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Commodity Prices and Growth in Africa

Institutional and Temporal Considerations

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Abstract

The paper analyses the short run and long impact of commodity prices on real GDP per capita growth in 29 African countries over the period 1980-2013. The paper uses the latent-class panel error correction model that captures both short-run and long-run effects of commodity prices, while at the same time relaxing the assumption that countries do belong to a single growth regime or latent class. The key finding of this study suggests that using models which assume that countries can be classified in a single growth regime may result in misleading policy conclusions. More specifically, using a model which assumes that countries follow a single growth regime, shows that commodities have an unambiguous positive effect on growth in the short run, while in the long run the positive effect of commodity prices on growth is only conditional upon the existence of good quality institutions. However, when we relax the assumption of a single growth regime across countries, results suggest that the short-run and long-run impacts of commodity prices on growth are conditional on the growth regime that countries belong to, which is mostly contrary to the findings based on a single growth regime. There is need, therefore, for policymakers to avoid assuming that countries belong to a single growth regime when carrying out policy-oriented economic analysis, as this may lead to inappropriate policy recommendations.

1. Introduction

The strong growth experienced by Africa over the past decade and a half coincided with a global commodity price boom leading some analysts to argue that the continent's growth is a commodity narrative. Questions have therefore been raised as to whether this growth will be sustainable in the face of weakening commodity prices. This study seeks to address two issues in this regard. First, it examines the impact of commodity prices on short-run growth, thereby addressing the question of the role of the commodity price boom in Africa's recent growth. Second, it investigates the combined short-term and long-term impact of commodity prices on growth, thereby addressing whether Africa's growth will be sustained in the face of weakening commodity prices.

Early experiences of most resource-rich countries around the world provided at least two stylized growth features. First, resource-poor economies tended to outperform resource-rich economies in terms of growth and development. Sachs and Warner (1995), for example, observe that in the nineteenth century, resource-poor countries such as Switzerland and Japan outperformed resource-rich countries such as Russia. Moreover, between the 1960s and the 1990s, resource-poor Asian-Tiger economies such as Republic of Korea, Taiwan, Hong Kong and Singapore outpaced resource-rich economies such as Mexico, Nigeria and Venezuela.[1] Second, a resources price boom or the discovery of mineral resources was associated with shrinking of the manufacturing sector in many resource-rich countries. For example, the discovery of gold deposits in Australia in the eighteenth century had a negative effect on some of that country's industries (Cairnes, 1859; Maddock and McLean, 1983; Corden, 1984). Similarly, the discovery of natural gas in the 1960s in the Netherlands stifled the growth of the manufacturing sector (Ellman, 1981).

It is not surprising, then, that the role of the commodities or resources price boom in economic growth and development has attracted substantial research interest. Despite extensive literature on the subject, there is still no consensus on whether a resources price boom promotes or derails growth and development. Empirical studies such as Sachs and Warner (1999, 2000), Gylfason et al.(1999), Leite and Weidmann (2002), Sala-i-Martin and Subramanian (2003) lent support to the sceptical view that a resources price boom has a negative influence on growth and development.

Different theoretical explanations have been used to support the idea that a resources price boom has a negative influence on growth. Early explanations were based on the social view that a sudden discovery or a boom in prices of natural resources may induce laziness (Bodin, 1962; Sachs and Warner, 1995). Subsequent explanations are based on the idea that, unlike the manufacturing sector, the resources exporting sector does not promote complex division of labour, and thus has limited forward and backward linkages with the rest of the economy (Hirschman, 1958; Baldwin, 1966). Another explanation has become popularly known as the Dutch disease, and is based on the effect that a natural resources discovery or boom might have on other sectors of the economy through its effects on the macroeconomy. Of particular interest in this regard is the idea that a natural resources boom may lead to de-industrialization through different channels. First, the wealth effect resulting from the resources price boom may result in misallocation of resources from the manufacturing sector to the resources sector (Matsuyama, 1992). Second, the resources price boom may result in the appreciation of the country's domestic currency thereby reducing the competitiveness of the non-resource sector, particularly the manufacturing sector (Treviño, 2011). There is also an argument that resource booms instill overconfidence among authorities and inhabitants to the extent that they downplay the value of sound economic policies and quality of education (Gylfason, 2001). Finally, there are political economy explanations for the resource curse. One explanation is based on the idea that the resources boom may promote rent-seeking behaviour, thereby precipitating corruption that is in turn detrimental to growth (Bardhan, 1997). Another ~~argues~~ that the distribution of government revenues from the resources sector can be motivated by political reasons and not economic efficiency (Robinson, et al., 2006). Yet others have argued that resource rent can fuel civil conflict and instability, thus having detrimental effects on growth (Tornell and Lane, 1999; Hodler, 2006).

[1] For more examples of instances where resource-poor economies performed better than resource-rich countries see Sachs and Warner (1995).

However, some studies have found that a natural resources boom is a blessing, or they at least question the idea that a natural resource boom is a curse (Lenderman and Moloney, 2007; Manzano and Rigobon, 2007; Raddatz, 2007; Alexeev and Conrad, 2009). Indeed, recent empirical studies in countries such as Canada, Australia, Norway and Botswana provide an optimistic view of the impact of a resources price boom on growth and development. From a theoretical point of view, it is possible that a resources price boom may have a positive impact on growth, for example by increasing public revenue. If that revenue is allocated to developmental areas, it can then improve long-term growth.

Alexeev and Conrad (2009) show that oil and mineral resources enhance, rather than derail long-term growth. Similarly, using the dynamic generalized method of moments (GMM) estimators of Blundell and Bond (1998) and Arellano and Bover (1995) to control for endogeneity, Lenderman and Moloney (2007) show that resource abundance can positively influence growth through trade. The same is true of Raddatz (2007) and Manzano and Rigobon (2007) who find evidence that contradicts the idea that commodity price booms are detrimental to growth. The former adopts a vector autoregressive model to show that the variability in real GDP of developing economies is mainly due to internal factors, while external shocks, including commodity price shocks, account for only a small percentage thereof. The authors show that the resource curse disappears once country-fixed effects are accounted for.

