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Exploring the role of energy, trade and financial development in explaining economic growth in South Africa: A revisit

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A B S T R A C T

South Africa is an emerging and industrializing economy which is experiencing remarkable progress. We contend that amidst the developments in the economy, the role of energy, trade openness and financial development are critical. In this article, we revisit the pivotal role of these factors. We use the ARDL bounds [72], the Bayer and Hanck [11] cointegration techniques, and an extended Cobb–Douglas framework, to examine the long-run association with output per worker over the sample period 1971–2011. The results support long-run association between output per worker, capital per worker and the shift parameters. The short-run elasticity coefficients are as follows: energy (0.24), trade (0.07), financial development (−0.03). In the long-run, the elasticity coefficients are: trade openness (0.05), energy (0.29), and financial development (−0.04). In both the short-run and the long-run, we note the post-2000 period has a marginal positive effect on the economy. The Toda and Yamamoto [91] Granger causality results show that a unidirectional causality from capital stock and energy consumption to output; and from capital stock to trade openness; a bidirectional causality between trade openness and output; and absence (neutrality) of any causality between financial development and output thus indicating that these two variables evolve independent of each other.

Contents

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1. Introduction

South Africa is an upper middle-income country and the second largest African economy behind Nigeria with a gross national income per capita of US$ 7190 in 2013. South Africa is part of the South African Customs Union (SACU) which comprises of Botswana, Lesotho, Namibia and Swaziland. Services are critical to the diversification of the SACU economies. The population size stands at about 53 million. Services accounts for 68.4% of South Africa's GDP, the manufacturing and mining sector for 22% and agriculture for 2.6% [101].

After the breakdown of the apartheid regime and ending of the economic sanctions of the USA and European Union in the middle of the 1990s, South Africa's gross domestic product has tripled since 1996. Nevertheless, the income inequality in South Africa is very large as noted from the Gini-coefficient of 0.631 in 2009. This is partly explained by the high unemployment rate which is around 25% (2012) [101] or 33% including discouraged workers [98]. Additionally, the average income of a non-white citizen is much lower than the average income of white citizens. According to Leibbrandt et al. [51], citizens with Asian background earned on average only 60% of the average income of a white person in 2008, black citizens only 13% and colored citizens only 22% of the average income of a white person. According to the World Bank [101] some 31% of the population has less than $ PPP 2 per day in 2009. On the other hand, the 40% top income earners received 84.5% of the total income in 2009. Despite that the GDP per capita increased by just 30% since the late 1990s, those below the 40th income percentile experienced a significant decline of their market income [98]. Only the provision of social assistance grants prevented them from experiencing a real income decline.

Even though the financial sector of South Africa is relatively well-developed compared to other middle income countries [99], it must be noted that close to a third of the population does not have a bank account and millions have limited access to formal financial services which includes micro and small businesses. Besides the problem of huge income differences, high concentration of financial service providers, a lack of microfinance institutions, and gaps in the regulatory environment pose challenges to financial inclusion. On the one hand, the small and medium enterprises (SMEs) are poised to innovate and expand the export markets in the economy; on the other hand, access of SMEs to credit is constrained. South Africa faces considerable challenges in financial inclusion, particularly caused by the uneven access to and use of financial services and by the concentrated ownership structure of the banking sector. Other factors such as distance and travel costs, policy induced distortions such as interest rate caps on lending and limitations on competition in the retail payment sector largely explain the weak financial inclusivity.

As a member of the World Trade Organization (WTO) under the specific commitments in the trade in services in the Uruguay round, South Africa made commitments in the insurance and insurance related, banking and other financial services sector. In the banking sector, South Africa's commitments on national treatment specify that natural persons holding deposit accounts in branches of banks not incorporated in South Africa will need to meet the minimum capital requirement. Given that the banking sector is owned by private companies and a sector that is competitive, commitments in this sector are justified.

International trade is very important for South Africa because the trade volume accounts for just over 50% of the GDP [101]. The export value of minerals, fuels and products from the metal sector add up to 50% of the total exports and these products account for some 90% of the export growth between 2007 and 2012 [100]. Additional, a crucial sector of South Africa's economy is the electricity sector, which is wholly state-owned. The state-owned firm Eskom supplies most of the electricity to the South African market (just 95%) and also exports electricity to neighboring countries within the Customs Union (CU). Additionally, South African municipalities and private companies serve the rest of electricity market. Despite this, it must be noted that South Africa suffers since the middle of the 2000 because of rolling blackouts. Eskom seems to be unable to eliminate the lack of capacity.

The electricity/energy sector on the other hand is not committed under the General Agreements on Trade in Services (GATS). This could be a direct result of the state owned interference in the sector which as a result limits market access. However, the rationale for energy being a crucial sector for South Africa's development and its cascading implications for other sectors may be a reason why the state controls this very crucial resource. Against this background, it is apparent that the role of the above-mentioned sectors needs to be explored within the context of its consequent contributions to economic growth. Subsequently, we investigate empirically the impact of energy consumption, trade openness and financial development on the growth and development of South Africa.

