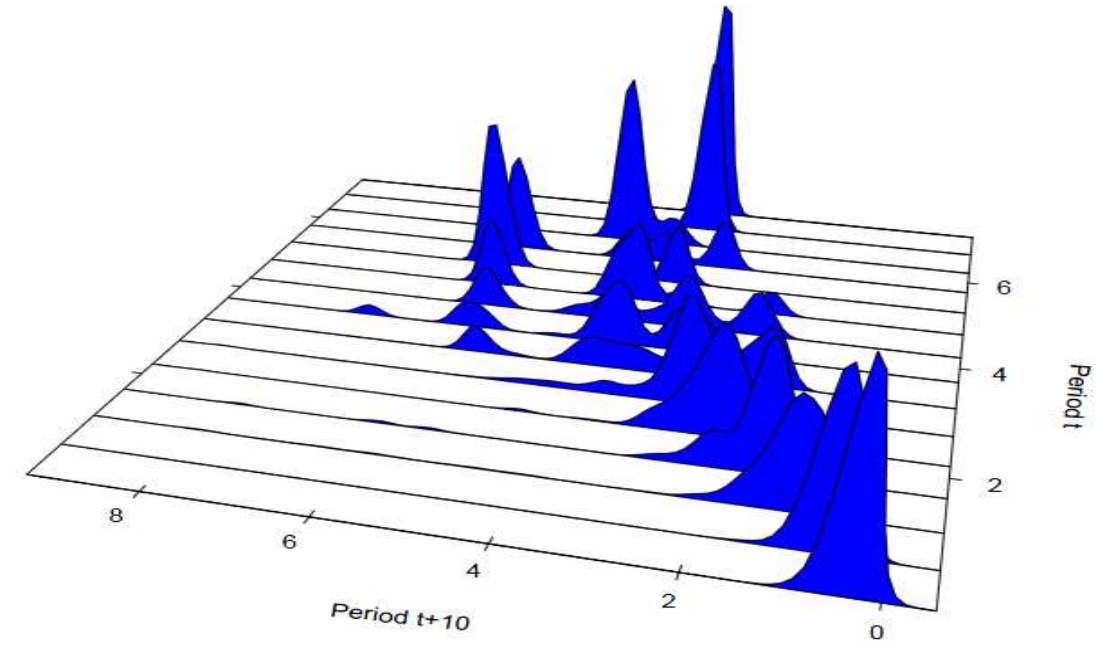
Appendix C: Dynamic approach

Stacked plots depict the stochastic kernel as a three-dimensional. When most of the values appear concentrated along this diagonal, the elements in the cross-sectional distribution remain where they started, and there is no convergence process.

The HDR plot instead reflects the smaller region in the sample space that contains a given probability.[10] From these plots, we would find strong persistence if the elements remained where they started (i.e., the 45-degree diagonal crosses the 50% HDR); weak persistence if the diagonal crossed only the 90% or 99% HDR; strong (weak) global convergence if the horizontal line traced at 1.0 of the period t + s axis crossed all the 50% (90%–99%) HDRs; and strong (weak) local or club convergence if some 50% (90%–99%) HDRs were crossed by a horizontal line traced at any value of the t + s axis.

[10] The mode plot of each conditional estimate (highest for multimodal distributions) is superimposed on the HDR plots as bullets.