In light of the mixed findings, an emerging strand of relevant literature has attempted to reconcile the different findings by examining the conditions under which commodity prices can influence growth. Studies such as Mehlum et al. (2006), Gregorio (2007), Andersen and Aslaksen (2008), Brunnschweiler (2008), Brunnschweiler and Bulte (2008) and Collier and Goderis (2012), among others, introduce heterogeneity in the coefficients of natural resources across countries, by interacting natural resources proxies with structural and institutional factors that may differ across countries. Most of them find that the "resource curse" is dependent upon the initial structural and institutional conditions (Brunnschweiler and Bulte, 2008; Brunnschweiler, 2008; Collier and Goderis, 2012). Countries with good quality institutions and sound structural conditions tend to escape the "resource-curse".

However, as argued by Konte (2015), a major concern in most of these studies is that the heterogeneity imposed tends to focus on the regressor(s) of interest and ignore other relevant regressors. This is done without testing whether the omitted regressors may induce heterogeneity in the coefficients on resources variables. Moreover, the empirical approach in most of the studies assumes that growth follows a single, unique regime that is identical across countries, a hypothesis that has been rejected by studies such as Durlauf and Johnson (1995), Owen et al. (2009), Bos et al. (2010), among others.

Konte (2015) explores the idea that the heterogeneity of the coefficients of the natural resources variable can be attributed to more than one regressor, by using the finite mixture of regression model (FMM). This is a semi-parametric technique that is premised on the idea that a variable (in this case the growth process) does not necessarily follow a single regime across countries. With FMM it is possible to model the unobserved heterogeneity in the growth process and relax the hypothesis of a single, unique growth regime across countries. Using a panel of 91 developed and developing countries, Konte (2015) found that these countries can follow either of the two growth groups. Furthermore, for countries in the first growth regime, natural resources abundance or boom has a positive and significant influence on growth, while for countries in the second regime it has a negative but insignificant effect on growth.

Using FMM, it is possible to compute the probability of countries being in a certain growth regime. It is then possible to examine the role of various factors in determining the probability of being in a certain growth regime. This ~~will~~ in turn ~~help~~ determine whether other determinants have an impact on the heterogeneity of growth coefficients across regimes, and address the omission issue that is common in studies that introduce heterogeneity in growth coefficients. These studies interact the natural resources proxy with selected regressors, without testing whether the remaining regressors matter. Through this exercise, Konte (2015), for example, finds that democracy significantly increases the probability of being in the growth regime, while economic institutions have no significant impact.

Konte's (2015) work is a step in the right direction but shares the same caveat as many other studies (Lenderman and Moloney, 2007; Manzano and Rigobon, 2007; Raddatz, 2007, etc.) that do not distinguish between the short-run and long-run effects of a natural resources boom on growth. Failure to do so often results in a phenomenon where long-run effects are contaminated by short-run effects (Collier, et al., 2012). Existing studies based on the vector autoregressive model, tend to support the idea that a natural resources boom has an unconditional positive and significant short impact on short-run growth, while results on the long-run effects are mixed. An exception is Collier et al. (2012) who used the panel error correction model to analyse the impact of commodity prices on short-run and long-run growth. However, like many of the studies, Collier et al. (2012) assume that countries follow a single-growth regime. We contend that this is not necessarily the case and hence we link commodity prices and growth controlling for differentiated growth regimes, institutional variables and varied temporal dimensions (i.e. examining both the short-term and the long-term growth impact of commodity prices).

The study contributes to the current literature by using an empirical methodology that reconciles the approaches followed by Collier et al. (2012) and Konte (2015). Specifically, we use the latent-class panel error correction model of Dijk et al. (2011). This model allows us to separate the short-run effect of international commodity prices on real GDP per capita from the long-run effect. Furthermore, we simultaneously consider the hypothesis that countries may follow different growth regimes which might have differentiated responses to a natural resources boom. An additional advantage of our approach is that it allows us to compute the probability of countries being in a certain growth regime, and determine the factors that affect this probability.

Our study provides interesting new and additional findings compared to previous studies. First, our analysis finds two unique growth regimes that characterize Africa's GDP per capita. Forty seven per cent of African countries are in the first growth regime, and the remaining 53 per cent are in the second growth regime (i.e. based on the basic model). As noted earlier, studies that model African growth dynamics using a single regime run the risk of misspecification and might lead to misleading interpretation of results that are produced without controlling for growth-regime heterogeneity. We find that commodity prices have a positive and significant impact on both short-run and long-run growth for countries in the second regime, while for countries in the first regime resources have a positive and significant impact in the short run and a negative impact in the long run. An analysis of the probability of being in the commodity price-growth enhancing regimes suggests that factors such as good institutional quality, life expectancy, the degree of openness and education improve the probability of being in the growth-enhancing regime, while corruption lowers this probability. These findings support the significant role of institutions, education, and trade in promoting growth.

The remainder of the paper is organized as follows: Section 2 outlines the empirical methodology and data, while Section 3 presents and discusses our empirical findings. Section 4 concludes the paper and articulates the policy implications of the findings.

2. Methodology and data

2.1 Econometric framework

The model draws on the latent-class panel time series models of Paap et al. (2005) and van Dijk et al. (2011). The latent-class model is based on the premise that the individual time series that constitute a panel can be grouped into a limited number of classes or clusters. Linear models can then be used to describe the long-term dynamics of the time series in each cluster.

Often, cross-country growth empirical studies are based on pooled panel regressions where the growth process of all countries within the panel is treated as homogeneous. Such models are, however, restrictive as growth processes are bound to vary across countries or regions. To accommodate the possibility of such variations, some researchers estimate fully heterogeneous models by allowing parameters to vary across countries. However, a fully heterogeneous model ignores some of the similarities across countries. In this regard, some studies try to exploit the homogeneities across countries in a panel by grouping them according to certain characteristics such as location, level of development, resource endowment, etc. However, apart from being subjective, such ex ante classifications are not based on testing the statistical properties of the data. The latent-class model is a purely data-driven approach to exploit the heterogeneities and the homogeneities that exist across the countries that form a panel.

