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Analyzing slowdown and meltdowns in the African countries: New evidence using Fourier quantile unit root test

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ABSTRACT

In this paper, we analyze growth dynamics in the 25 African countries over the period 1950–2016. To this end, first, we test the stochastic properties of real per capita GDP series. While conventional unit root and standard quantile unit root tests do not reject a unit root, using a novel quantile unit root test which allows for smooth breaks, we could find the results in favor of trend stationarity of 16 out of 25 real per capita GDP series. Our results indicate that in some countries positive shocks to real per capita GDP series have permanent effect and in some of them, the negative shocks. Whereas all of African countries in our sample specialized in producing and exporting primary products, hence to have favorable growth performance, they have to manage terms of trade shocks to avoid large swings in the real per capita GDP.

1. Introduction

Economic theories offer different explanations for one of the stylized facts in the postwar growth literature namely stability of growth process. While neoclassical growth theory predicts the output per capita of countries converge to steady state and when approach to the station, the economy will grow at a long-run constant rate. Hence the theory predicts that all shocks to the income per capita have transitory effect. In contrast, the endogenous growth theories pioneered by Romer (1986), Lucas (1988), Grossman and Helpman (1991), and Aghion and Howitt (1992) predict that due to spillover effects of physical capital, human capital, and research and development activities, the economy will growth in a permanent increasing rate. Empirical studies prepared mixed findings on output per capita dynamics. While Kaldor (1961) found evidence for sustainable growth rate over the postwar period, Romer (1986) and Maddison (1982) found evidence for increasing growth rates.

Most of empirical studies on stability of economic growth process, used unit root/stationary tests. Ben-David and Papell (1995) tested the growth stability for 16 OECD countries using Vogelsang's (1997) test approach and found most of OECD countries experienced increasing growth rate over post world wars I and II. Ben-David and Papell (1998) tested the growth stability for 74 countries over the post wars. The findings indicate that most of developing countries especially for Latin American countries experienced growth slowdown over the 1980s. Ben-David, Lumsdaine, and Papell (2003) using Lumsdaine and Papell (1997) unit root test with two sharp

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Table 1
Dynamics and distribution of RPCGDP.

Country	Panel A: Average real GDP per capita							Panel B: Statistical properties			
	1950s	1960s	1970s	1980s	1990s	2000s	2010s	Standard deviation	Skewness	Kurtosis	Jarque-Bera P-Value
Algeria	1530	1840	2548	3220	2754	3302	3738	0.316	−0.614	2.139	0.043
Angola	1136	1522	1359	828	716	1091	1452	0.337	−0.054	1.764	0.117
Burkina Faso	534	681	723	786	869	1084	1174	0.282	0.286	2.454	0.418
Cameroon	746	882	1039	1452	1035	1091	1046	0.209	0.108	2.872	0.916
Côte d'Ivoire	1118	1533	1867	1760	1339	1262	1195	0.190	0.236	1.847	0.115
DR Congo	704	748	735	575	327	207	237	0.514	−0.522	1.616	0.015
Egypt	913	1129	1500	2351	2788	3542	3657	0.538	−0.137	1.542	0.046
Ethiopia	412	521	614	607	504	607	852	0.252	1.004	4.189	0.001
Ghana	1204	1375	1324	1030	1188	1551	1948	0.233	1.103	3.970	0.000
Kenya	705	770	971	1047	1044	1043	1087	0.188	−0.521	2.393	0.132
Madagascar	1042	1126	1129	854	695	686	610	0.227	0.014	1.342	0.022
Malawi	359	410	569	578	581	633	673	0.247	−0.420	2.117	0.126
Mali	492	551	648	698	742	954	973	0.264	0.317	2.051	0.163
Morocco	1442	1418	1846	2369	2740	3524	4008	0.406	0.299	1.907	0.114
Mozambique	1222	1412	1535	1069	1274	2236	2869	0.369	0.993	2.987	0.004
Niger	673	861	739	666	484	481	496	0.222	0.087	1.820	0.137
Nigeria	819	842	1276	1070	1176	1746	2189	0.365	0.753	2.699	0.037
Senegal	1355	1474	1385	1281	1236	1412	1383	0.080	0.088	2.019	0.250
South Africa	2781	3478	4186	4123	3710	4395	4454	0.183	−0.546	2.691	0.166
Sudan	907	968	949	876	858	1282	1313	0.204	0.952	2.876	0.006
Tanzania	451	505	600	553	531	646	742	0.189	0.918	3.573	0.006
Tunisia	1199	1571	2378	3065	3831	5428	5742	0.574	−0.098	1.789	0.123
Uganda	676	773	785	575	649	938	1090	0.241	0.731	2.765	0.047
Zambia	763	1016	1038	819	701	787	973	0.189	0.058	1.796	0.130
Zimbabwe	813	974	1334	1339	1360	1019	843	0.221	−0.311	1.794	0.077

Note: figure with double underline (underline) indicate countries which have the most (the least) average GDP per capita or yearly average value of GDP per capita. Data for decade 2010s cover the period 2010–2016.

breaks found about half of the countries experience postwar slowdowns and most of them exhibit faster growth after the second structural breaks. Chang, Chu, and Ranjbar (2014) tested the stochastic properties of real per capita GDP of African countries using sequential panel selection method and found that real GDP per capita are stationary in 50 out of the 52 African countries. More recently, Ranjbar, Li, Chang, and Lee (2015) test growth stability in East Asian region using panel stationarity test with a sharp break. Their findings indicate that most of countries experienced a growth slowdown after structural breaks (which related to Asian financial crisis for some countries).

Regarding the African countries, there are scarce literature (to the best of our knowledge, only Ben-David and Papell (1998)) investigated the growth stability in the countries. While sustained and a substantial economic growth is a pre-request to reduce the poverty in the countries. Since the early 1990s many African countries have been on a trajectory of higher growth, so, African poverty, infrastructure, education access and infant mortality have improved significantly. In a recent study, Sy (2016) point out that: "If the region was able to regain its 2004–2014 growth rate GDP per capita could be doubled in 20.5 years, by 2036. In contrast, at a growth rate of 1.4% as currently predicted, this achievement would only be realized in 50 years, by the year 2065". Economic growth across the region is likely to remain slower in coming years than it has been over the past 10–15 years. The International Monetary Fund's (IMF) baseline projection for 2016 is now down to 3%, from what was a forecasted 6.1% in April 2015(1). The main reasons for a relative slowdown are not unique to Africa and are the same as those weighing down the global economy: a general slowdown in emerging market economies, and in particular the rebalancing of China's economy; ongoing stagnation in most developed economies; lower commodity prices, especially softening oil prices; and higher borrowing costs.

However, although growth in region has relatively slowed, two-thirds of Sub-Saharan African economies are still growing at rates above the global average, and will remain the second fastest-growing region in the world for the foreseeable future, after Emerging Asia. This is further supported by the year-on-year increase in FDI project numbers in Africa in 2015 that occurred in a context in which the total number of FDI projects globally dropped by 5%. In fact, Africa was one of only two regions in the world in which there was growth in the number of FDI projects over the past year.