A few studies have looked at the nexus between energy consumption [45,65,96], trade openness [58,73] and financial development ([[45,65,31]; and [97]) in the African countries. Although these factors are germane to the growth and development of Africa, prior studies have considered the role of these variables either in isolation or with different methods of assessment, thus resulting in mixed conclusions [73]. For instance, Kumar and Kumar [44] support the energy-led growth hypothesis in South Africa and Kenya; Kumar [45] looks at the role of financial development and remittances on output in the Sub-Saharan Africa, and finds that financial development per se does not have any statistically significant impact on output per worker; Menyah et al. [58] looks at 21 African countries (including South Africa) and finds no evidence of finance-led growth and trade-led growth hypothesis in majority of the SSA countries. Polat et al.[73] find mixed results where trade has a negative effect while financial development has a positive effect on the economic growth. In this regard, this paper contributes to the literature in providing another perspective on South Africa's economic growth viz. energy, trade and financial development which closely characterize the booming and transformative economy of South Africa.

We start with the augmented Solow type Cobb–Douglas model [44,47] as the framework of analysis. The paper is motivated by the following stylized facts about South Africa: (1) trade openness plays a critical role in the growth process of the economy, although there are signs of poor performances of exports from the country, (2) the financial sector is reasonably developed, however, there remains a large number of population without complete access to financial services; and (3) energy is an extremely important source of economic growth as it feeds into other productive economic activities. Hence claiming energy as the key source of economic growth besides capital productivity, we extend the model of Kumar and Kumar [44] with trade openness and financial development.

Subsequently, contending the role of energy consumption, we examine the energy elasticity with other critical factors influencing growth – trade openness and financial development, and finally review the causality effects. The study largely benefits from background information and insights provided in a number of studies [65,96,44,45,73]. Briefly, our findings are consistent with Kumar and Kumar [44], Menyah et al [58], and Odhiambo [64], and deviates from Polat et al. [73] and Wolde-Rufael [96]. In summary, the results show that capital per worker, and energy explains a bulk of the economic growth. Trade positively influences the output level, thereby supporting the trade-led growth hypothesis in South Africa. However, we note that it has a negative effect on labor productivity. The rest of the paper is set out as follows. In Section 2, we provide a brief literature survey. In Section 3, we discuss the framework, data, method and results. Finally in Section 4, some concluding remarks follow.

2. A brief literature survey

There are a huge number of studies exploring the nexus between energy, trade openness, financial development and economic growth. To motivate our paper, we briefly mention a few.[1]

2.1. Energy and growth

When considering the nexus between energy and economic growth, the findings from studies converge to one of the four hypotheses. According to Payne [69] the energy-growth causality can be divided into (1) the growth hypothesis; (2) the conservation hypothesis, (3) the neutrality hypothesis; and (4) the feedback hypothesis. The growth hypothesis supports a unidirectional causality from energy consumption to economic growth; the conservation hypothesis supports unidirectional causality from economic growth to electricity consumption; (3) the neutrality hypothesis supports absence of any causal relationship between electricity consumption and economic growth; and (4) the feedback hypothesis supports a bidirectional causation between energy consumption and growth.

Evidence supporting the growth hypothesis includes: Stern [89,90] for the US, Erol and Yu [21] for Japan, Masih and Masih [56] for India and Indonesia, Glasure and Lee [28] for Singapore, Soytas and Sari [87] for Turkey, France, Germany and Japan, Wolde-Rufael [94] for Shanghai, Lee [50] for eighteen developing countries, Odhiambo [63] for Tanzania, Odhiambo [64] for South Africa and Kenya, Kumar and Kumar [44] for South Africa and Kumar et al. [46] for Gibraltar.

The studies supporting the conservation hypothesis dates back to Kraft and Kraft [43] which examine the US economy and find a unidirectional causality from income to energy. Many other similar studies followed. Among these include: Abosedra and Baghestani [2] for the US and Soyta and Sari [87] for South Korea, Erol and Yu [21] for West Germany, Masih and Masih [56] for Indonesia, Soytas and Sari [87] for Italy, Oh and Lee [67] for South Korea, Wolde-Rufael [95] for of the African countries, Narayan and Smyth [60] for Australia, Lee [49] for France, Italy and Japan, Huang et al. [36] for middle income groups (lower and upper middle income groups) and high income group countries, and Odhiambo [63] for Congo (DRC), and Kumar et al. [47] for Albania, Bulgaria, Hungary and Romania.

Studies that support the neutrality hypothesis are Yu and Hwang [103], Erol and Yu [21] for the case of the US, Masih and Masih [56] for Malaysia, Singapore and Philippines, Glasure and Lee [28] for South Korea (based on the standard Granger causality), Soytas and Sari [87] for nine countries including the US, Asafu-Adjaye [7] for Indonesia and India, Altinay and Karagol [6] for Turkey, Wolde-Rufael [95] for eleven African countries (including Kenya and South Africa), Lee [49] for the UK, Germany and Sweden, Soytas and Sari [88] for China; and Huang et al. [36] for low income group countries.