The latent-class model used in this study allows for flexibility in both the intercept and the slope coefficient of growth. We allow the intercept to vary across latent classes to accommodate the possibility that the mean growth rate of real GDP per capita may vary across countries. The mean growth rates are likely to be heterogeneous across countries. However, in this model, they are demeaned so that the coefficient for each cluster is equal to the average growth rate of countries in that cluster. With regard to the slope parameter, we seek to examine whether real GDP per capita follows a long-run trend with commodity prices, and whether this trend varies across latent classes. As discussed earlier, we also examine the short run dynamics of the relationship between real GDP per capita and commodity prices, and whether any short run deviations from the long run path are corrected. Following van Dijk et al. (2011), we employ the following latent-class error correction model (ECM) to examine the short run and long run relationship between commodity prices across different latent classes:

$$\Delta \log(y_{i,t}^{pc}) = \beta_{0,ki} + \beta_{0,ki}[\log(y_{i,t-1}^{pc}) + \gamma_{ki} \log(p_{i,t-1})] + \eta_{i,t}$$

(1)

where y^{pc} is real GDP per capita, p denotes the commodity price, parameters β and γ are cluster-specific parameters, subscript $K_i = 1, \ldots, K$ denotes the latent class ~~which~~ *i* belongs to, with *K* being the number of latent classes. The probability that a country lies in latent class *k* is denoted by π_k, where $0 \le \pi_k \le 1$ and $\sum_{k=1}^{K} \pi_k = 1$.

In the presence of cointegration between real GDP per capita and commodity prices $y_{it}^{pc} - \gamma_{ki} p_{it}$, and $y_{jt}^{pc} - \gamma_{kj} p_{jt}$ are stationary series. This implies that the commodity price indices of countries in each cluster are integrated. Based on this intuition, it is possible to write the following:

$$(y_{it}^{pc} - \gamma_{ki} p_{i,t}) - \delta(y_{jt}^{pc} - \gamma_{kj} p_{jt}) = (y_{i,t}^{pc} - \delta y_{i,t}^{pc}) - (\gamma_{kj} - \delta \gamma_{kj}) p_{i,t}$$

(2)

In equation (2), since the left-hand side is stationary, so is the right-hand side. For $\delta = \gamma_{ki} / \gamma_{kj}$ the second term in the right-hand side disappears, and countries *i* and *j* must have $(1; -\delta)$ ~~a~~ cointegrating relationship. Two countries in the same cluster will have a (1, -1) cointegrating relationship as they share the same γ parameter.

As the growth literature suggests, there are also some cross-sectional correlations among the growth rates of countries that are not captured by commodity prices, but by other factors such as human capital, investment, institutions, etc. Holloy, et al. (2008) suggests that these factors can be accommodated by allowing the composite error term $\eta_{i,t}$ to be correlated across countries, due to these other determinants of growth. More specifically $\eta_{i,t}$ can be specified as follows:

$$\eta_{i,t} = \alpha_{1i}\Delta\log(p_{i,t-1}) + \alpha_{2i}\Delta\log(y^{pc}_{i,t-1}) + \sum_{p=1}^{P}\alpha_{pi}\log(\mathbf{X}_{pi,t-1})$$
(3)

It is important to note that equation (1) cannot be directly estimated because it is non-linear due to the presence of the term $\log(y^{pc}_{i,t-1}) + \gamma_{ki}\log(p_{i,t-1})$. As is the case in the standard literature (Boswijk, 1994; Van Dijk, 2011; Collier and Goderis, 2012), equation (1) can be rearranged as follows:

$$\Delta\log(y^{pc}_{i,t}) = \beta_{0,ki} + \beta_{1,ki}\log(y^{pc}_{i,t-1}) + \beta_{2,ki}\log(p_{i,t-1}) + \eta_{i,t}$$
(4)

where $\beta_{2,ki} = \beta_{1,ki}\cdot\gamma_{ki}$. The maximum likelihood estimate $\hat{\gamma}_{ki}$ is then estimated from maximum likelihood estimates of $\hat{\beta}_{1,ki}$ and $\hat{\beta}_{2,ki}$ as follows: $\hat{\gamma}_{ki} = \hat{\beta}_{2,ki}/\hat{\beta}_{1,ki}$.

The parameters in equations (3) and (4) can be estimated using the expectation maximization algorithm of Dempster et al. (1977). This is a two-step algorithm that utilizes the joint density of the GDP per capita and the latent classes k_i. The two steps are performed in ~~an alternating basis~~ and they can be described as follows. In the first step (E step), the expected value of the full data log-likelihood function is maximized with respect to the latent classes k_i, for $i = 1, 2, ...N$, given the real GDP per capita and the current values of the model parameters. In the second step (M step), the expected value of the full data log-likelihood is maximized with respect to the model parameters. Since the expected maximization algorithm maximizes the log-likelihood function, the resulting estimates are equal to the maximum likelihood estimates (van Diyk, et al., 2011). The standard errors of the estimates are estimated using the second derivative of the log-likelihood function.

Formally, the full data likelihood function, based on equation (4) above, is given by:

$$l(P,K,\theta) = \prod_{i=1}^{N}\left(\prod_{k=1}^{K}\left(\pi_k\prod_{t=1}^{T}\frac{1}{\sigma_i}\phi\left(\varepsilon^k_{i,t}/\sigma_i\right)\right)^{I[k_i=k]}\right)$$
(5)

where $\phi(.)$ is the probability density function of a standard normal random variable and θ is a vector containing all the parameters of the model.

The expectation of the full data log-likelihood function with respect to K/P, θ (i.e. the E step) is given by

$$L(P;\theta) = \sum_{i=1}^{N}\left(\sum_{k=1}^{K}\hat{\pi}_{i,k}\left(\ln\pi_k + \sum_{t=1}^{T} -\frac{1}{2}\ln\sigma_i^2 - \frac{1}{2}\ln 2\pi - \frac{(\varepsilon^k_{i,t})^2}{2\sigma_i^2}\right)\right)$$
(6)

where $\hat{\pi}_{i,k}$ is the conditional probability that country ***i*** belongs to class ***k*** and is given by.

$$\frac{\partial L(P;\theta)}{\partial\theta} = 0 \Rightarrow \hat{\pi}_{i,k} = \frac{\pi_k\prod_{t=1}^{T}\frac{1}{\sigma_i}\phi(\varepsilon^k_{i,t}/\sigma_i)}{\sum_{l=1}^{K}\pi_l\prod_{t=1}^{T}\frac{1}{\sigma_i}\phi(\varepsilon^l_{i,t}/\sigma_i)}$$
(7)

Hence, a given country i will be allocated in latent class k than l if and only if $\hat{\pi}_{i,k} > \hat{\pi}_{i,l}$

Given that the number of latent class K is a priori unknown, we use the corrected Akaike information criterion (CAIC) and the Bayesian information criterion (BIC) to choose the optimal value of K. Bozdogan (1987) shows that these two information criteria perform better than the Akaike information criterion as the sample size increases.