To fill the gap in the economic growth literature regarding to stability of growth in the African countries, in this paper, we analyze growth stability in the countries over the period 1950–2016. To this end, we use a novel quantile unit root test that developed by Bahmani-Oskooee, Chang, Elmi, and Ranjbar (2018a). The test has several advantages over traditional unit root and standard quantile unit root test. First, exogenous growth theory predicts that output per capita converge toward a steady state level. Thus whether it is above or below the steady state level, may show different (or asymmetric) behavior to shocks. Without specification of a special assumption regarding the functional form of nonlinearities, using the quantile regression, we able to allow for different speed of adjustment at various quantiles of output per capita distribution and capture its asymmetric behavior. Second, as noted by Basu, Calamitsis, and Ghura (2005), most of African countries involve(d) in the civil wars, armed conflicts, and political instabilities and also most of them specialize in the producing and exporting primary products, therefore, there is possible that their output per capita experience breaks in various times. To capture the nonlinearities, the Bahmani-Oskooee et al. (2018a) test allows for smooth breaks in

Table 2
Conventional, Fourier type, and quantile unit root test.

$$\Delta e_t = \varpi e_{t-1}^3 + \sum_{i=1}^{l} \iota_i \Delta e_{t-i} + \xi_t$$

$$t_{KSS} = \frac{\widehat{\varpi}}{se(\widehat{\varpi})}$$

$$\Delta e_t = \varpi e_{t-1} + \sum_{i=1}^{l} \iota_i \Delta e_{t-i} + \xi_t$$

$$t_{ADF} = \frac{\widehat{\varpi}}{se(\widehat{\varpi})}$$

Commodity	Panel A: Conventional unit root tests				Panel B: Fourier type unit root tests		Panel C: Quantile unit root tests			
	ADF	DF-GLS	PP	NP	FADF	FKSS	QKS	10%	5%	1%
Algeria	−1.899 (9)	−1.974 (9)	−1.986 [5]	−5.860 [5]	−4.364** (9)	−3.718** (9)	1.626	3.17	3.66	4.23
Angola	−1.378 (6)	−1.600 (6)	−0.936 [3]	−3.095 [3]	−5.382*** (11)	−4.962*** (1)	3.198**	2.87	3.01	3.29
Burkina Faso	−1.387 (10)	−1.855 (10)	−1.688 [1]	−6.177 [1]	−3.569 (10)	−3.995* (1)	1.472	3.03	3.27	4.65
Cameroon	−1.774 (9)	−1.428 (9)	−1.919 [5]	−4.888 [5]	−3.634 (11)	−3.425* (8)	9.367***	2.76	3.3	3.74
Côte d'Ivoire	−2.034 (2)	−1.528 (2)	−1.856 [4]	−2.675 [4]	−4.037* (8)	−2.181 (11)	2.569	3.4	3.89	4.74
DR Congo	−1.804 (3)	−1.948 (3)	−1.999 [5]	−3.485 [5]	−4.035* (11)	−2.092 (11)	1.719	3.26	3.72	6.92
Egypt	−2.275 (1)	−2.170 (1)	−1.933 [4]	−5.756 [4]	−4.642** (6)	−4.603** (1)	2.155	3.22	3.63	5.95
Ethiopia	−2.732 (10)	−2.977 (10)	−0.371 [4]	−2.177 [4]	−2.048 (7)	−0.433 (7)	1.917	3.36	3.54	3.98
Ghana	−1.460 (8)	−2.148 (8)	0.033 [4]	−0.743 [4]	−4.131** (11)	−5.281*** (3)	2.824	3.62	4.05	5.24
Kenya	−2.813 (9)	−2.476 (9)	−2.052 [0]	−6.662 [0]	−3.557 (9)	−1.759 (7)	1.537	3.13	3.47	3.81
Madagascar	−1.788 (8)	−1.339 (0)	−2.253 [3]	−2.974 [3]	−2.831 (11)	−5.897** (3)	2.421	3.22	3.38	4.4
Malawi	−1.838 (3)	−1.599 (3)	−2.133 [3]	−6.701 [3]	−3.604 (5)	−4.254** (5)	2.076	3.57	3.97	4.87
Mali	−2.859 (0)	−2.927 (0)	−2.790 [1]	−13.114 [1]	−1.919 (6)	−4.093*** (11)	2.207	3.01	3.59	4.08
Morocco	−2.649 (10)	−2.211 (10)	−2.476 [4]	−1.426 [4]	−1.505 (10)	−2.03 (3)	2.916	3.6	4.02	5.87
Mozambique	−2.234 (9)	−2.614 (9)	−0.345 [4]	−1.244 [4]	−4.229** (9)	−3.04 (9)	1.667	3.18	3.69	4.31
Niger	−2.256 (9)	−2.022 (9)	−1.874 [4]	−4.451 [4]	−4.250** (9)	−0.937 (10)	1.808	3.32	3.47	3.93
Nigeria	−1.937 (5)	−2.077 (5)	−1.441 [2]	−5.083 [2]	−1.968 (5)	−2.606 (5)	1.987	3.63	4.23	6.18
Senegal	−1.295 (0)	−1.066 (4)	−0.992 [2]	−3.331 [2]	−5.809*** (0)	−1.688 (10)	1.988	2.84	2.99	3.24
South Africa	−4.194** (10)	−2.076 (6)	−1.764 [4]	−2.650 [4]	−3.208 (1)	−1.881 (1)	1.682	2.88	3.29	3.68
Sudan	−2.238 (6)	−2.358 (6)	−1.182 [0]	−3.675 [0]	−3.352 (9)	−2.508 (6)	1.674	2.85	3.12	3.79
Tanzania	−1.831 (8)	−2.123 (8)	−0.394 [5]	−2.197 [5]	−0.021 (11)	1.923 (11)	2.614	3.63	4.43	5.25
Tunisia	−3.001 (9)	−3.422** (9)	−2.500 [3]	−10.909 [3]	−0.999 (10)	−0.94 (10)	2.307	3.68	4.14	4.73
Uganda	−2.131 (6)	−2.324 (6)	−0.378 [3]	−1.009 [3]	−4.293** (7)	−2.683 (6)	1.427	3.05	3.43	4.05
Zambia	−2.493 (9)	−3.027 (9)	−1.109 [4]	−2.586 [4]	−3.407 (11)	−1.372 (10)	2.892	3.1	3.27	4.99
Zimbabwe	−0.941 (7)	−1.621 (5)	−1.734 [3]	−2.538 [3]	−5.032*** (5)	−3.525* (5)	2.063	3.23	3.63	4.1

