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Multiple Breaks, Terms of Trade Shocks and the Unit-Root Hypothesis for African *Per Capita* Real GDP

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Summary. — This paper presents an investigation of the unit root hypothesis for *per capita* real GDP series in 46 African countries from Maddison (2003) over the period spreading during 1950 and 2001. Toward this end, we employ highly flexible panel techniques which incorporate multiple mean and slope shifts in the output series. Our findings are clearly supportive of regime-wise trend stationarity in output after (1) allowing for cross-dependence and multiple breaks, and (2) removing four countries that exert undue influence on the whole panel. Remarkably, our main results hold true for alternative *per capita* real GDP proxies retrieved from the Penn World Table 6.2 as well as for different country-groups constructed on the basis of the country's participation in regional integration processes. Interestingly, the timing of the breaks broadly coincides with terms of trade shocks associated with large fluctuations in the price of primary commodities. Based on our results, we draw some policy prescriptions that point to the need for managing adequately terms of trade booms and busts to avoid large swings in Africa's aggregate output.

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Key words — Africa, panel stationarity test, multiple structural breaks, aggregate output, terms of trade shocks

1. INTRODUCTION

Researchers have devoted great effort to investigate the presence of a unit root in aggregate output since the seminal work of Nelson and Plosser (1982). These authors provided strong evidence of a unit root in several macroeconomic variables for the US economy, including gross national product (GNP). These findings called into question the traditional business cycle theories which viewed fluctuations as temporary deviations from a secular trend. In contrast, permanent shocks could be responsible for the fluctuations in the trend function defining the output path.

The presence of a unit root in aggregate output carries major implications for macroeconomic modeling and for economic policy formulation. As regards theoretical modeling, traditional monetary and Keynesian business cycle models conceive aggregate output as stationary around a deterministic trend (Lucas, 1972). In contrast, stochastic real business cycle models view output fluctuations as largely the result of technology shocks, which generate permanent fluctuations in output for the one-sector growth model (King, Plosser, Stock, & Watson, 1991) and for the two-sector growth model that distinguishes between technology shocks to consumption and investment (Whelan, 2006). Regarding policymaking, the existence of a unit root in aggregate output casts doubts on the appropriateness of running counter-cyclical stabilization policies since there is no well-defined steady output path to which the economy would revert after the occurrence of a shock. In addition, contractionary aggregate demand policies may exert a permanent negative impact on the economy which does not dissipate over time, thus affecting the whole future path of output.¹

This paper investigates the unit root hypothesis for *per capita* real GDP in 46 African countries over the period 1950–2001. Toward this end, we employ a panel stationarity test that allows for multiple level and slope shifts in the data generating process of the output series. This will allow us to establish whether *per capita* real GDP in African countries is best described as a stochastic trend, for which shocks have a persistent effect every period, or is stationary around a broken

trend, for which much of the time shocks exert a temporary effect, but occasionally, the occurrence of large infrequent changes leads to permanent effects on output. Therefore, the inclusion of multiple breaks is crucial for capturing the true degree of persistence of output series since it enables us to overcome the classical dichotomy between nonstationary and trend-stationary processes supporting the view that the trend changes every period or never. Thus, in our analysis we can allow for a process that is stationary around a trend that infrequently shifts due to the occurrence of occasional shocks. For economic regions like Africa which are subject to multiple adverse shocks like episodes of civil war and military conflict as well as terms of trade shocks, rejection of the unit root hypothesis is particularly important since it would imply that the deleterious effects of recurrent shocks would generally be temporary.²

Our study makes several contributions to the area of testing the unit root hypothesis for aggregate output in less developed countries. First, we employ the more powerful panel unit root tests of Smith, Leybourne, Kim, and Newbold (2004), the combination panel unit root test of Maddala and Wu (1999) in addition to the panel stationarity of Hadri (2000), all allowing for cross-sectional dependence through bootstrap methods. Since these panel tests are subject to Perron (1989)'s critique, we use the panel stationarity test of Carrion-i-Silvestre, del Barrio-Castro, and Lopez-Bazo (2005), which allows for a highly flexible trend function by incorporating an unknown number of changes in level and slope. It is remarkable that our study constitutes the first attempt to

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study the time series properties of *per capita* real GDP series for the African continent over the postwar era using panel techniques that allow for multiple structural breaks in the series. This is important for African output series which were subject to multiple large infrequent shocks over the past 50 years. This includes large swings in the price of primary commodities leading to terms of trade shocks, recurrent episodes of civil war as well as of social and political unrest, adverse weather conditions leading to prolonged droughts, changes in political regimes toward dictatorships, *etc.* Second, we conduct a formal investigation of the presence of cross-sectional dependence, which may derive from the high similarity in the output and export structures of African countries.