2.2 Data and variables

The study uses annual data for the period 1980–2013. The dependent variable is the real GDP per capita. The explanatory variable of main interest is the export commodity price index. We construct two types of export commodity indices both of which are economy-wide and sectoral (i.e. for sectors such as agriculture, mining, energy). The first is the commodity export index (both economy-wide and sectoral) based on weights of over 35 commodity exports by African countries. Details of the construction of the indices is provided in the section below.

Following the existing literature (for example Solow, 1957; Sala-i-Martin, et al, 2004; Collier and Goderis, 2012), we control for additional determinants of growth. These include, among others, investment share of GDP, trade to GDP, population growth, population (0-14), years of secondary schooling, life expectancy, GDP deflator, the real exchange rate, etc. Data on these variables were obtained from World Development Indicators (WDI) of the World Bank. Regional dummies control for growth heterogeneity across regions, which could be due to a variety of structural reasons such as differences in resource endowment across regions, weather conditions, institutions, landlockedness, etc. The dummy variable for the post-2000 period is used to capture the impact of the strong growth in real GDP that Africa has experienced since 2000.

We also account for institutional quality indicators based on the International Country Risk Guide 2014 (ICRG 2014). Table 1 provides details of the variables used and the sources of data (see the appendix).

We construct country-specific indices using commodity prices. The first set of indices is based on the prices of countries' exports. Following Deaton and Miller (1999), Dehn (2000), Ehrhart and Guerineau (2011), these indices are based on geometrically weighting common international prices with fixed individual country weights. More formally, we compute the index as follows:

$$I_{i,t}^{x} = \prod_{i=1}^{n}\left(p_{i,t}^{x}\right)^{w_{c,t}}$$

(9)

where the superscript ***x*** denotes exports, $I_{i,t}$ and $p_{i,t}$ denote the country-specific export commodity index and the international price of commodity ***i*** in year ***t***, respectively, $w_{i,t}$ is the average share of commodity ***c*** exports in total commodity exports in country ***i***, and ***n*** denotes the number of commodities. Data on shares of these commodities in exports[2] of each country are obtained from World Integrated Trade Solution (WITS) with Standard International Trade Classification (SITC) 2 disaggregated over four digits. A total of 35 commodities were considered for exports.[3] The country-specific price indices were deflated by the unit value index of developed countries' exports (Ehrhart and Guerineau, 2011). Equation (9) is used to construct both economy-wide and sectoral commodity export indices. The sectoral indices are for agricultural, mining and energy exports.

[2] The list of commodities used are summarized in table 2 in appendix.
[3] The commodities considered, see table 1. Table 2 provides illustrative examples of countries' shares of selected commodities in exports and imports.

3. Results and discussions

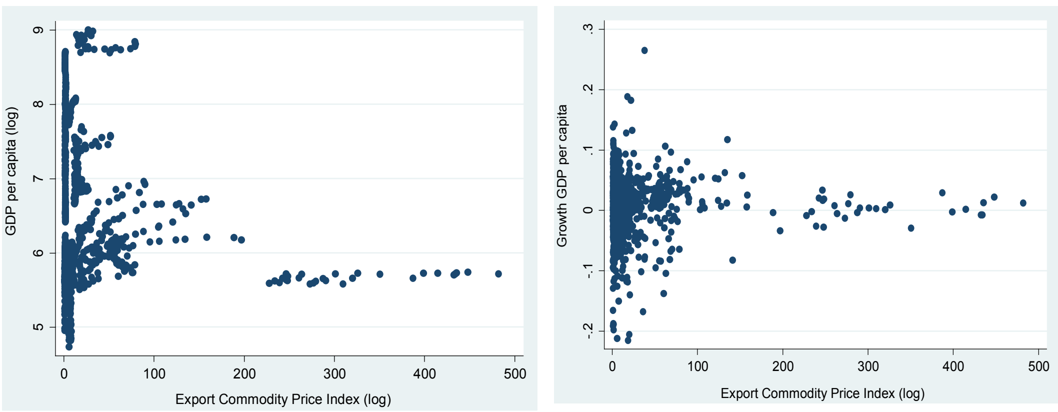
3.1 Checking for a priori clusters

Before turning to conditional clustering analysis using latent class techniques, a simple correlation analysis of key variables of the model could provide insight into a possible existence of latent and unobserved components. For this purpose, figure 1 shows that assessing the impact of export commodity prices on GDP growth per capita could be undertaken by dividing the sample into more than one cluster. Although at this stage it is difficult to determine the exact number of clusters, the figure shows that aggregating the sample as a pool or one group to measure the impact of commodity price on growth may lead to biased and inconsistent results and therefore misleading policy conclusions. The paper then further determines the exact number of clusters or latent classes using robust and sound econometric techniques by minimizing the Bayesian information criterion and the corrected Akaike information criterion – see Section 3.3.