Note:
(1) Christopoulos and Leon-Ledesma (2011) developed a new version of Kapetanios, Shin, and Snell (2003, KSS) and ADF unit root tests which allows for smooth breaks using Fourier function. To this end, first we obtain estimates of the residuals from equation (1) which was denoted by e_t in the text and then test the null hypothesis of a unit root using KSS-Fourier unit root test, we obtain the t-statistic from the following equation:
The test statistic is calculated as follows:
To test the null hypothesis of a unit root using ADF-Fourier unit root test, we obtain the t-statistic from the following equation:
(3) We determine optimum lag(s) for ADF, DF-GLS, FADF, FKSS, and QKS unit root tests based on the recursive t-statistic. For the Ng-Perron and PP tests, we select bandwidth by the Bartlett Kernel.
(3) We computed critical values for FADF and FKSS using Monte Carlo simulation and 5000 replications as described in Christopoulos and Leon-Ledesma (2011) and Becker, Enders, and Lee (2006). To save the space, we did not report them but they are available from the authors upon request. Also, we computed the critical values for QKS unit root test using Monte Carlo simulations and 5000 replications.
(4) *, **, and *** denote the null of unit root is rejected at 10%, 5%, and 1%, respectively.

the trend function components using Fourier expansion. Whereas we use annual GDP per capita as proxy for output per capita and due to it has low frequency, we think using Fourier expansion, we are able to capture breaks in the GDP per capita. Third, as explained, due to various factors, GDP per capita series may be experience breaks in some years and thus may be they have outliers that using the quantile regression, we are able to control for non-normality distribution and for the presence of such outliers.

The rest of the paper proceeds as follows. Section 2 prepare the data, section 3 discusses the methodology. The empirical results are discussed in Section 4. In section 5, we speak about growth dynamics and conclusion is presented in the final section.

2. Data

We use Maddison Project Database of annual per capita real GDP in 1990 PPP-adjusted dollars for 25 African countries over the

Table 3
OLS estimator's results of equation (1).

Countries	k	Coefficients				t-student statistics				F statistics	critical values		
		α_1	α_2	α_3	α_4	α_1	α_2	α_3	α_4		90%	95%	99%
Algeria	1.4	7.368	0.015	−0.123	−0.092	349.394	27.702	−8.334	−6.096	53.863	3.248	4.209	6.405
Angola	1.2	6.815	0.005	0.483	−0.110	193.403	5.118	19.374	−4.629	187.805	8.214	9.885	13.763
Burkina Faso	1.2	6.164	0.015	0.101	−0.020	519.525	49.421	11.998	−2.527	71.979	2.710	3.574	5.666
Cameroon	1.4	6.744	0.007	−0.167	−0.085	289.437	11.786	−10.231	−5.102	65.921	3.683	4.821	7.293
Côte d'Ivoire	1.1	7.140	0.004	0.123	−0.255	353.258	8.076	8.144	−21.709	241.175	4.536	5.635	8.149
DR Congo	1.3	6.883	−0.021	−0.036	−0.332	223.009	−26.172	−1.699	−14.932	116.730	5.712	7.191	10.200
Egypt	1.5	6.665	0.028	−0.062	0.069	493.830	80.653	−6.364	7.392	47.296	2.677	3.589	5.571
Ethiopia	1.5	6.080	0.008	−0.066	−0.208	270.217	14.681	−4.093	−13.330	97.541	4.184	5.247	7.699
Ghana	1.1	6.800	0.011	0.286	0.106	408.331	25.384	23.074	10.919	403.265	4.932	6.101	9.431
Kenya	1.5	6.584	0.009	−0.100	−0.031	689.885	35.402	−14.520	−4.721	116.964	2.826	3.653	5.864
Madagascar	1.3	7.078	−0.009	0.060	−0.147	616.869	−30.075	7.565	−17.784	174.852	3.203	4.135	6.426
Malawi	1.5	5.911	0.011	−0.094	−0.069	381.211	28.784	−8.366	−6.411	55.859	2.821	3.738	5.839
Mali	2.3	6.106	0.013	0.025	0.047	437.879	36.286	2.615	4.780	15.638	2.386	3.184	5.125
Morocco	2.2	7.036	0.020	0.053	0.083	561.776	62.571	5.994	9.585	70.243	2.797	3.717	5.871
Mozambique	1.2	6.735	0.016	0.395	0.041	248.400	23.259	20.613	2.214	235.290	6.932	8.514	11.791
Niger	1	6.410	0.001	0.311	−0.048	244.802	1.254	15.671	−3.859	127.755	3.867	4.923	7.378
Nigeria	2	6.629	0.014	−0.164	0.099	197.115	15.810	−6.846	4.483	33.014	3.594	4.566	6.714
Senegal	1.2	7.148	0.002	0.116	−0.013	891.334	9.548	20.388	−2.372	209.859	2.881	3.783	6.003
South Africa	1.5	8.023	0.007	−0.063	−0.127	1054.728	37.292	−11.483	−24.060	356.991	3.147	4.081	6.252
Sudan	1.2	6.604	0.008	0.197	0.037	267.721	12.896	11.263	2.225	74.620	3.716	4.725	6.833
Tanzania	1.7	6.144	0.006	−0.116	−0.079	426.653	16.404	−11.561	−7.911	103.875	3.096	4.167	6.521
Tunisia	2.2	6.969	0.029	−0.035	0.061	623.109	99.390	−4.481	7.925	38.320	2.552	3.314	5.119
Uganda	1.2	6.275	0.010	0.293	0.016	329.134	19.647	21.705	1.268	253.721	4.917	6.209	9.036
Zambia	1.2	6.595	0.005	0.248	−0.181	460.727	13.310	24.447	−18.656	393.572	4.690	5.914	8.783
Zimbabwe	0.8	6.825	0.003	0.182	−0.261	109.437	1.608	4.651	−8.536	112.922	4.829	6.040	9.034

Note: k* is optimum frequency. The critical values for F statistics are computed using Monte Carlo simulation.

Table 4
Fourier quantile unit root test results.