(a) Stacked density



(b) Relative per capita income

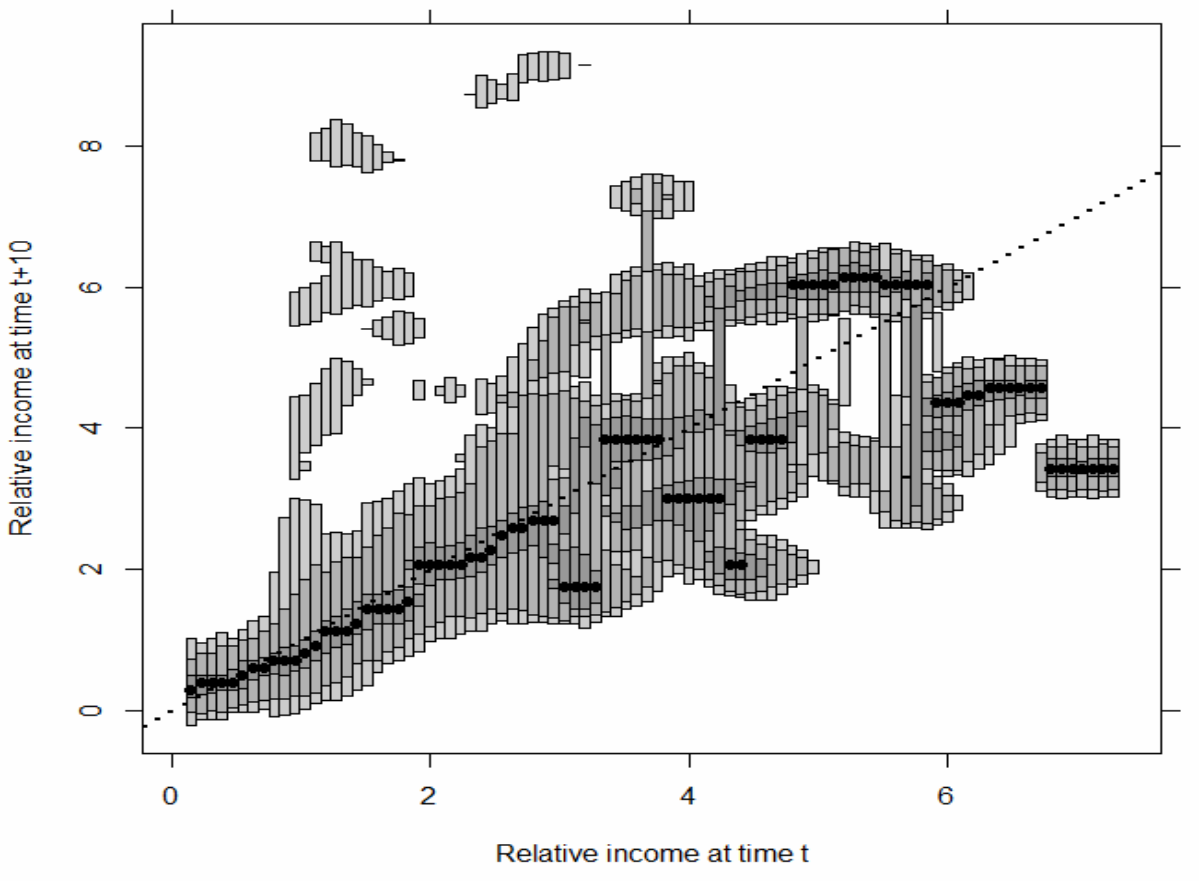


Figure C1: Dynamics across 53 African countries

Appendix D: Stochastic convergence and panel unit root tests

In a stochastic framework, *i* economies, *1*, *2*, …, *N*, are said to converge if a common trend exists. If a_{t+k} is this common trend, we have: $\lim_{k\to\infty} E_t(y_{i,t+k} - a_{t+k}) = \mu_i$,

where the parameter μ_i determines the level of economy *i*'s balanced growth path, and y_i is the logarithm of its real per capita income. The common trend is not observable, but according to the convergence hypothesis, the per capita income of the benchmark country y^* must converge to this trend, that is, $\lim_{k\to\infty} E_t(y^*_{t+k} - a_{t+k}) = 0$.

Costantini and Lupi (2005) and Hurlin and Mignon (2005) provide the details of these tests, which we do not repeat here.