Quite a few studies support the feedback hypothesis. Among these are: Erol and Yu [21] for Japan and Italy, Masih and Masih [56] for Pakistan, Glasure and Lee [28] for South Korea and Singapore, Soytas and Sari [87] for Argentina, Ghali and El-Sakka [25] for Canada, Oh and Lee [68] for Korea, Wolde-Rufael [95] for Gabon and Zambia, Lee [49] for the US, and Mahadevan and Asafu-Adjaye [55] for energy exporting developed countries. Shahbaz et al [83] investigate the relationship between energy use and economic growth by incorporating financial development, international trade and capital in case of China over the sample period 1971–2011, and find all variables including energy use have a positive impact on economic growth. In another study, Shahbaz et al [82] examine a similar relationship in case of Indonesia using quarterly data and find that economic growth and energy consumption increase while financial development and trade openness reduce the CO_2 emissions, respectively. Polat et al. [73] examine the link between financial development, trade openness and economic growth in South Africa and find financial development has a negative but not-statistically significant association in the short-run and a positive association in the long run. Aïssa et al. [1] in using panel data examine the relationship between renewable energy consumption, trade and output of 11 African countries (Algeria, Gabon, Mauritius, Swaziland, Comoros, Ghana, Morocco, Tunisia, Egypt, Kenya, and Sudan) over the period 1980–2008 and find inter alia, that in the long run, renewable energy consumption and trade (measured by exports and imports) have a statistically significant and positive impact on output.

2.2. Trade openness and growth

The question of whether trade promotes economic growth gain greater attention after the seminal article by Romer [79], paving way to further insightful contributions in the literature ([10,32,33,77,78]; Young, 1991; Taylor, 1993; [9,92,76]). More recent literature includes the work of Connolly (2000), Howitt [35], Acemoglu et al. [3], Galor and Mountford [24], Wacziarg and Welch [93], and Coe and Helpman [17]. Chang and Mendy [15] examine the effects of trade policies on economic growth in 36 African countries (including South Africa) over the period 1980–2009. Their results show that openness in trade and investment is statistically significant and positively related to economic growth. In general, there is consensus that trade promotes economic growth. According to Yenokyan et al. [102], trade influences economic activities through two channels: an aggregate scale effect and technology transfer. The scale effect is realized from trade openness which results in increase in firms' size and subsequently leads lower average costs and hence increased output per firm. The technology transfer channel arises as a result of knowledge spill-over which is brought about as countries develop the infrastructure such as communications to facilitate greater trade activities. Jouini [39] examines the links between international trade and economic growth in GCC (Gulf Cooperation Council) member countries over the sample period 1980–2010. The results

[1] Please note that the list of studies mentioned here are not exhaustive. Given space limitations, we record only a few. Notably, recent literature on economic growth studies now considers the role of energy with other relevant and contemporary drivers such as trade and financial development.

show that economic growth responds positively to trade openness both in the short-run and the long-run.

2.3. Financial development and growth

The literature on financial development and economic growth dates back to at least Schumpeter [81], Goldsmith [29], McKinnon [56], Shaw [85] and Levine [54] which resonates the unequivocal fact that financial sectors (can be) are pivotal in reallocating and mobilizing resources to most productive investments, diversifying risks and supporting growth of other sectors and subsequently being the engine of economic growth. Moreover, the discussion on financial and banking sector development has been linked to the advancement of technology and the need for stable sources of capital inflows for the sector to realize expansion in credit. Often, three indicators are used to assess financial development. These include: bank credit to the private sector as a percent of GDP, turnover rate of stock market or value of shares traded as a percent of GDP, and the extent of shareholder and creditor protection as part of the legal or regulatory characteristics of a financial system [41,42,52].

It is argued that greater financial depth measured by the ratio of financial asset to income is associated with higher levels of productivity and thus per capita income. Financial systems serve multiple objectives in expediting economic activities—they produce information ex ante about possible investments; mobilize and pool savings and allocate capital; monitor investments and exert corporate governance after providing finance; facilitate the trading, diversification and management of risk; and ease the exchange of goods and services ([12]; Greenwood and Jovanovic, 1990; [41,42,52,57,53]). Greater accessibility of financial services to more individuals spreads out risk, which in turn boosts investment activity in both physical and human capital, thus supporting output growth.

A number of research shows a positive relationship between economic growth and financial development ([16,41,42,61]; Rosseau and Wachtel, 1998; [84,37,70]). On the hand, some studies have shown that financial development does not support economic growth. Hassan et al. [34] find that there has been a positive association between finance and economic growth for developing countries but contradictory results for high-income countries. The consensus of various other studies is that there is a positive correlation between financial development and economic growth despite mixed views on the direction of causality between the two ([40,65]; Savvides, 1995).

In regards to studies pertaining to SSA, Ghirmay [27] explores the causal link between financial development and economic growth in 13 SSA countries and find a unidirectional causation from financial development to economic growth for in 8 countries and bi-directional causation for 6 countries, hence concluding that African countries can accelerate economic growth by improving financial systems. Agbetsiafa [4] examines the causality nexus between financial development and economic growth for 8 SSA countries including South Africa over the sample 1963–2001. The results show a unidirectional causation from financial development to economic growth in Ghana, Nigeria, Senegal, South Africa, Togo and Zambia and a bi-directional causality in Kenya and Zambia.

Odhiambo [62] investigates the direction of causality between financial development and economic growth for Kenya, South Africa and Tanzania, and finds that the direction of causality is sensitive to the choice of measurement for financial development. Wolde-Rufael [97] reports a bi-directional causality between economic growth and financial development in Kenya. Gries et al. [31] find a weak causal link between financial depths and economic growth and find evidence of finance-led growth in Rwanda, Sierra Leone, and South Africa; bidirectional causation for Nigeria and Senegal; a reverse causation (growth to financial development) for Cameroon, Ghana, and Madagascar. Furthermore, they find finance causes openness for Gabon, Kenya, Nigeria and Sierra Leone; and trade openness causes finance for Ghana, Madagascar, and Rwanda; and bidirectional causation for Burundi, Mauritius, Senegal and South Africa. Ahmed and Wahid [5] examine the relationship between financial structure and economic growth in for seven African countries (Botswana, Cote d'Ivoire, Ghana, Kenya, Mauritius, Nigeria and South Africa) and they find presence of causality running from financial activity to economic growth in Kenya, Nigeria, and South Africa; and a reverse causation in Mauritius and South Africa. Moreover, they also find that the financial structure (index based on the ratio of stock market total value traded and capitalization to private credit) caused income in Cote d'Ivoire, Mauritius and South Africa.