Country	Panel A: P – values of $t_n(\tau_i)$									Panel B: Fourier QKS statistic			
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	FQKS	10%	5%	1%
Algeria	0.170	0.260	0.050	0.040	0.050	0.140	0.400	0.200	0.400	2.477	3.23	3.65	4.64
Angola	0.020	0.170	0.000	0.000	0.000	0.000	0.010	0.020	0.180	3.673**	2.93	3.6	5.2
Burkina Faso	0.220	0.000	0.000	0.000	0.000	0.010	0.100	0.140	0.140	4.676***	3.02	3.28	3.54
Cameroon	0.080	0.050	0.000	0.010	0.000	0.000	0.030	0.030	0.070	3.972**	3.33	3.77	5.47
Côte d'Ivoire	0.600	0.440	0.070	0.090	0.140	0.010	0.000	0.000	0.000	5.572***	3.37	3.67	4.68
DR Congo	0.140	0.130	0.050	0.020	0.200	0.220	0.180	0.510	0.280	2.929	3.53	4.48	5.05
Egypt	0.010	0.010	0.130	0.220	0.110	0.160	0.400	0.070	0.210	3.323**	3.03	3.29	4.6
Ethiopia	0.290	0.360	0.290	0.150	0.800	0.860	0.890	0.970	0.500	2.033	3.68	3.9	5.22
Ghana	0.000	0.010	0.020	0.000	0.000	0.020	0.160	0.410	0.770	4.806**	3.72	4.43	4.94
Kenya	0.130	0.050	0.040	0.050	0.070	0.010	0.000	0.000	0.000	4.575***	3.29	3.75	4.53
Madagascar	0.050	0.000	0.010	0.000	0.320	0.210	0.710	0.880	0.650	2.951*	2.75	2.99	3.83
Malawi	0.490	0.450	0.280	0.330	0.020	0.050	0.000	0.030	0.020	3.389*	3.28	3.55	5.79
Mali	0.060	0.070	0.070	0.050	0.190	0.150	0.080	0.000	0.010	4.335**	2.79	3.31	4.48
Morocco	0.400	0.570	0.470	0.160	0.080	0.080	0.250	0.210	0.030	3.117	3.38	3.63	3.93
Mozambique	0.070	0.070	0.080	0.040	0.020	0.000	0.010	0.100	0.550	3.681**	3.01	3.65	5.01
Niger	0.220	0.120	0.010	0.000	0.010	0.000	0.040	0.020	0.010	4.566***	3.07	3.49	4.13
Nigeria	0.530	0.600	0.470	0.900	0.930	0.610	0.630	0.640	0.250	1.85	3.14	3.32	3.91
Senegal	0.110	0.090	0.010	0.000	0.000	0.000	0.000	0.020	0.020	6.879***	2.92	3.51	4.26
South Africa	0.120	0.050	0.000	0.010	0.080	0.050	0.120	0.330	0.330	3.234*	3.14	3.33	3.87
Sudan	0.300	0.220	0.040	0.120	0.030	0.130	0.010	0.060	0.250	2.970*	2.84	3.48	5.94
Tanzania	0.120	0.100	0.050	0.030	0.380	0.460	0.630	0.800	0.640	2.854	3.55	3.79	4.63
Tunisia	0.710	0.690	0.300	0.240	0.300	0.680	0.120	0.110	0.100	2.269	3.28	3.51	4.86
Uganda	0.170	0.580	0.300	0.480	0.250	0.230	0.130	0.020	0.470	2.799	3.27	3.69	4.31
Zambia	0.030	0.090	0.010	0.230	0.150	0.110	0.020	0.030	0.170	2.711	2.99	3.46	4.19
Zimbabwe	0.330	0.210	0.060	0.000	0.000	0.000	0.000	0.030	0.180	5.042***	3.36	3.89	4.43

Notes: The P - values for $t_n(\tau_i)$ and critical values for F-QKS statistics computed using bootstrapping procedure and 5000 replications.

period 1950–2016 which was prepared by The Conference Board (2016). Our sample includes Algeria, Angola, Burkina Faso, Cameroon, Côte d'Ivoire, DR Congo, Egypt, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mali, Morocco, Mozambique, Niger, Nigeria, Senegal, South Africa, Sudan, Tanzania, Tunisia, Uganda, Zambia, and Zimbabwe.

3. Methodology

To analyze the slowdowns, meltdowns and long run growth, we have to test the stochastic properties of RPCGDP series and then estimate a trend function. Due to non-normal distribution of and structural breaks in the RPCGDP series, application of quantile type unit root test will appropriate for the case. First candidate will be the standard quantile unit root test which developed by Koenker and Xiao (2004). But whereas most of African countries experienced wars, political instability and also huge shocks to their terms of trade over the period, we would like to allow for breaks in the trend component. To this end, we apply a new versions of quantile unit root test which developed by Bahmani-Oskooee et al. (2018a) [1] and Bahmani-Oskooee, Chang, and Ranjbar (2017) allows for smooth breaks in the trend components. In this section we prepare a short account of the test.

We present time series variable $RPCGDP_t$ with unknown number and form of break points by a Fourier expansion as follows:

$$RPCGDP_t = \alpha_1 + \alpha_2 t + \alpha_3 \sin\left(\frac{2\pi kt}{N}\right) + \alpha_4 \cos\left(\frac{2\pi kt}{N}\right) + o_t \quad (1)$$

Where α, N, and t are vector of coefficients, sample size and a trend term, respectively, and $\pi = 3.1416$. o_t is the residuals of regression models.[2] K is the number of frequencies of the Fourier function and apply in the model to capture the smooth breaks in the $RPCGDP_t$ series. The integer value of k related to transitory shocks and fractional value related to permanent shocks. To find the optimum frequency (k*), we consider $k \in [0.1, 5]$ and using the Becker, Enders, and Lee (2004) method, set k at a value that minimizes the sum of squared residuals when OLS is applied to (1). Once k* is determined, the residuals from (1) yields adjusted RPCGDP to which we apply the quantile unit root test. From equation (1), we define the τ_{th} conditional quantile of $\hat{o}_t$ as follows:

[1] Over the recent years, applications of quantile unit root test have increased to test the various economic hypothesis for example see Bahmani-Oskooee, Chang, Elmi, and Ranjbar (2018b), Bahmani-Oskooee et al. (2019), Bahmani-Oskooee and Ranjbar (2016), Ma, Li, and Park (2017).

[2] Various factors may be result in deviation of GDP per capita from its long run steady state situation. For example, interest rates, confidence, the credit cycle technological shocks, terms of trade shocks, wars, political and economic instabilities. Some of them have permanent effect and others have transitory effects.