3.2 Evidence from the error correction model with no latent classes

We begin by estimating equation (4) assuming that $k = 1$. The results reported in table 1 are akin to the ECM estimated by Collier and Goderis (2012). In model (1), we control for the usual Solow (1956) growth regressors and other key determinants that have been used in the growth literature. In the first specification, we do not include institutional quality, while in model (2), we control for the effects of the proxy of institutional quality on the intercept of the regression. We subsequently include more determinants of growth in addition to the ones included in model (1). In model (3), we control for the effect of institutional quality on both the intercept and the slope coefficients of commodity prices. In each of the subsequent models (4), (5), (6) and (7), we use disaggregated commodity price indices for agricultural, mineral and energy exports. In model (4), we control for the effect of institutional quality on the intercept. In models (5), (6) and (7), we control for the effect of institutional quality on the slope coefficients of the agricultural, mining and energy commodity indices, respectively. In all the models, we include measures of both level and differenced commodity prices in order to simultaneously capture the long-run and short-run effects of commodity prices on the growth rate of real GDP per capita. In all the models, we also control for regional effects based on the classification of the five subregions of Africa.[4] Furthermore, we control for the trend in data, and

Figure 1: Correlation between GDP per capita, growth in GDP per capita and export commodity price in Africa, 2000-2013



Source: Authors' calculation.

[4] These subregions include Central Africa, East Africa, North Africa, Southern Africa and West Africa.

for a possible structural break in average growth in GDP per capita in the post-2000 period. Note that in areas where some coefficients are not reported, it is due to their automatic omission induced by multicollinearity between variables.

With regards to the analysis of the long-run effect of commodity prices on real GDP per capita growth, under model (1), the long run and lagged coefficients of the commodity price index is negative but statistically insignificant. When we control for the effects of institutional quality on the intercept, the contemporaneous coefficient of commodity prices and lagged coefficient of commodity prices becomes significantly positive (at 10 per cent level) and negative (at 5 per cent level) respectively. Note that the coefficient of institutional quality is positive and significant at 1 per cent.

When we control for the effect of institutional quality on the slope coefficient of commodity prices by interacting the commodity price with the proxy of institutional quality (i.e. *governance*commodity price)*, it is notable that the coefficient of the commodity price becomes insignificant, while the coefficient on the term interacted with institutional quality is positive and highly significant. Note also that the coefficient of *governance*commodity price* is almost twice larger than the coefficient on commodity price. Generally, these results suggest that an increase in the commodity price exports enhances the growth rate of GDP per capita in countries with good quality institutions, but not in countries with poor quality institutions. This result is consistent with the findings of Collier and Goderis (2012) and Mehlum, et al. (2006).

Table 1: Parametric results in the homogenous panel ECM

Dependent variable: growth in real GDP per capita

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Short run							
Δ commodity price (log)	0.000218* (0.000117)			0.000210* (0.000117)	0.000204* (0.000122)	0.000220* (0.000117)	0.000202* (0.000118)
Δ commodity price (log) (-1)	0.000191** (0.0000975)	0.000193** (0.0000947)	0.000192** (0.0000965)	0.000179* (0.000102)	0.000182* (0.000103)	0.000188* (0.0000981)	0.000177* (0.000103)
Δ commodity price (log) (-2)				-0.0000353 (0.000107)	-0.0000320 (0.0000990)	-0.0000245 (0.000100)	-0.0000384 (0.0000995)
Δ population (log)	0.00999 (0.0615)	0.0102 (0.0626)	0.00488 (0.0633)	0.00862 (0.0620)	0.00242 (0.0613)	0.0101 (0.0634)	0.00879 (0.0625)
Long run							
Commodity price (log)		0.000223** (0.000112)	0.000220* (0.000117)				
Commodity price (-1) (log)	-0.0000266 (0.0000192)	-0.000249** (0.000113)	-0.000245** (0.000120)				
GDP per capita (-1) (log)	-0.00352* (0.00212)	-0.00483** (0.00217)	-0.00424** (0.00214)	-0.00688*** (0.00231)	-0.00338* (0.00199)	-0.00463** (0.00218)	-0.00441** (0.00208)
Investment (log)	0.0168*** (0.00624)	0.0169*** (0.00583)	0.0176*** (0.00622)	0.0183*** (0.00674)	0.0172*** (0.00640)	0.0171*** (0.00627)	0.0178*** (0.00626)
Openness (log)	0.00287 (0.00544)	0.00268 (0.00541)	0.00235 (0.00517)	0.00179 (0.00561)	0.00253 (0.00531)	0.00250 (0.00552)	0.00146 (0.00555)
Dummy governance		0.0129*** (0.00463)		0.0169*** (0.00508)			
Governance*commodity prices (log)			0.00428*** (0.00157)				
Agricultural commodity price (log)				0.000373 (0.00244)	-0.000291 (0.00222)		
Mineral commodity price (log)				-0.000348		-0.00140	

				(0.00173)		(0.00159)	
Energy commodity price (log)				0.00492** (0.00249)			0.00386* (0.00233)
Governance* agricultural commodity prices (log)					0.0140** (0.00574)		
Governance* mineral commodity prices (log)						0.0246* (0.0136)	
Governance* energy commodity prices (log)							0.0153 (0.0136)
Constant	-0.0500** (0.0219)	-0.0405* (0.0222)	-0.0449** (0.0223)	-0.0305 (0.0261)	-0.0505** (0.0230)	-0.0416* (0.0240)	-0.0439** (0.0218)
Dummy_20002013	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dummies regional	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	907	907	907	907	907	907	907
R-squared	0.129	0.133	0.132	0.139	0.130	0.131	0.133

Notes: Standard errors in parenthesis; *, **, *** denotes 10%, 5% and 1% levels of significance, respectively. Columns (1) to (7) are estimated using two-stage least square (2SLS) and assuming a 1,000 replication bootstrap on the variance-covariance matrix.

If the commodity price is disaggregated by sectors, it is noted that the coefficients for agricultural and energy commodity export prices are positive and negative, respectively, but are not statistically significant. On the other hand, the coefficient for the mining commodity exports is positive and statistically significant at 5 per cent. When we control for the effects of institutional quality, the coefficient for the variables where we interact the commodity prices of agricultural and mining exports with institutional quality are positive and statistically significant, while the coefficients of the individual commodity price indices for these two sectors remain insignificant. In terms of size, the coefficient of *governance*agricultural commodity price* is almost 50 times larger than that of agricultural commodity price, while the coefficient of *governance*mining commodity price* is more than 17 times larger than that of *mining commodity price*. Once again, these results suggest that commodity prices can only promote long-run growth in countries where the quality of institutions is good.