Fowowe [23] examines the causal relationship between financial development and economic growth for 17 SSA countries and finds a homogeneous bi-directional causality between financial development and economic growth. In contrast, Demetriades and James [19] examine 18 SSA countries for 1975–2006 and find bank liabilities in Sub-Saharan Africa are follow (but not lead) economic growth and the link between bank credit and growth is altogether absent. However, Chang and Mendy [15] find a negative association between domestic savings on growth in Africa and highlight the need to improve the current financial markets to ensure better utilization of resources. Menyah et al. [58] find a unidirectional causality running from financial development to economic growth in Benin, Sierra Leone and South Africa, and a reverse causality from economic growth to financial development is noted in Nigeria; and a bi-directional causality for Zambia; a unidirectional causality running from financial development and trade is noted in Burundi, Malawi, Niger, Senegal and Sudan, and a reverse causality in Gabon; a unidirectional causation from trade to economic growth is noted in Benin, Sierra Leone and South Africa; and a reverse causality is noted in Kenya and Madagascar, and a bi-directional causation for Gabon.

3. Framework, data, method and results

3.1. Framework

The modeling framework follows the extended Cobb–Douglas type production function with insights from Solow [86] and used in Kumar and Kumar [44] and Kumar et al. [47]. In this model, the per worker output (y_t) equation is defined as

$$y_t = A_t \; k_t^{\alpha}, \alpha > 0 \tag{1}$$

where A=stock of technology and k=capital per worker, and α is the profit share. The Solow model assumes that the evolution of technology is given by

$$A_t = A_o e^{gT} \tag{2}$$

where A_{o0} is the initial stock of knowledge and T is time.

The time variant technology is ‘unpacked’ and defined to include energy, trade openness and financial development. Hence

$$A_t = f(eng, \;\; trd, \;\; crd) \tag{3}$$

where *eng* refers to energy consumption per capita, *trd* refers to trade openness measured by the sum of imports and exports as a percent of GDP, and *crd* refers to financial development which is proxied by domestic credit to private sectors as a percent of GDP [66]. The effects of *eng, trd and crd* on total factor productivity (TFP) can be captured when these variables are entered as shift variables into the production function. This idea of adding the shift variables (besides capital and labor) was developed by Rao [75]. Subsequently

$$A_t = A_o e^{gT}\ eng_t^{\beta}\ trd_t^{\theta}\ crd_t^{\gamma} \tag{4}$$

and

$$y_t = \left(A_o e^{gT}\ eng_t^{\beta}\ trd_t^{\theta}\ crd_t^{\gamma}\right) k_t^{\alpha} \tag{5}$$

Eq. (6) is obtained by transforming Eq. (5) into natural logarithm and further simplifying it. This is the equation that would be used to estimate long-run relationship once a cointegration relationship is identified.

$$\ln y = \lambda + \alpha \ln k_t + \varphi \ln eng_t + \theta \ln trd_t + \gamma \ln crd_t + \pi\, TB + \varepsilon_t \tag{6}$$

where λ is the constant, α, φ, θ, and γ denotes the elasticity coefficient of capital per worker ($\ln k$), energy consumption per capita ($\ln eng$), trade openness ($\ln trd$), and financial development ($\ln crd$), respectively, π refers to the coefficient of trend or break period in trend (TB), and ε_t is the error term.

3.2. Data and method

The sample data covers the period 1971–2011. The capital stock data is built using the perpetual inventory method where we use the gross fixed capital formation as a proxy for investment. Hence the capital stock, K_t, is defined as $K_t = (1-\delta)K_{t-1} + I_t$, where δ is the depreciation rate and I_t is the investment in constant US dollars. The labor stock (L_t) is estimated from the average employment to population ratio multiplied by the annual population. We used $\delta = 0.07$ and initial K_0 is set as 1.01 times the 1960 constant GDP.[2] The data on energy use is in kilogram of oil equivalent per capita (eng_t), and the data on gross fixed capital formation (I_t), GDP (Y_t) are in constant 2005 US$; trade openness ($trd_t$) is measured by the sum of exports and imports as a percent of GDP, and financial development (crd_t) is measured as the domestic credit as a percent of GDP. The data is sourced from the *World Development Indicators and Global Development Finance* database [101]. The descriptive statistics and correlation matrix is provided in Table 1. As noted, output per worker is highly and positively correlated with capital per worker (0.61), energy (0.58) and trade openness (0.73), respectively. Notably, the correlation between financial development and economic growth is very small albeit positive (0.08). One argument for this is because although the poor have access to financial services in the form of microloans, they cannot use these loans to support growth as usually is expected. The simple reason is the inequality of income and wealth. In this respect South Africa is according to World Bank [98] one of the most unequal economies, and this prevents the poor from investing in businesses. Using 2011 as a reference year, we note that majority of the citizens earn very low incomes and the economy is suffering from a high degree of inequality with a Gini coefficient of 0.69.[3] Moreover, some 20.2 percent of population live below the food poverty line of 321 ZAR (48 USD) per month (10.2 million people), and on total 45.5% live from less than 620 ZAR (92 USD) per month (all data are from 2011.) Therefore, the banking sector offers the poor only unsecured microloans with high margins, which are profitable for banks, but rarely beneficial for borrowers. Not surprisingly, the majority of these loans are used for consumption purposes or to repay microloans taken out earlier. Moreover, although the ratio of private credits to GDP exceeded 100% since 1992 and reached to 149% in 2013, the household debt to disposable income ratio was just 75% in 2013 [80].[4].