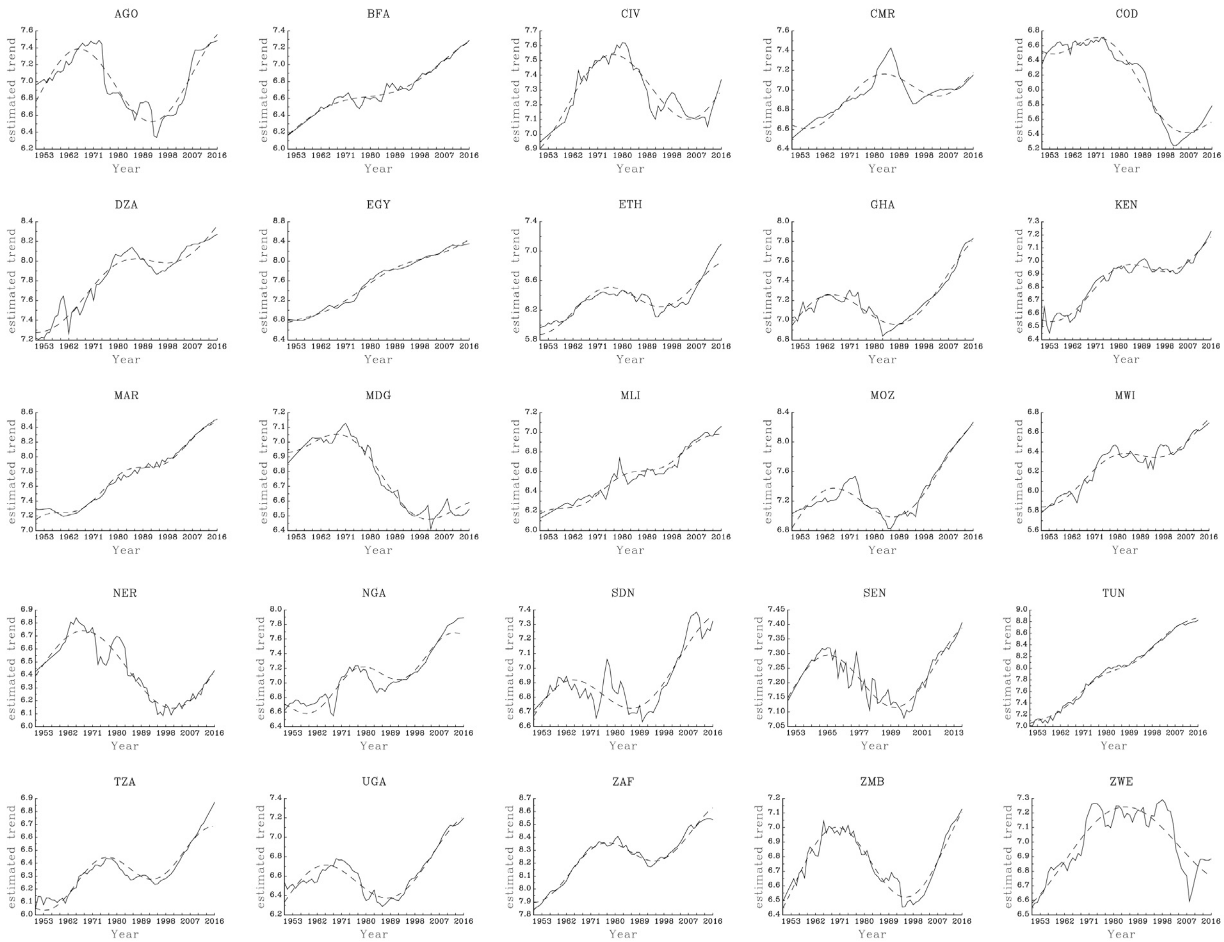


Fig. 1. RPCGDP dynamics and fitted nonlinearities.
Note: Solid line is the RPCGDP series and dashed lines are estimated trend function (equation (2)). The abbreviations are: Algeria (DZA), Angola (AGO), Burkina Faso (BFA), Cameroon (CMR), Côte d'Ivoire (CIV), DR Congo (COD), Egypt (EGY), Ethiopia (ETH), Ghana (GHA), Kenya (KEN), Madagascar, (MDG), Malawi (MWI), Mali (MLI), Morocco (MAR), Mozambique (MOZ), Niger (NER), Nigeria (NGA), Senegal (SEN), South Africa (ZAF), Sudan (SDN), Tanzania (TZA), Tunisia (TUN), Uganda (UGA), Zambia (ZMB), and Zimbabwe (ZWE).

$$Q_{\widehat{o}_t}(\tau|\zeta_{t-1}) = \delta_0(\tau) + \delta_1(\tau)\widehat{o}_{t-1} + \sum_{p=1}^{p=1}\delta_{1+p}(\tau)\Delta\widehat{o}_{t-p} + \vartheta t \tag{2}$$

where $Q_{\widehat{o}_t}(\tau|\zeta_{t-1})$ is τ_{th} quantile of $\widehat{o}_t$ conditional on the past information set, ζ_{t-1}. $\delta_0(\tau)$ is τ_{th} conditional quantile of ϑ_t and its estimated values captures the magnitude of RPCGDP shock in each quantile. Optimum lags (p*) are selected by the AIC information criteria. As noted by Tsong and Lee (2011), the intercept terms in the regression (2), i.e. $\delta_0(\tau)$, denotes the size of the observed shock within the τ_{th} quantile that hits the GDP per capita. Negative (positive) sign represents negative (positive) shock which might result, for example, from terms of trade shocks, civil wars, political instabilities.

While equation (2) follows standard ADF test at each quantile, the special attention related to estimate the vector δ. Following to Bahmani-Oskooee et al. (2018a), we use the following *t ratio* statistic to test the unit root hypothesis within the τ_{th} quantile:

$$t_n(\tau_i) = \frac{\widehat{f}(F^{-1}(\tau_i))}{\sqrt{\tau_i(1-\tau_i)}}\left(E_{-1}^{`}P_x E_{-1}\right)^{1/2}\left(\widehat{\delta}_1(\tau_i) - 1\right) \tag{3}$$

where E_{-1} is the vector of lagged dependent variable $(\widehat{o}_{t-1})$, P_x is the projection matrix onto the space orthogonal to $X = (1.\ \Delta\widehat{o}_{t-1}.\ ....\ \Delta\widehat{o}_{t-k})$. $\widehat{f}(F^{-1}(\tau_i))$ is a consistent estimator of $f(F^{-1}(\tau_i))$.[3] Bahmani-Oskooee et al. (2018a) recommend the following

[3] For details see Koenker and Xiao (2004).