Turning to the effect of commodity prices on real GDP per capita growth in the short run, it is notable that all the coefficients of the contemporaneous, and first lag of the proxies for short-run commodity prices are positive and significant across all the specifications.[5] This is consistent with past findings that the commodity process has an unconditional positive influence on growth in the short run (Deaton and Miller, 1995; Raddatz, 2007).

In relation to the other long-run determinants of growth, it is notable that the coefficients of most determinants (e.g. trade openness and population growth) are not significant across all the specifications, except those for investment which are positive and significant across all specifications. These results underscore the role of investment in reducing bottlenecks such as physical and energy deficits that affect economic efficiency. The results on the coefficients of population growth are positive but not statistically significant across all specifications. This result is consistent with the findings of Collier and Goderis (2012). The coefficients of trade openness are positive but not statistically significant, which is contrary to Collier and Goderis (2012) findings, whose coefficients were positive and statistically significant across most of their specifications. We believe that this difference in results stems from the fact that Collier and Goderis (2012) used a sample comprising both African and non-African countries. On the other hand, we only use African countries, most of which have negative net exports and negative terms of trade due to the fact that the value of imports is higher than the value of their exports. This result on trade openness seems to support the recommendation of the 2015 Economic Report on Africa (ECA, 2015) that

[5] Note that in some specifications, the coefficients of the contemporaneous proxy for the short-run commodity price is not reported to avoid multicollinearity issues.

African countries need to improve value addition and strengthen their manufacturing sectors before fully opening their markets. ECA (2015) suggests that this can be done by deepening their regional value chains before entering or breaking into the global value chains.

The coefficient of lagged real GDP per capita is important as it measures whether or not there is conditional convergence of real GDP per capita to its steady state following a short-run disequilibrium. For convergence to occur, the coefficient should be negative and statistically significant. As evident from table 1, this coefficient is negative and statistically significant across all specifications, suggesting that any short-run deviations from the steady state are corrected. However, the speed of adjustment is very slow, with only between 0.34 and 0.7 per cent of the deviation of real GDP per capita from its new long-run growth path corrected each year. According to Collier and Goderis (2012), such slow adjustment implies that there will be a prolonged phase of slower growth in real GDP per capita until the new equilibrium growth path is reached.

The regional dummies are statistically significant across specifications, suggesting the existence of growth heterogeneity across regions. Growth heterogeneities across regions are due to a variety of structural reasons such as differences in resource endowment across regions, weather conditions, institutions, landlockedness, etc. The trend is statistically significant, suggesting the existence of trend non-stationarity in the data. The dummy variable for the post-2000 period is not statistically significant. This suggests that despite the strong growth in real GDP that Africa has experienced since 2000, the real growth of GDP per capita has not been strong which has implications for the poverty reducing power of Africa's growth. This is mostly due to fast population growth on the continent, resulting in low pass-through of real GDP growth to real GDP per capita.

3.3 Evidence from error correction model with latent classes

Next we estimate equation (5) allowing ***k*** to be different from 1. We begin by determining the appropriate number of latent classes using CAIC and BIC. As noted earlier, the optimal latent classes are the ones with minimum CAIC and BIC. An important question in selecting the appropriate latent classes relates to the maximum number of classes allowed. Previous studies suggest that the number of latent classes varies from two to three (Paap, et al., 2004; Alfo, et al., 2008; Owen, et al., 2009). In this regard, we limit the maximum number of latent classes to four. Table 4 reports BIC and CAIC derived from the log-likelihood values of the four different models estimated. Both BIC and CAIC suggest that the optimal number of growth regimes is two.

Tables 3 and 4 present the estimated long-run and short-run coefficients for the selected model with $K = 2$. The model reported is based on the aggregate commodity price index while controlling for institutional quality (in table 4) and without (in table 3). In model 1, the first latent class (growth regime) includes 48 per cent of the countries, while the second latent class consists of the remaining 52 per cent of the countries.

Table 2: Selection of mixture models

	Model 1		Model 2	
	BIC	*CAIC**	*BIC*	*CAIC*
K=1	-3042.66	-3090.63	-3035.2	-3093.05
K=2	**-3183.00**	**-3388.08**	**-3168.102**	**-3353.86**
K=3	-3156.36	-3323.00	-3107.623	-3303.19
K=4	-3165.24	-3292.95	-3092.445	-3298.27

Notes: Only BIC and CAIC criteria are reported. K is the number of latent classes or components. The optimal model selected is in bold.

* $CAIC = -2\ln f(y/\hat{\theta}_k) + \frac{2kn}{n-k-1}$ where $\ln f(y/\hat{\theta}_k)$ is the log likelihood under the alternative hypothesis (H1), is the total number of parameter and is the number of observation.

Table 3: Mixture model estimations in panel ECM (model 1)

Dependent variable: growth in real GDP per capita

	Model (1): Mixture with K=2		Wald test	
	Latent class 1	Latent class 2	Statistic (Khi-square)	p-value
Short run				
Δ Commodity prices (log)	2.16e-05	0.000386**	3.42	0.064*
	(8.03e-05)	(0.000184)	-	-
Δ Commodity prices (log) (-1)	4.94e-05	0.000151***	3.12	0.029**
	(7.92e-05)	(5.63e-05)	-	-
Δ Population (log)	-0.184***	0.0249	2.65	0.104
	(0.0641)	(0.0945)	-	-
Long run				
GDP per capita (log) (-1)	-0.00494***	-0.00268	0.45	0.504
	(0.00171)	(0.00247)	-	-
Commodity prices (log) (-1)	-5.04e-05***	-2.70e-05	0.45	0.504
	(1.89e-05)	(2.72e-05)	-	-
Investment (log)	0.0344***	0.00732***	6.88	0.009***
	(0.00637)	(0.00586)	-	-
Openness (log)	-0.0196***	0.00978	10.86	0.001***
	(0.00520)	(0.00600)	-	-
Constant	0.0453**	-0.0922***	21.19	0.000***
	(0.0180)	(0.0239)	-	-
Dummy 20002013	Yes	Yes	-	-
Trend	Yes	Yes	-	-
Observations	**431**	**486**		

Source: Authors' estimates.

Note: Standard errors in parenthesis; *, **, *** denotes 10%, 5% and 1% levels of significance, respectively.