A standard procedure in examining the cointegration (the presence of long-run association), is to check the stationarity properties of the series. It is often the case that the series may suffer from unknown structural breaks due to changes in the economic and political environment, and this is not detected using the conventional unit root tests. Moreover, although the ARDL bounds tests [72] can be applied irrespective of the order of integration, it is important to note that the series are at most integrated of order one. In the presence of a higher order integration, $I(2)$ and above, the computed F-statistics will provide unreliable indicators since the ARDL approach is developed for series with a highest order of integration of one. Moreover, examining the unit root properties provides the maximum order of integration which is important when carrying out the causality assessment. In the standard pair-wise causality assessment, all variables need to be stationary, and using the method proposed by Toda and Yamamoto [91] for non-Granger causality tests, the maximum lag-length is the sum of the highest order of integration and the lag-length chosen by the AIC/SBC criteria for long-run estimation.

To examine the unit root properties, we use the conventional Augmented Dickey Fuller (ADF), Phillips & Peron (PP) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) unit root tests, respectively (Table 2), which duly confirm that the maximum order of integration for each series is one. Moreover, we use the Perron [71] test to detect the unknown single structural break in the series. As noted (Table 3), all variables are stationary at first difference with respective structural breaks in the series.

The maximum lag-length selected for the ARDL estimation for long-run association and short-run dynamics is 2 ($k=2$), which is supported by the majority of the lag selection criteria (LR, FPE, AIC) (Table 4).

3.3. Cointegration results

Next, to examine the long-run association of level variables (cointegration), we use two tests. First, we use the most widely used ARDL procedure [72] (results provided in Table 5) followed by the combined cointegration test (Table 6) proposed by Bayer and Hanck [11]. The latter is a group of cointegration tests of Engle and Granger [20], Johansen [38], Boswijk [13] and Bannerjee et al [8].

The ARDL approach is used because this procedure is relatively simple and recommended for a small sample size [72,26,63]. Since we do not have prior information about the direction of the long-run relationship between output per worker, capital per worker and energy per capita, we construct the following ARDL equations:

$$\begin{aligned}\Delta \ln y_t = {} & \beta_{10} + \beta_{11} \ln y_{t-1} + \beta_{12} \ln k_{t-1} + \beta_{13} \ln eng_{t-1} \\ & + \beta_{14} \ln trd_{t-1} + \beta_{15} \ln crd_{t-1} + \alpha_{10} TB \\ & + \sum_{i=1}^{p} \alpha_{11i} \Delta \ln y_{t-i} + \sum_{i=0}^{p} \alpha_{12i} \Delta \ln k_{t-i} + \sum_{i=0}^{p} \alpha_{13i} \Delta \ln eng_{t-i} \\ & + \sum_{i=0}^{p} \alpha_{14i} \Delta \ln trd_{t-i} + \sum_{i=0}^{p} \alpha_{15i} \Delta \ln crd_{t-i} + \varepsilon_{1t}\end{aligned} \tag{7}$$

$$\begin{aligned}\Delta \ln k_t = {} & \beta_{20} + \beta_{21} \ln y_{t-1} + \beta_{22} \ln k_{t-1} + \beta_{23} \ln eng_{t-1} \\ & + \beta_{24} \ln trd_{t-1} + \beta_{25} \ln crd_{t-1} + \alpha_{20} TB \\ & + \sum_{i=1}^{p} \alpha_{21i} \Delta \ln y_{t-i} + \sum_{i=0}^{p} \alpha_{22i} \Delta \ln k_{t-i} + \sum_{i=0}^{p} \alpha_{23i} \Delta \ln eng_{t-i}\end{aligned}$$

[2] The $\delta = 0.07$ is arbitrarily chosen, so long as the capital per worker exhibits a diminishing returns to scale which is identified through the concavity of the plot of capital per worker.

[3] Countries like Fiji and Germany has a Gini coefficient of 0.428 and 0.30, respectively.

[4] A ratio of 75% is not the problem, but it is a problem that these debts are mostly unsecured loans and that the majority of debtors are extremely poor. According to Bateman (2013), 40% of the workforce's income is spent for repaying debts.