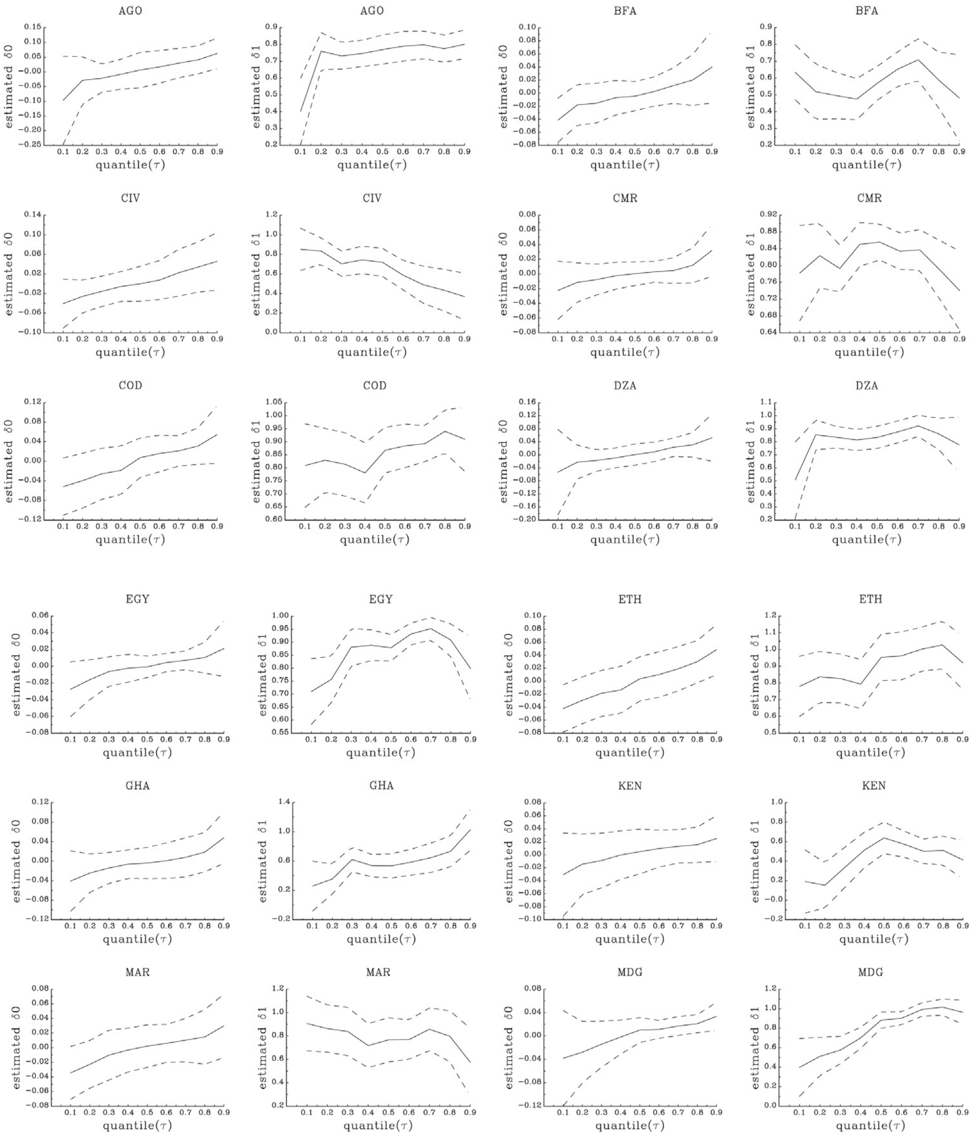


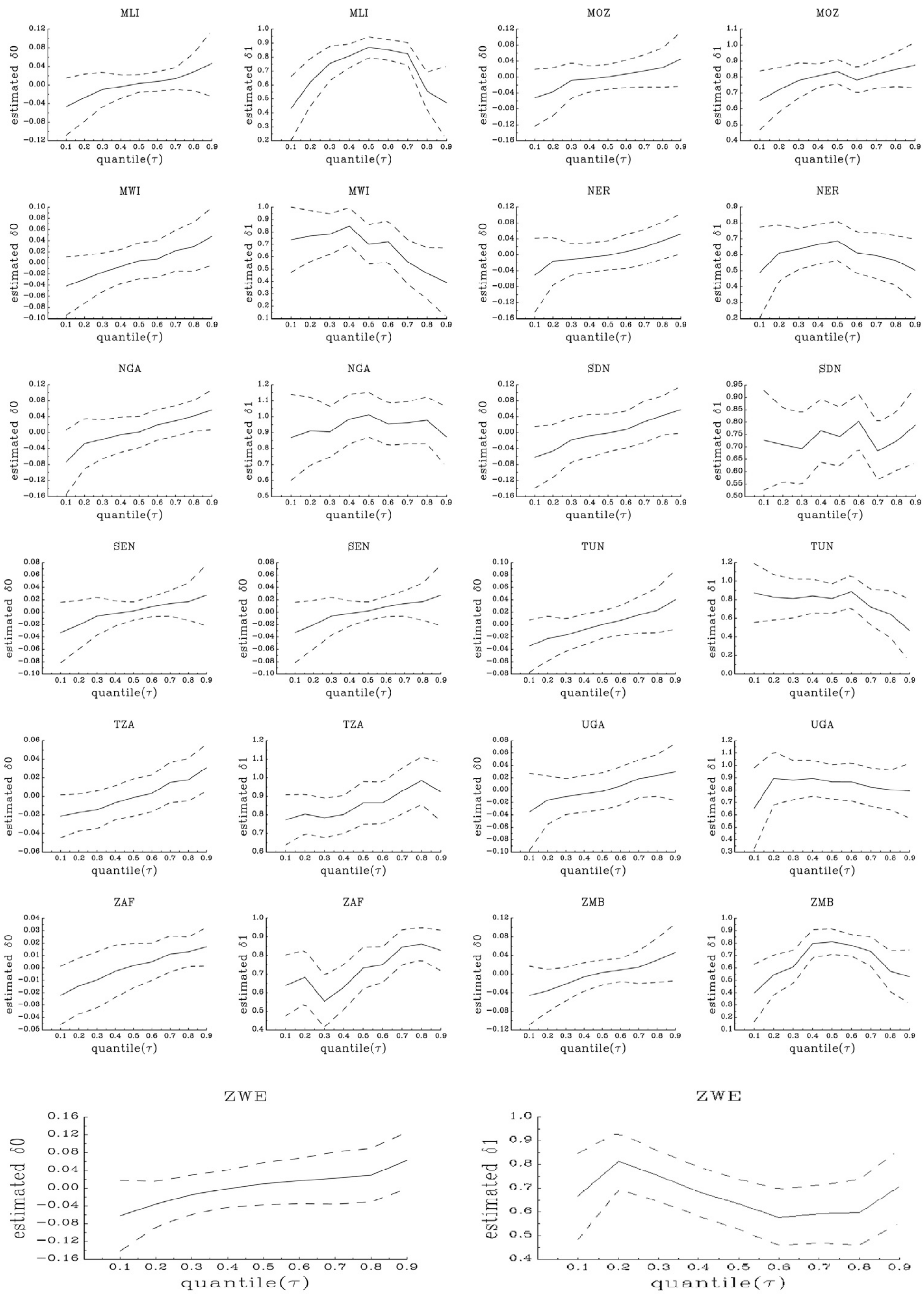
Fig. 2. Quantile intercepts ($\delta_0(\tau)$) and autoregressive coefficients ($\delta_1(\tau)$).
Note: Solid line is the values of $\delta_1(\tau)$ and $\delta_0(\tau)$ and dashed lines are 95% confidence intervals.

quantile Kolmogorov–Smirnov (FQKS) test statistics to assess the unit root behavior over a range of quantiles between $\underline{\mu} = 0.1$ and $\overline{\mu} = 0.9$:

$$FQKS = \sup_{\tau_i \in [\underline{\mu}, \overline{\mu}]} |t_n(\tau)| \tag{4}$$

We construct the FQKS statistics by selecting maximum $|t_n(\tau)|$ statistics over range quantiles between $\underline{\mu} = 0.1$ and $\overline{\mu} = 0.9$. Due to nonstandard distribution of $t_n(\tau_i)$ and *FQKS* test statistics, we compute their critical values using the re-sampling procedures which outlined in detail in Bahmani-Oskooee et al. (2018a). After rejection of unit root hypothesis for a RPCGDP series, using the OLS estimated coefficients of equation (1), we compute its derivation for any year and then calculate the average its derivation for any decades as estimated growth rate using Fourier expansion. To analyze the meltdowns, slowdowns, and increasing growth, we use following method:

If average growth rate in decade t be positive and in decade t+1 be negative, in the case we say country experienced meltdowns over decade t+1. If average growth rate in decade t be positive and in decade t+1 be positive but less than period t, in the case, we say country experienced slowdowns in growth rate over decade t+1. If average growth rate in decade t be positive and in decade t+1 be positive but greater than period t, in the case, we say country experienced increasing growth rate over decade t+1.



Note: Solid line is the values of $\delta_1(\tau)$ and $\delta_0(\tau)$ and dashed lines are 95% confidence intervals.

Fig. 2. . (*continued*).