Table D1: Independent panel unit root tests, 1950–2008 (no individual effects: absolute convergence)

	Benchmark Country GDP					
	Sample Mean Africa	World	USA	Europe	West Asia (a)	Latin America (b)
Null: Unit root (assumes common unit root process)						
Levin, Lin & Chu t*	3.548 (0.99)	9.942 (1.00)	7.350 (1.00)	11.466 (1.00)	7.872 (1.00)	6.147 (1.00)
Breitung t-statistic	0.187 (0.57)	3.229 (0.99)	5.399 (1.00)	9.593 (1.00)	4.433 (1.00)	1.492 (0.93)
Null: Unit root (assumes individual unit root process)						
ADF - Fisher chi-square	51.591 (1.00)	36.190 (1.00)	43.413 (1.00)	22.281 (1.00)	32.882 (1.00)	48.877 (1.00)
PP - Fisher chi-square	52.078 (1.00)	35.608 (1.00)	43.827 (1.00)	19.446 (1.00)	31.605 (1.00)	60.385 (0.99)

Notes: The probabilities for the Fisher tests are computed using an asymptotic chi-square distribution. All other tests assume asymptotic normality. ADF = augmented Dickey–Fuller test; PP = Philipps-Perron. The *p*-values are in parenthesis.

*Significant at the 10% level. **Significant at the 5% level.

(a) West Asia: Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey, UAE, Yemen and West Bank & Gaza.

(b) Latin America: Argentina, Brazil, Chile, Colombia, Mexico, Peru, Uruguay and Venezuela

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Table D2: Independent panel unit root tests: 1950–2008 (individual effects: conditional convergence)

	Benchmark Country GDP					
	Sample Mean Africa	World	USA	Europe	West Asia (a)	Latin America (b)
Null: Unit root (assumes common unit-root process)						
Levin, Lin & Chu t*	3.790 (0.99)	2.109 (0.98)	2.131 (0.98)	-4.155** (0.00)	-2.849** (0.002)	1.473 (0.92)
Breitung t-statistic	0.947 (0.82)	3.536 (0.99)	6.750 (1.00)	7.910 (1.00)	2.910 (0.99)	1.691 (0.95)
Null: Unit root (assumes individual unit-root process)						
Im, Pesaran & Shin W-statistic	7.011 (1.00)	7.786 (1.00)	7.613 (1.00)	2.972 (0.99)	2.454 (0.99)	5.663 (1.00)
ADF - Fisher chi-square	51.266 (1.00)	42.853 (1.00)	33.247 (1.00)	91.236 (0.84)	80.912 (0.96)	51.319 (1.00)
PP - Fisher chi-square	45.934 (1.00)	40.279 (1.00)	33.602 (1.00)	90.169 (0.86)	75.317 (0.98)	46.099 (1.00)
Null: No unit root (assumes common unit-root process)						
Hadri Z-statistic	28.149** (0.00	30.909** (0.00)	30.261** (0.00)	32.451** (0.00)	29.334** (0.00)	29.369** (0.00)

Notes: The probabilities for the Fisher tests are computed using an asymptotic chi-square distribution. All other tests assume asymptotic normality. Individual effects are the exogenous variables. There were balanced observations for each test. ADF = augmented Dickey–Fuller test; PP = Philipps-Perron. The *p*-values are in parenthesis.

*Significant at the 10% level. **Significant at the 5% level.

(a) West Asia: Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey, UAE, Yemen and West Bank & Gaza.

(b) Latin America: Argentina, Brazil, Chile, Colombia, Mexico, Peru, Uruguay and Venezuela.

Table D3: Dependent panel unit root tests: 1950–2008 (individual effects: conditional convergence)