In table 3 it is notable that the impact of an increase in commodity price on growth varies across the two growth regimes. The long-run coefficients of export commodity prices are negative in both regimes, but statistically significant only in latent class (or growth regime) 1. Furthermore, the coefficient in growth regime 1 is almost three times larger than that in growth regime 2, suggesting that commodity prices have a negative effect on long-run growth only for countries in regime 1. These results clearly differ from those from the heterogeneous model (table 1) where the conclusion is that the impact of commodity price increase on growth is negative but not statistically significant for all countries.

When we control for institutional quality, the coefficient of commodity price remains significant and negative in regime 1, and negative but insignificant in regime 2 (table 6). On the other hand, the coefficient of *governance*commodity price* is positive in both regimes, but only significant in regime 1. In summary, these results suggest that good quality institutions are only likely to improve the positive impact of commodity prices on growth in countries where commodity prices have a negative and significant impact on growth. The implication of this is that countries that face the *Dutch-disease trap* can escape such a ***trap*** by improving the quality of their institutions, while in countries that do not face the *Dutch disease*, the positive long-term impact of commodity prices on growth cannot necessarily be solely enhanced by improving institutions.

Once again the results show that assuming that countries follow a single growth regime and classifying them into a single latent class might lead to wrong conclusions and inappropriate policy recommendations. For example, in the above case, one policy implication from a homogenous error correction model like that of Collier and Goderis (2012) is that countries should improve institutions if they are to enhance the long-run impact of commodity prices on growth. However, our results from the latent class model suggest that this policy implication is only applicable for countries where the negative impact of commodity price on growth is significant, but inapplicable for countries where the impact of commodity prices

Table 4: Mixture model estimations in panel ECM (model 2)

Dependent variable: growth in real GDP per capita

	Model (2): Mixture with K=2		Wald test	
	Latent class 1	Latent class 2	Statistic (Khi-square)	p-value
Short run				
Δ Commodity prices (log)	2.19e-05	0.000404**	3.88	0.049**
	(8.11e-05)	(0.000183)	-	-
Δ Commodity prices (log) (-1)	4.61e-05	0.000154***	3.75	0.078*
	(8.33e-05)	(5.84e-05)	-	-
Δ Population (log)	-0.189***	0.0387	3.27	0.070*
	(0.0570)	(0.0983)	-	-
Long run			-	-
GDP per capita (log) (-1)	-0.00649***	-0.00370	0.55	0.458
	(0.00202)	(0.00261)	-	-
Commodity prices (log) (-1)	-4.62e-05**	-1.97e-05	0.55	0.458
	(1.99e-05)	(2.75e-05)	-	-
Investment (log)	0.0353***	0.00748***	7.59	0.0059***
	(0.00656)	(0.00562)	-	-
Openness (log)	-0.0201***	0.00931	11.40	0.007***
	(0.00503)	(0.00598)	-	-
Governance	0.00347	0.0105	4.37	0.045**
	(0.00736)	(0.00850)	-	-
Governance* commodity prices(log)	0.00534**	0.000767	3.27	0.070*
	(0.00272)	(0.00160)	-	-
Constant	0.0559***	-0.0832***	19.48	0.000***
	(0.0182)	(0.0252)	-	-
Dummy 2000-2013	Yes	Yes	-	-
Trend	Yes	Yes	-	-
Observations	**394**	**523**		

Source: Authors' estimates.

Note: Standard errors in parenthesis; *, **, *** denotes 10%, 5% and 1% levels of significance, respectively.

on growth is not significant. For the latter group of countries, policies that go beyond improving the quality of institutions are needed if commodity prices are to positively enhance long-term growth. Unfortunately, what such complementary policies should be is beyond the scope of this study and thus remains an important question that warrants further research.

In relation to the short-run parameters, it is notable that the results also vary across the growth regimes. Commodity prices (both contemporaneous and lagged) have no significant impact on growth in the short run for countries in regime 1, but have a positive and statistically significant effect on growth for countries in regime 2. This result is robust across specifications i.e. with or without measures of institutional quality.

Moving on to the other determinants of growth, the Wald tests in tables 3 and 4 suggest that some parameters differ across the two regimes (tables 3 and 4). It is important to note that the coefficients of most of the determinants are always significant across regimes. Particularly, the coefficients of investment remain positive and significant irrespective of regime or specification. The results underscore the importance of investment for long-term growth. The coefficients of lagged real GDP per capita are negative across all the models and latent classes, but they are only statistically significant in regime 1. This suggests that conditional convergence to the steady state only occurs for countries in regime 1. As is the case for the model with a single growth regime, the speed of adjustment is very slow, ranging from between 0.3 and 0.7 per cent per annum.

Table 4 shows the allocation of countries to different growth regimes with their respective probabilities. In model 1 for example, 47 per cent of countries in the sample belong to latent class 1 and the remaining 53 per cent belong to regime 2, while in model 2 these proportions shift slightly to 43 per cent for regime 1 and 57 per cent for regime 2 when we control for institution.

Countries from different regions of the continent and at different levels of development and institutional quality follow the same growth process. For instance, countries like Algeria, Burkina Faso, Cameroon, South Africa and Uganda are in the same latent class, while countries like the Cote d'Ivoire, Democratic Republic of Congo, the Niger, Nigeria, Sierra Leone are in the same growth regime irrespective of the model. However, countries close to the frontier — countries with posterior probabilities near 0.5[6] — are more likely to shift from one regime to another.