4. Empirical results

We prepare average real per capita GDP (RPCGDP, hereafter) for any decade in panel A. We show the most value in any decade using double underline and the least value using underline. The results indicate countries namely, South Africa, Algeria, Morocco, Tunisia, and Egypt have the highest RPCGDP in our sample and in contrast the countries namely, Malawi, Tanzania, Ethiopia, DR Congo, and Niger have the lowest RPCGDP over most of decades. So over the 1950s, the RPCGDP of South Africa was 2781 $ about 1.7 times RPCGDP of Malawi (which was 359 $). The gap between richest and poorest countries in our sample increased to 24 fold over the 2010s, so, RPCGDP of Tanzania (richest country) and DR Congo (poorest country) were 5742 $ and 237 $. In panel B, we prepare statistical

Table 5
Slowdowns and meltdowns in African countries growth rate.

Country	Average slope of Fourier trend function for any decade							Ratio of growth rates any decade to previous decade					
	1950s	1960s	1970s	1980s	1990s	2000s	2010s	1960s–1950s	1970s to 1960	1980s–1970s	1990s–1980s	2000s–1990s	2010s–2000s
Angola	5.4%	0.7%	−4.2%	−3.8%	1.4%	5.6%	4.6%	0.1	−5.6	0.9	−0.4	3.9	0.8
Burkina Faso	2.5%	1.6%	0.6%	0.7%	1.8%	2.6%	2.4%	0.6	0.4	1.2	2.7	1.5	0.9
Cameroon	−0.2%	2.5%	2.5%	−0.2%	−1.6%	0.5%	2.7%	−16.8	1.0	−0.1	6.6	−0.3	5.7
Côte d’Ivoire	2.8%	2.9%	0.6%	−1.9%	−2.1%	0.1%	2.4%	1.0	0.2	−3.0	1.1	−0.1	18.0
Egypt	1.6%	2.5%	3.9%	3.4%	1.9%	1.8%	3.1%	1.6	1.6	0.9	0.5	1.0	1.7
Ghana	3.0%	0.0%	−1.8%	−0.8%	2.1%	4.1%	3.5%	0.0	−111.4	0.4	−2.7	1.9	0.9
Kenya	0.2%	1.9%	1.8%	0.1%	−0.4%	1.2%	2.3%	9.1	1.0	0.1	−3.5	−3.1	1.9
Madagascar	0.7%	0.5%	−1.5%	−2.7%	−1.5%	0.5%	0.9%	0.7	−3.0	1.8	0.6	−0.3	1.8
Malawi	0.9%	2.6%	1.8%	−0.1%	0.0%	2.0%	2.7%	2.9	0.7	0.0	−0.5	63.4	1.4
Mali	0.7%	1.0%	2.2%	0.6%	1.2%	2.1%	0.6%	1.5	2.1	0.3	2.2	1.8	0.3
Mozambique	4.8%	0.5%	−2.5%	−0.8%	3.7%	5.9%	3.9%	0.1	−5.2	0.3	−4.6	1.6	0.7
Niger	2.7%	0.9%	−1.7%	−2.8%	−1.5%	1.0%	2.7%	0.3	−2.0	1.6	0.5	−0.7	2.6
Senegal	1.3%	0.1%	−1.0%	−0.7%	0.6%	1.4%	1.1%	0.1	−7.8	0.8	−0.8	2.5	0.8
South Africa	1.3%	2.5%	0.7%	−1.1%	0.1%	2.3%	2.2%	2.0	0.3	−1.5	−0.1	23.2	0.9
Sudan	2.3%	0.1%	−1.3%	−0.2%	2.0%	2.9%	1.8%	0.0	−16.7	0.2	−8.1	1.5	0.6
Zimbabwe	2.3%	2.6%	1.6%	0.0%	−1.5%	−2.0%	−1.5%	1.1	0.6	0.0	98.1	1.4	0.7

Note: We calculate the yearly growth rate of RPCGDP using the derivation of estimated Fourier trend function, Equation (1). We compute the simple average yearly growth rate for any decades as average growth rate of decade.

properties (standard deviation, Skewness, Kurtosis, and P-Value of Jarque-Bera) of RPCGDP series. The Jarque–Bera test results indicate that 12 out of 25 RPCGDP series clearly exhibit a clear sign of non-normal distribution and as noted by Koenker and Xiao (2004), in the cases the quantile autoregressive based unit root test has higher power than conventional unit root tests.

To analyze the growth dynamics of African countries, first we have to test the stochastic properties of RPCGDP series (in logs form) (see Table 1). To this end, as a preliminary exercise we apply four conventional linear unit root test, including ADF, Elliot, Rothenberg, Stock. (1996, DF-GLS), Phillips and Perron (1988, PP), and Ng-Perron (Ng & Perron, 2001). The results of abovementioned tests are presented in panel A of Table 2. As can be seen, using the ADF test, the null of unit root is rejected only for RPCGDP series of South Africa and using DF-GLS test, the null is rejected only for Tunisia. According to PP and NP unit root tests, the null of unit root is not reject for all RPCGDP series. As can be seen, using the conventional unit root tests, we could not find favorable results favor of stationary properties of RPCGDP series. It may relate to low power of conventional unit root tests when RPCGDP series exhibit structural breaks (due to wars or terms of trade's shocks) and/or non-normal distribution.

In panel B of Table 2, we prepare the results for two Fourier type unit root tests namely Fourier-ADF (FADF) and Fourier-Kapetanios et al.'s (2003) (FKSS) which allows for smooth breaks using Fourier expansion in the ADF and KSS unit root tests. Using FADF unit root test, we could reject the null of unit root test for 11 out of 25 RPCGDP series including Algeria, Angola, Côte d'Ivoire, DR Congo, Egypt, Ghana, Mozambique, Niger, Senegal, Uganda, and Zimbabwe. Using to FKSS test, the null hypothesis of unit root is rejected for 10 out of 25 RPCGDP series including Algeria, Angola, Burkina Faso, Cameroon, Egypt, Ghana, Madagascar, Malawi, Mali, and Zimbabwe. As can be seen, inclusion of smooth breaks in the conventional unit root tests, we could find more evidence favor of stationary properties of RPCGDP series.

In panel C of Table 2, we prepare the results for standard quantile unit root test proposed by Koenker and Xiao (2004) and its critical values at 10%, 5%, and 1%.[4] The results indicate that the null of unit root is rejected only for two countries Angola and Cameroon.

To incorporate the Fourier expansions in the quantile unit root tests, first we estimate equation (1) using OLS estimators. The results, coefficients, related t-student statistics, optimum frequency, and F-statistics, are presented in Table 3. After a grid-search we find the integer optimum frequency to be 1 ($K^* = 1$) for RPCGDP of Niger and 2 ($K^* = 2$) Nigeria. For other RPCGDP series, we found fractional and low frequencies. The results indicate almost RPCGDP series experienced permanent changes in the level and growth rates over the period. The results of the F statistics and its critical values for both sine and cosine terms indicate that these two terms should be included in the model for most of RPCGDP series. Dynamics of RPCGDP series and estimated nonlinear trend functions clearly show that the actual nature of break(s) (number and form of break(s)) is generally unknown (see Fig. 1) (see Table 4).