		Benchmark country GDP					
		Sample Mean					
Null: Unit root	Statistic	Africa	World	USA	Europe	West Asia	Latin America
		0.748	-0.550	-1.653	2.774**	2.260**	0.488
Choi (a)	*Pm*	(0.22)	(0.70)	(0.95)	(0.003)	(0.01)	(0.31)
		1.353	1.901	2.017	-1.940**	-2.318**	0.440
	Z	(0.91)	(0.97)	(0.97)	(0.02)	(0.01)	(0.67)
		1.846	1.931	2.012	-2.232**	-2.062**	0.669
	L^*	(0.96)	(0.97)	(0.97)	(0.01)	(0.02)	(0.74)
Moon & Perron		0.651	1.063	0.208	0.773	0.865	0.308
(b)	t_a^*	(0.74)	(0.85)	(0.58)	(0.78)	(0.80)	(0.62)
		3.171	9.881	1.813	11.721	4.332	1.793
	t_b^*	(0.99)	(1.00)	(0.96)	(1.00)	(1.00)	(0.96)
		0.261	2.099**	0.217	1.763**	-0.775	0.816
Bai & Ng (c)	*PCe_Choi*	(0.39)	(0.02)	(0.41)	(0.03)	(0.78)	(0.21)
		109.805	136.568**	109.164	131.673**	94.710	117.893
	PCe_MW	(0.38)	(0.02)	(0.39)	(0.05)	(0.77)	(0.20)
		-1.476	-1.885	-1.741	-2.014	-1.704	-1.891
Pesaran (d)	*CIPS p=1*	(0.93)	(0.31)	(0.56)	(0.14)	(0.63)	(0.30)
		-1.494	-1.881	-1.751	-2.045*	-1.556	-1.795
	p=2	(0.92)	(0.32)	(0.55)	(0.10)	(0.86)	(0.46)
		-1.573	-2.012	-1.895	-2.123**	-1.589	-1.772
	p=3	(0.82)	(0.13)	(0.28)	(0.04)	(0.80)	(0.49)

(a) Lag selection in the augmented Dickey–Fuller/generalized least squares (ADF-GLS) test is determined using the Bayesian information criterion.
(b) t_a^* and t_b^* tests are computed using a quadratic spectral kernel.
(c) *PCe_Choi* is a pooled test standardized statistic on idiosyncratic components (N[0,1] under H0). *PCe_MW* is a pooled tests statistic on idiosyncratic components (χ^2 at 2N degrees of freedom under H0).
(d) The *CIPS* test is the mean of individual cross-sectional ADF statistics. The truncated statistics (*CIPS**) are not reported because they are always equal to the nontruncated ones. *p* denotes the nearest integer of the mean of the individual lag lengths in ADF tests.
Notes: The *p*-values are in parenthesis. *Significant at the 10% level. **Significant at the 5% level.

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Appendix E: Composition of groups

Table E1: Groups according to different criteria

Criteria	Countries
GDP per capita in 1950	
Group 1: GDP>900	Algeria, Angola, Benin, Egypt, Mauritius, Gabon, Senegal, Morocco, Ghana, Liberia, Mozambique, Namibia, Congo-Brazzaville, Ivory Coast, Djibouti, Seychelles, Somalia, South Africa, Tunisia
Group 2: 600<GDP<900	Cameroon, Central Africa Rep., Gambia, Kenya, Libya, Madagascar, Niger, Nigeria, Rwanda, Sao Tome, Small_Afr, Sierra Leone, Sudan, Swaziland, Uganda, Zambia, Zimbabwe
Group 3: GDP<600	Botswana, Burkina, Burundi, Cap Verde, Chad, Comoros, DR Congo, Eritrea/Ethiopia, Guinea, Guinea Bissau, Guinea Equatorial, Lesotho, Malawi, Mali, Mauritania, Tanzania, Togo
HDI (2009)	
Group 1: HDI>0.6	Algeria, Botswana, Egypt, Gabon, Libya, Mauritius, Namibia, Seychelles, South Africa, Tunisia
Group 2: 0.4<HDI<0.6	Angola, Benin, Cameroon, Cap Verde, Comoros, Congo-Brazzaville, Djibouti, Gambia, Ghana, Guinea Equatorial, Kenya, Lesotho, Madagascar, Morocco, Mauritania, Nigeria, Uganda, Rwanda, Sao Tome, Senegal, Sudan, Swaziland, Tanzania, Togo, Zambia.
Group 3: HDI<0.4	Burkina Faso, Burundi, Central Africa Rep., DR Congo, Ivory Coast, Eritrea/Ethiopia, Guinea, Guinea Bissau, Liberia, Malawi, Mali, Mozambique, Niger, Sierra Leone, Somalia, Chad, Zimbabwe
Access to the sea	
Countries with access	Morocco, Mauritania, Senegal, Cap Verde, Gambia, Guinea Bissau, Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Togo, Benin, Nigeria, Cameroon, Guinea Equatorial, Gabon, Congo-Brazzaville, Sao Tome et Principe, DR Congo, Angola, Namibia, South Africa, Mozambique, Madagascar, Mauritius, Seychelles, Tanzania, Kenya, Somalia, Eritrea/Ethiopia, Djibouti, Sudan, Egypt, Tunisia, Libya, Algeria, Comoros.
Countries without access	Mali, Burkina Faso, Niger, Chad, Central Africa Rep, Uganda, Rwanda, Burundi, Zambia, Zimbabwe, Botswana, Lesotho, Swaziland.
Production structure	
Producer of oil and minerals	South Africa, Algeria, Angola, Botswana, Cameroon, Central Africa Rep., Congo-Brazzaville, Egypt, Gabon, Guinea, Equatorial Guinea, Libya, Morocco, Mauritania, Namibia, Nigeria, Sudan, Tanzania, Chad, Togo, Tunisia, DR Congo, Zambia.
Producer of raw materials agricultural	Zimbabwe, Swaziland, Somalia, Sierra Leone, Seychelles, Sao Tome, Rwanda, Uganda, Niger, Mozambique, Mauritius, Mali, Malawi, Madagascar, Lesotho, Kenya, Guinea-Bissau, Gambia, Eritrea/Ethiopia, Djibouti, Ivory Coast, Comoros, Cap Verde, Burundi, Burkina Faso, Benin.