Table 1
Descriptive statistics and correlation matrix.

	ln *y*	ln *k*	ln *eng*	ln *trd*	ln *crd*
Mean	8.5172	9.8604	6.1112	3.9574	4.4522
Median	8.5114	9.8558	6.1122	3.9730	4.2647
Maximum	8.6692	10.1067	6.1780	4.3151	5.0091
Minimum	8.4057	9.5540	6.0642	3.6544	3.8881
Std. dev.	0.0712	0.1120	0.0254	0.1429	0.3694
Skewness	0.4295	-0.3141	0.6736	-0.1007	0.1887
Kurtosis	2.3921	3.6850	3.4453	2.9902	1.3955
Jarque–Bera	1.8920	1.4756	3.4391	0.0694	4.6413
Probability	0.3883	0.4782	0.1792	0.9659	0.0982
ln *y*	1.0000	–	–	–	–
ln *k*	0.6065	1.0000	–	–	–
ln *eng*	0.5813	0.3822	1.0000	–	–
ln *trd*	0.7286	0.2876	0.3611	1.0000	–
ln *crd*	0.0750	0.1960	0.1551	0.2108	1.0000

Notes: ln *y*=log of output per worker (*y*), ln *k*=log of capital per work (*k*), ln *eng*=log of energy consumption (kg) per capita (*eng*), ln *trd*=log of exports+imports as a percent of GDP (eng); ln *crd*=domestic credit as a percent of GDP (*crd*). *N*=41 (1971–2011).

Table 2
Unit root tests results.
Source: Author estimation using Eviews 8.

Variables in log form	[Intercept]		[Intercept and Trend]	
	Level	1st Diff.	Level	1st Diff.
Augmented Dickey Fuller (ADF)				
ln *y*	−0.9242 [1]	−3.9662 [0]***	−0.9202 [1]	−4.0674 [0]**
ln *k*	−1.0809 [3]	−2.0234 [1]	−2.0406 [3]	−1.9156 [1]
ln *eng*	−1.1062 [0]	−5.2246 [0]***	−1.2431 [0]	−5.4159 [0]***
ln *trd*	−1.8961 [0]	−5.7826 [0]***	−1.9298 [0]	−5.1447 [2]***
ln *crd*	−0.2335 [0]	−5.0538 [1]***	−2.5599 [0]	−5.0187 [1]***
Phillips and Peron (PP)				
ln *y*	−0.5177 [2]	−3.9791 [2]***	−0.4577 [1]	−3.9534 [4]**
ln *k*	−2.0651[5]	−1.7597 [1]	−2.1122 [5]	−1.4385 [5]
ln *eng*	−1.1062 [0]	−5.2108 [3]***	−1.4666[1]	−5.3643 [4]***
ln *trd*	−1.9031 [4]	−6.0503 [16]***	−1.9351 [4]	−6.1941 [17]***
ln *crd*	−0.2743 [3]	−4.8178 [5]***	−2.5921 [3]	−4.7502 [5]***
Kwiatkowski–Phillips–Schmidt–Shin (KPSS)				
ln *y*	0.1555 [5]***	0.2978 [2]***	0.1524 [5]*	0.1643 [1]*
ln *k*	0.2602 [4]***	0.2040 [5]***	0.1135 [5]***	0.1965[5]*
ln *eng*	0.1536 [4]***	0.1821 [2]***	0.1297 [4]***	0.0667 [3]***
ln *trd*	0.1872 [4]***	0.1358 [14]***	0.1648 [4]*	0.1382 [15]**
ln *crd*	0.7171 [5]	0.1621 [3]***	0.1422 [4]**	0.1166 [4]***

Notes: The ADF and PP critical values are based on Mackinnon [54] and KPSS are based on Kwiatkowski et al [48]. The optimal lag based on the Akaike Information Criterion for ADF and bandwidth for PP and KPSS are automatically determined by Eviews 8. The null hypothesis for ADF and Phillips–Perron tests is that a series has a unit root (non-stationary) and for KPSS, the series is stationary.

*** 1% level of significance at which the respective series are stationary.
** 5% level of significance at which the respective series are stationary.
* 10% level of significance at which the respective series are stationary.

Table 3
Perron [71] unit root with break.

Variables	Level		First difference	
	PP-stat	T_B	PP-stat	T_B
ln *y*	−3.517	2000	−5.007**	1987
ln *k*	−1.942	2004	−5.543*	1992
ln *eng*	−3.047	2005	−5.720*	2001
ln *trd*	−3.344	1994	−6.177*	1983
ln *crd*	−3.448	1979	−5.519**	1995

Notes: TB=break period.
** Significant at 5% level of significance. All estimations are with trend.
* Significant at 10% level of significance. All estimations are with trend.

$$+\sum_{i=0}^{p}\alpha_{24i}\Delta \ln trd_{t-i}+\sum_{i=0}^{p}\alpha_{25i}\Delta \ln crd_{t-i}+\varepsilon_{2t} \tag{8}$$

$$\begin{aligned}\Delta \ln eng_t = {} & \beta_{30}+\beta_{31}\ln y_{t-1}+\beta_{32}\ln k_{t-1}+\beta_{33}\ln eng_{t-1} \\ & +\beta_{34}\ln trd_{t-1}+\beta_{35}\ln crd_{t-1}+\alpha_{30}TB \\ & +\sum_{i=1}^{p}\alpha_{31i}\Delta \ln y_{t-i}+\sum_{i=0}^{p}\alpha_{32i}\Delta \ln k_{t-i} \\ & +\sum_{i=0}^{p}\alpha_{33i}\Delta \ln eng_{t-i}+\sum_{i=0}^{p}\alpha_{34i}\Delta \ln trd_{t-i} \\ & +\sum_{i=0}^{p}\alpha_{35i}\Delta \ln crd_{t-i}+\varepsilon_{3t}\end{aligned} \tag{9}$$