In the next step, using the OLS residuals from equation (1), we tested the unit root hypothesis using quantile regression. The results presented in Table 3. The P-values of $t_n(\tau_i)$ statistics are presented in panel A which are used to measure the degree of persistence in each quantile. Its results indicate that for RPCGDP series of Angola, Cameroon, Kenya, Mali, Mozambique, Niger, and Senegal, the null of unit root is rejected in most of quantiles. The values of $\widehat{\rho}_1(\tau)$ in Fig. 2 indicate that the RPCGDP of abovementioned countries show three types response to shocks. The PCRGDP series of Angola and Niger show same response to negative and positive shocks. The RPCGDP series of Cameroon, Kenya, and Mali display concave patterns. So the negative shocks to RPCGDP of the countries have more long lasting effect than positive shocks. In contrast the values of $\widehat{\rho}_1(\tau)$ of RPCGDP series of Mozambique and Senegal show straight-line upward patterns, so positive shocks are more persistence than negative shocks.

For RPCGDP series of Burkina Faso, Ghana, Madagascar, South Africa, and Zambia, the null of unit root is rejected in low quantiles. The values of $\widehat{\rho}_1(\tau)$ of RPCGDP series of Ghana, Madagascar, and Zambia indicate straight-line upward patterns in low quantile, so greater negative shocks (in absolute values) are more transitory than moderate shocks. In contrast, The values of $\widehat{\rho}_1(\tau)$ of RPCGDP series of Ghana and South Africa show straight-line upward patterns in low quantile that indicate negative shocks to these RPCGDP series are more persistent than positive shocks.

For the RPCGDP series of Côte d'Ivoire, Malawi, and Zimbabwe, the null of unit root is rejected in high quantiles. The values of $\widehat{\rho}_1(\tau)$ of RPCGDP series of Côte d'Ivoire and Malawi indicate straight-line downward patterns in high quantile. The finding indicates positive shocks to the RPCGDP series of the countries have more transitory than moderate shocks. In contrast, the RPCGDP series of Zimbabwe indicate upward pattern in high quantiles that represent the positive shocks are more persistence than negative shocks.

5. Analyzing slowdowns and meltdowns in growth rates

To analyze the slowdowns and meltdowns in the growth rates of African countries, we use the coefficients of estimated Fourier-trend function in equation (2) for RPCGDP series that the null of unit root is rejected for them by Fourier quantile unit root test (i.e. 16 out of 25 series). According to the estimated coefficients of Equation (1), we calculate the its derivation for any year as estimated growth rate and calculate the average value of its derivation for any decades as average growth rate of any decade and prepare the results in Table 5. According to the method presented in section 3, we decide about slowdowns and meltdowns. The results indicate that all of 16 African countries in our sample experienced positive growth rate over the decade 1960 and 1970 except Angola, Ghana, Madagascar, Mozambique, Niger, Senegal, and Sudan which experienced negative growth rate over the period 1970s. Also, all of them except Egypt and Mali (that had increasing growth rate) experienced slowdowns in growth rates over two decades 1960 and 1970. The evidence related to high growth performance of industrialized countries over the decades and high demand for primary products and whereas all of African countries specialized in produce and export of raw materials, hence experienced expansion in their terms of trade and increasing (slowdowns) positive growth rate. Due to by the recessionary period of the late 1970s and early 1980s in the industrialized

[4] We compute the critical values using re-sampling procedures which outlined in Koenker and Xiao (2004).

countries and deterioration of African countries terms of trade, 7 out of 16 countries, namely Angola, Ghana, Madagascar, Mozambique, Niger, Senegal, and Sudan, experienced meltdowns in the growth rate over the decade 1980.8 out of the countries namely, Cameroon, Côte d'Ivoire, Egypt, Kenya, Malawi, Mali, South Africa, and Zimbabwe experienced slowdowns in the RPCGDP growth rates. Only Burkina Faso had small increasing growth over the decade. As noted by Kaminski (2011, pp. 107–124), The cotton sector in Burkina Faso accounted for about 60 percent of its exports. Cotton booms over 1970s accelerate improvement infrastructure in the Burkina Faso since 1980s and also increase investment in the cotton sector to adapt new technology, high-quality research, cooperation between French and local researchers, farmer organizations, and top-down implementation policies.

Over two decades 1990s and 2000s, most countries experienced increasing growth rate, so over the decade 2000s, due to terms of trade boom from 2004 onwards, 14 out of 16 countries, experienced increasing growth rate. Egypt experienced slowdowns in the growth rate over the two decades 2000s and 2010s. Egypt experienced increasingly growth rate until 2008, so in 2008 it experienced highest growth rates over last three decades. But after the year, due to the global economic crisis (2007–2009) and "January 25th revolution" its growth rates lie in decreasing path Tsuchiya (2016). Zimbabwe experienced meltdowns in the growth rate from 1990s onward. Since 1997, Zimbabwe has been embroiled in an increasingly severe economic and political crisis including fiscal deficit, hyperinflation over 2004–2009, the government of land reform program, intimidation of the judiciary, and economic difficulties due to sanctions imposed by US and the EU (Sibanda & Makwata, 2017).

Over the recent decade 2010s, increasing growth rate in the African countries was stopped that may be related to the unfavorable terms of trade after huge reduction in the crude oil prices.[5]

Among African countries in our sample, six countries namely, Burkina Faso, Egypt, Kenya, Malawi, Mali, and South Africa do not experience negative growth rate (on the average) in any decades and among them, Malawi and Mali have experienced increasing growth rate over 4 decades. In contrast, Zimbabwe, Niger and Madagascar experienced meltdowns in the growth rate over 3, 2, and 2 decades, respectively. Some of unfavorable growth performance in African countries may be related to domestic political instability, military conflicts and wars, for example, Angola (1974), Madagascar (1971), and Mozambique (1974).

The major policy implications of our study is that to reduce the unfavorable growth performance in African countries, it is very important for the governments of the African countries (for those experienced meltdown growth) to set up policies to create a political stable environment, reduce the military conflicts and wars either in domestic or international and balance their terms of trade. As we know that a stable and secure environment is very important for the people to survive and work hard. War and military conflicts only damage the economic growth and the people living.

6. Conclusion

In this paper, we tested the stochastic properties of RPCGDP of African countries and their growth rates dynamics over the period 1950–2016. Using the conventional/quantile unit root tests, we could not find results favor of trend stationarity of RPCGDP series. But when we allow for both smooth breaks using Fourier expansion in the trend function and nonlinear response using quantile regression, we could find evidence in favor of trend stationarity for 16 out of 25 RPCGDP series. Our results indicate: (1) RPCGDP series of African countries response to shocks different behavior. In some of them the negative shocks have permanent effects and in some positive shocks. In some of them, both of two types shock have transitory effects. Our results indicate that due to negative shock from unfavorable terms of trade, most of African countries experienced meltdowns growth rate over the decades 1980s and 1990s. in contrast due to terms of trade booms over send half of 2000s, most of them experienced positive and increasing growth rate.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.iref.2019.10.008.

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[5] For more details on the relationship between primary commodity prices and the terms of trade, see Cashin and Pattillo (2006), Bidarkota and Crucini (2000), Collier, Gunning, and Associates (1999), and Romero-Avila (2009).

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