Table E1 (continued)	
Openness (1990–2009 average)	
Group 1: Open <50%	Benin, Burkina Faso, Burundi, Cameroon, Central African Rep., Comoros, Rwanda, Sierra Leone, Somalia, Sudan, Tanzania, Uganda, Zambia
Group2:50%<Open<90%	Algeria, Botswana, Cape Verde, Chad, Ivory Coast, Egypt, Eritrea-Ethiopia, Gabon, Gambia, Guinea, Guinea-Bissau, Kenya, Liberia, Libya, Madagascar, Malawi, Mali, Morocco, Mozambique, Namibia, Niger, Nigeria, Senegal, South Africa, Togo, Zimbabwe
Group 3: Open >90%	Angola, DR Congo, Congo-Brazzaville, Djibouti, Equatorial Guinea, Ghana, Lesotho, Mauritania, Mauritius, Sao Tome and Principe, Seychelles, Swaziland, Tunisia
FDI inflows/GDP (1990–2009 average)	
Group 1: Ratio < 2%	Algeria, Benin, Burkina Faso, Burundi, Cameroon, Central African Rep., Comoros, Egypt, Eritrea & Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Kenya, Madagascar, Malawi, Mali, Mauritius, Namibia, Niger, Sao Tome, Seychelles, Sierra Leone, Somalia, Swaziland, Togo
Group 2: Ratio> 2%	Angola, Cape Verde, Botswana, Chad, Djibouti, DR Congo, Congo-Brazzaville, Equatorial Guinea, Lesotho, Liberia, Libya, Mauritania, Morocco, Mozambique, Nigeria, Rwanda, Senegal, South Africa, Sudan, Tunisia, Tanzania, Uganda, Zambia, Zimbabwe

Note: DR Congo or Congo Kinshasa or Zaire. Congo-Brazzaville or Republic of Congo. Equatorial Guinea or Republic of Equatorial Guinea. Small_Afr refers to three small countries: Mayotte, Saint Helena, and West Sahara.

The statistics came from three main sources: data on GDP per capita were extracted from Maddison (http://www.ggdc.net/maddison/), openness was measured as the ratio of trade to GDP (Source: Penn World Table, http://pwt.econ.upenn.edu/php_site/pwt_index.php), and FDI inflows came from CNUCED, UNCTADstat.