Third, we allow for more general forms of cross-sectional dependence than the traditional cross-sectional demeaning, which constitutes a highly restrictive form of cross-correlation. We do so by approximating the empirical distribution of the statistics through bootstrap simulations following Maddala and Wu (1999). This is crucial since panel unit root and stationarity tests that do not explicitly allow for cross-sectional dependence across individuals exhibit large size distortions.³ This analysis for less developed economies will complement those for developed countries that, through the use of panel tests with breaks, have generally provided evidence against the unit root hypothesis. Finally, since most African countries exports' are concentrated in one or two primary commodities, this low degree of diversification in production and export structures makes African economies highly vulnerable to external conditions. Hence we try to relate the timing of the breaks to terms of trade shocks associated with the large fluctuations in the price of primary commodities.⁴ The evidence supports the presence of clustering patterns of the break dates that can be explained on the basis of external shocks like booms and busts of primary commodity prices.⁵

As a robustness check, we also investigate the time series properties of *per capita* real GDP for more homogenous groups of countries forming different Regional Economic Communities (RECs hereafter), which constitute integration processes with the aim of achieving deep forms of integration like currency and monetary unions. Next, we check whether the findings supporting regime-wise trend stationarity in African *per capita* real GDP are partly influenced by the lower quality associated with the early observations of the sample in Maddison's dataset, particularly the 1950s when most of the African countries did not yet exist. For that purpose, we construct two balanced panels with the data available in the Penn World Table (PWT) 6.2 developed by Heston, Summers, and Aten (2006): one spanning the period 1960–2004 with data for 33 countries, and another covering the period 1970–2004, which has data for 44 countries.

Overall, our findings are clearly supportive of regime-wise trend stationarity in *per capita* real GDP after controlling for multiple breaks and cross-sectional dependence, thereby removing four outlier countries exerting high influence on the panel as a whole. These results hold true for different country-groups forming RECs in the African continent as well as for alternative *per capita* real GDP proxies retrieved from the PWT 6.2.

The remainder of this paper is structured as follows. Section 2 presents a brief literature review on this issue. In Section 3, we provide a description of the data and the panel unit root and stationarity tests used in the econometric analysis. Section 4 reports the results of the analysis of the time series properties in *per capita* real output for 46 African countries over 1950–2001. Section 5 conducts some robustness checks through the analysis of different country-groups based on regional inte-

gration arrangements as well as of different *per capita* real GDP series from the PWT 6.2. Section 6 puts forward some policy implications that point to the need for managing adequately terms of trade booms and busts to avoid large swings in Africa's aggregate output.

2. BRIEF LITERATURE REVIEW

Early studies investigating the nonstationarity properties of US real GNP failed to reject the unit root null hypothesis. However, these results are questioned by Christiano and Eichenbaum (1990) and Rudebusch (1993) on the grounds that standard unit root tests like the augmented Dickey–Fuller (1979, ADF) test exhibit limited power to discriminate between trend stationarity and a unit root in aggregate output. Furthermore, Perron (1989) finds that standard unit root tests tend to misinterpret trend stationarity with a structural break as a unit root. Perron (1989) strongly rejects the unit root hypothesis for US real GNP by exogenously imposing a structural break. This result was challenged by Zivot and Andrews (1992) on the grounds that unit root tests tend to over-reject the unit root null when the break is exogenous.

As a way to increase statistical power, researchers apply panel unit root tests to aggregate output series. While Fleissig and Strauss (1999) provide evidence that output series for 15 OECD countries over the period 1900–87 are trend stationary, Rapach (2002) finds strong support for the unit root hypothesis in OECD aggregate output. As argued by Romero-Avila (2007), the reason for the discordant results from both studies using similar techniques may derive from misspecification of the trend function of the output series. Employing the panel stationarity test with multiple breaks of Carrion-i-Silvestre *et al.* (2005), he finds broad evidence supporting regime-wise trend stationarity in OECD output series.

In contrast to this important amount of evidence gathered for developed countries, not much work has been done on testing the unit root hypothesis for aggregate output in less developed countries. A few exceptions are Ben-David and Papell (1998) who, by applying a one-break unit root test to *per capita* real GDP for 74 developing and developed countries, found evidence of stationarity in *per capita* GDP for 20 countries over the period 1950–90. Among the 14 African countries analyzed, only Ghana, Malawi, Mauritius, and Zambia support stationarity in *per capita* real GDP. Using univariate unit root tests with one exogenous break as well as tests with one endogenously determined break, Lutz (1999) finds that nearly two-thirds of the 31 developing countries investigated reject a unit root in output in favor of stationarity around a segmented trend. His sample of countries only includes four African countries: Egypt, Ghana, Malawi, and South Africa, of which the former three countries are best described as a unit root. Interestingly, for the test with an exogenous break, Lutz (1999) assumes the occurrence of breaks in 1973–74 and 1979–80, with the former being associated with the first oil shock of the 1970s and the latter being related to several factors such as the second oil crisis, the high real interest rates, and the recession experienced in the industrialized world which depressed primary commodity demand and the terms of trade, thus leading many developing countries to experience difficulties in servicing their debt obligations.

Applying univariate nonlinear (logistic) unit root tests to *per capita* real GDP from the PWT, Nieh and Wei (2005) are able to reject the unit root null for over one-third of the 26 African countries investigated during 1960–2000. In addition, Chang, Chang, Chu, and Su (2006) apply the seemingly-unrelated-

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