$$\begin{aligned}\Delta \ln trd_t = {} & \beta_{40}+\beta_{41}\ln y_{t-1}+\beta_{42}\ln k_{t-1}+\beta_{43}\ln eng_{t-1} \\ & +\beta_{44}\ln trd_{t-1}+\beta_{45}\ln crd_{t-1}+\alpha_{40}TB \\ & +\sum_{i=1}^{p}\alpha_{41i}\Delta \ln y_{t-i}+\sum_{i=0}^{p}\alpha_{42i}\Delta \ln k_{t-i} \\ & +\sum_{i=0}^{p}\alpha_{43i}\Delta \ln eng_{t-i}+\sum_{i=0}^{p}\alpha_{44i}\Delta \ln trd_{t-i} \\ & +\sum_{i=0}^{p}\alpha_{45i}\Delta \ln crd_{t-i}+\varepsilon_{4t}\end{aligned} \tag{10}$$

$$\begin{aligned}\Delta \ln crd_t = {} & \beta_{50}+\beta_{51}\ln y_{t-1}+\beta_{52}\ln k_{t-1}+\beta_{53}\ln eng_{t-1} \\ & +\beta_{54}\ln trd_{t-1}+\beta_{55}\ln crd_{t-1}+\alpha_{50}TB \\ & +\sum_{i=1}^{p}\alpha_{51i}\Delta \ln y_{t-i}+\sum_{i=0}^{p}\alpha_{52i}\Delta \ln k_{t-i} \\ & +\sum_{i=0}^{p}\alpha_{53i}\Delta \ln eng_{t-i}+\sum_{i=0}^{p}\alpha_{54i}\Delta \ln trd_{t-i} \\ & +\sum_{i=0}^{p}\alpha_{55i}\Delta \ln crd_{t-i}+\varepsilon_{5t}\end{aligned} \tag{11}$$

According to Bayer and Hanck [11], the combination of the computed significance level (*p*-value) of individual cointegration tests is specified in the Fisher's formulae as

$$EG-JOH = -2[\ln(p_{EG})+\ln(p_{JOH})] \tag{12}$$

$$EG-JOH-BO-BDM = -2[\ln(p_{EG})+\ln(p_{JOH}) + \ln(p_{BO})+\ln(p_{BDM})] \tag{13}$$

where p_{EG}, p_{JOH}, p_{BO}, and p_{BDM} are the p-values of individual cointegration tests, respectively. If the estimated Fisher statistics exceed the critical values of Bayer and Hanck [11], the null hypothesis of no cointegration is rejected. The results (Table 6) supports cointegration at 5% level of significance for Johansen, EG-Johansen, and EG-J-Banerjee-Boswijk and 10% level for EG and Boswijk, respectively.

As noted, in both tests, the results support a cointegration relationship thereby justifying the existence of long-run

Table 4
Lag length selection.

Lag	*LL*	*LR*	*FPE*	*AIC*	*SC*	*HQ*
0	272.8157	–	6.77e−13	−13.8324	−13.4015	−13.6791
1	466.7702	316.4520	9.50e−17	−22.7248	−21.2164***	−22.1881***
2	498.0178	42.7599***	7.48e−17***	−23.0536***	−20.4679	−22.1336
3	520.6657***	25.0312	1.06e-16	−22.9298	−19.2668	−21.6265

Notes: LR: sequential modified LR test statistic, FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, and HQ: Hannan–Quinn information criterion.

*** Maximum statistics to identify the corresponding lag-length.

association between the variables. Notable, from the ARDL cointegration results, it is clear that the long-run association exists between the variables when output per worker is set as the dependent variables ($F\text{-}statistics = 6.1654$), which is significant at 1% level for the sample size of 45 (critical bound = 5.865), and 5% when the sample size is 40 (critical bound = 4.587). It is important to highlight that the critical bounds statistics used are from Narayan [59] which is specifically computed for sample size between 30 and 80 with the intervals of 5. The bounds statistics from Pesaran et al [72] are applicable for a sample size of more than 80. Since our sample size, $n = 41$, and hence $40 < n < 45$, we use the critical bounds of 40 and 45 to make reliable inference on cointegration.

Before presenting the ARDL long-run and short-run results, the diagnostic tests are in order.[5] These tests include: Lagrange multiplier test of residual serial correlation(χ^2_{sc}); Ramsey's RESET test using the square of the fitted values for correct functional form(χ^2_{ff}); normality test based on the test of skewness and kurtosis of residuals(χ^2_n); and heteroscedasticity test based on the regression of squared residuals on squared fitted values(χ^2_{hc}). In what follows (Table 7), we find that the diagnostic test rejects the null hypothesis of the presence of biasness of serial correlation ($\chi^2_{sc}(1) = 0.4878$: $F(1, 28) = 0.3546$), functional form ($\chi^2_{ff}(1) = 1.2984$: $F(1, 28) = 0.9643$), normality ($\chi^2_n(2) = 0.7326$) and heteroscedasticity ($\chi^2_{hc}(1) = 0.0472$: $F(1, 37) = 0.0448$). The CUSUM and CUSUM of squares (CUSUMQ) figures are examined to determine the stability of the parameters of the model (Fig. 1a and b) and as noted, the plots indicate that parameters are stable in the model.