Table 5: Country classification into latent classes for model 1 and model 2

Model 1				**Model 2**			
Latent class 1		**Latent class 2**		**Latent class1**		**Latent class 2**	
Country	**Probability**	**Country**	**Probability**	**Country**	**Probability**	**Country**	**Probability**
Algeria	0.57	Congo, Rep.	0.54	Algeria	0.57	Congo, Rep.	0.54
Burkina Faso	0.54	Cote d'Ivoire	0.59	Burkina Faso	0.53	Cote d'Ivoire	0.59
Cameroon	0.52	Ethiopia	0.55	Cameroon	0.53	Ethiopia	0.56
Egypt, Arab Rep.	0.67	Gabon	0.52	Egypt, Arab Rep.	0.67	Gabon	0.52
Ghana	0.57	Gambia, The	0.56	Ghana	0.56	Gambia, The	0.56
Guinea	0.61	Madagascar	0.54	Guinea	0.60	Madagascar	0.57
Mali	0.51	Malawi	0.58	Morocco	0.51	Malawi	0.58
Morocco	0.52	Namibia	0.53	Mozambique	0.54	Mali	0.51
Mozambique	0.55	Niger	0.59	South Africa	0.54	Namibia	0.54
South Africa	0.53	Nigeria	0.57	Sudan	0.54	Niger	0.60
Sudan	0.54	Senegal	0.51	Tanzania, United Republic	0.54	Nigeria	0.59
Tanzania, United Republic	0.55	Sierra Leone	0.51	Tunisia	0.61	Senegal	0.51
Tunisia	0.61	Togo	0.65	Uganda	0.58	Sierra Leone	0.52
Uganda	0.58	Zambia	0.64			Togo	0.65
		Zimbabwe	0.58			Zambia	0.62
						Zimbabwe	0.58
Proportion of countries in class	47%		53%		43%		57%

[6] Countries like Mali, Morocco, Senegal and Sierra Leone are very close to the frontier between the two regimes.

4. Conclusions and policy implications

The paper analysed the short ~~run~~ and ~~long~~ impact of commodity prices on real GDP per capita growth in 29 African countries for the period ~~19802013~~ using an error correction model. The paper's main contribution is the use of a model that captures both short-run and long-run effects of commodity prices, while at the same time relaxing the assumption that countries ~~do~~ belong to a single growth regime. Our statistical tests indeed confirm that African countries do not belong to a single growth regime or latent class.

The key finding of the study suggests that using models which assume that countries can be classified in a single growth regime may result in misleading policy conclusions. More specifically, using a model which assumes that countries follow a single growth regime, we find evidence that is consistent with Collier and Goderis (2012), where commodities have an unambiguous positive effect on growth in the short run, but in the long run the positive effect of commodity prices on growth is only conditional on the existence of good quality institutions.

However, when we relax the assumption of a single growth regime across countries, a number of interesting contrary findings emerge. The results suggest that the short-run and long-run impacts of commodity prices on growth are conditional upon the growth regime that countries belong to. For countries belonging in a given growth regime, say regime 1, commodity price increases are not good for growth both in the short run and long run. Specifically, commodity prices have no significant impact on growth in the short run, and a negative and significant impact on growth in the long run. For countries in growth regime 2, commodity prices have a positive and significant impact on growth in the short run but have no significant impact on growth in the long run. In addition, when we control for institutional quality, we find that good quality institutions can only enhance the positive impact of commodity prices on growth for countries where commodity prices have a detrimental effect on long-run growth (i.e. in regime 1). With regard to other determinants of real GDP per capita, we find that their impact on growth statistically varies across growth regimes.

These results have a number of policy implications. The main implication is that policymakers need to avoid the assumption that countries belong to a single growth regime when carrying out policy-oriented economic analysis. This may lead to misleading interpretations of results and recommendations. For example, in the context of this study, assuming that countries belong to a single growth regime will result in a policy conclusion that countries simply need to improve their institutions if they are to enhance the long-run benefits of commodity prices. However, relaxing the single growth regime assumption suggests that this conclusion is only applicable to countries that experience the Dutch disease (i.e. where commodity prices have a negative and significant impact on long-run growth). The results also suggest that where commodities prices have no significant impact on long-run growth, improving institutional quality might not be a sufficient condition for enhancing commodity prices pass-through impacts on long-run growth.

Despite being beyond the scope of the current study, we believe that augmenting institutional reforms with policies such as labour market policy reforms, human capital development and other structural reforms may yield positive results. However, it is important to note that these are not evidence-based suggestions, and constitute an interesting area ~~of~~ further research.

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Appendix

A1: Dictionary of variables

N	Variable	Source	Description
1	GDP per capita (log)	World Bank WDI	real GDP divided by population
2	Investment (log)	World Bank WDI	investment is the gross fixed capital formation
3	Inflation	World Bank WDI	inflation is CPI based
4	Openness	World Bank WDI	share of exports + imports over GDP
5	Government stability	International Country Risk Guide (ICRG), table 3B	for more details see ICRG
6	Internal conflict	ICRG, table 3B	for more details see ICRG
7	External conflict	ICRG, table 3B	for more details see ICRG
8	Corruption	ICRG, table 3B	for more details see ICRG
9	Military in politics	ICRG, table 3B	for more details see ICRG
10	Religion in politics	ICRG, table 3B	for more details see ICRG
11	Law and order	ICRG, table 3B	for more details see ICRG
12	Ethnic tensions	ICRG, table 3B	for more details see ICRG
13	Democratic accountability	ICRG, table 3B	for more details see ICRG
14	Bureaucracy quality	ICRG, table 3B	for more details see ICRG
15	Governance	Authors' calculation	a dummy variable which takes the value 1 if the sum of (5) to (14) is higher than 70 and 0 otherwise
16	Commodity price	United Nations Conference on Trade and Development	annual commodity prices
17	Commodity exports	World Integrated Trade Statistics SITC two-digit classification disaggregated over four digits	exports (volume) of each commodity (annual) as a share of total exports from 2000 to 2013.
18	Commodity price index	Authors' calculation	weighted average of commodity prices of each country deflated by the unit value index of developed countries exports
19	Average years of secondary schooling	Barro and Lee database	linear interpolation is used for missing data
20	Life expectancy	World Bank WDI	see World Bank for more details
21	Unit value index of developed countries' exports	UNCTAD	see UNCTAD for more details

A2: List of commodities included in analysis

Agricultural commodities	Bananas; barley; hides; cocoa; coconut oil; coffee; cotton; groundnut oil; groundnuts; linseed oil; maize; rubber; olive oil; oranges; palm oil; rice; lamb; soya bean oil; soya bean; sunflower seed oil; poultry; sugar and honey; tea; wood
Mineral and natural commodities	Aluminum; iron; lead; uranium; gold; silver; zinc; copper
Energy commodities	Coal; petrol crude

Note: Number of commodities used: 35; number of countries: 43.