3.4. Regression results – short-run and long-run elasticity coefficients

3.4.1. Short-run results

As noted from the short-run results (Table 8: Panel b), capital productivity has a mixed result ($\Delta \ln k = 2.6998 : t-ratio = 7.4317$, $\Delta \ln k_{t-1} = -0.8671 : t-ratio = -2.8154$), however the net effect is positive (1.8327). As expected, the coefficient of energy consumption per capita is positive ($\Delta \ln eng = 0.2414 : t-ratio = 2.6954$) and significant at 1% level of statistical significance. Moreover, we note a positive and statistically significant coefficient of trade openness ($\Delta \ln trd : t-ratio = 2.7060$). However, the coefficient of financial development is negative ($\Delta \ln crd = -0.0328 : t-ratio = -3.0306$) and significant at 1% level of statistical significance. Notably, the coefficient of the break period dummy has a marginal positive association ($TB_{\geq 2000} = 0.0114 : t-ratio = 1.7016$) indicating the structural changes post 2000 has had marginal albeit a positive contribution to the short-run economic growth. Furthermore, the coefficient of the error-correction term ($ECM_{t-1} = -0.8363 : t-ratio = -4.7273$) is -0.84 and significant at 1% level of significance, thus implying a relatively speedy convergence to the long-run equilibrium. In other words, roughly 84% of the disequilibrium from the previous year's shocks adjusts back to the long-run equilibrium in the current year.

3.4.2. Long-run results

The long-run results (Table 8: Panel a) provides the long-run elasticity coefficients of the key variables. Notably, the capital share is positive and significant at 1% level of statistical significance ($\ln k = 0.4391 : t-ratio = 14.0445$). Moreover, the energy elasticity is positive and significant at 5% level of statistical significance ($\ln eng = 0.2887 : t-ratio = 2.4281$), which implies that a 1% increase in energy consumption is likely to increase the output by 0.29%. Notably, the estimation of the energy elasticity is very close to Kumar and Kumar [44] which find that the long-run elasticity is about 0.34. The plausible reason for a slightly lower elasticity coefficient (0.29) in case of this study is due to the fact that we have included other variables such as trade openness and financial development and hence minimize the issue of omitted variable biasness. As noted, the elasticity coefficient of trade openness is positive ($\ln trd = 0.0519 : t-ratio = 1.866$) and statistically significant at 10% level. Hence, a 1% increase in trade activity (measured by import+exports as a percent of GDP) results in roughly a 0.05% increase of the output per worker. On the other hand, we note that the elasticity coefficient of financial development (measured by domestic credit as a percent of GDP) is negative ($\ln crd = -0.0393$) and significant at 1% level of statistical significance. The negative coefficient indicates that financial development has a marginal growth-impeding effect in the economy. This is plausible in the presence of poor and/lack of allocation of funds to productive economic activities, and poor access of key financial services. Similar to the short-run results, we note that the coefficient of the post-2000 break in series dummy is positive ($TB_{\geq 2000} = 0.0172 : t-ratio = 1.7356$) association with the long-run output level.

While the results mentioned above give some insights into the impact of trade openness, energy, and financial development, they need to be interpreted within caveats. Using the augmented Cobb–Douglas model, where capital per worker is a critical input in the production function to examine the impacts of shift parameters on the output per worker, we note that the long-run coefficient of the capital per worker (capital share) is slightly higher than the stylized value of one-third [74,22]. Although the relatively high capital share is not a problem for an economy which is on its path to growth, the reasons for this can vary. Among some notable reasons include: when the quality of data and the small sample size which makes it difficult to compute the capital stock [14] that can ideally exhibit decreasing returns to scale and thus conform to a desirable steady-state convergence.; when the capital and labor inputs tend to grow at relatively similar rates; when a significant share of the labor force earn its income in the shadow economy; when there is a large number of self-employed persons who earn income from both capital and their own labor [30] thus making it difficult to obtain meaningful measures of income shares. We agree

[5] The ARDL lag estimation results, which precedes the long-run and short-run estimation is not included here. We only provide the diagnostic tests in order to ascertain the robustness of the long-run and short-run estimated results.

that the positive or negative coefficient of financial development is somewhat sensitive to the choice of the proxy used [40,62,66,58].

3.5. The Toda–Yamamoto approach to Granger non-causality test

Next, to give further merit to the cointegration results and the estimations of short-run and long-run results, the Granger causality test using the Toda–Yamamoto [91] approach is carried out. The Toda and Yamamoto [91] provides a method to test for the presence of non-causality irrespective of whether the variables are $I(0)$, $I(1)$ or $I(2)$, not cointegrated or cointegrated of an arbitrary order. In the presence of mixed order of integration, the error-correction method cannot be applied for Granger causality and the standard (pair-wise) Granger causality test will require that all series used are strictly stationary. Hence, opting for the Toda and Yamamoto [91] procedure, the causality model is set-up in the following VAR system:

$$\ln y_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} \ln y_{t-i} + \sum_{j=k+1}^{d\max} \alpha_{2j} \ln y_{t-j} + \sum_{i=1}^{k} \eta_{1i} \ln k_{t-i} + \sum_{j=k+1}^{d\max} \eta_{2j} \ln k_{t-j} + \sum_{i=1}^{k} \phi_{1i} \ln eng_{t-i} + \sum_{j=k+1}^{d\max} \phi_{2j} \ln eng_{t-j} + \sum_{i=1}^{k} \delta_{1i} \ln trd_{t-i} + \sum_{j=k+1}^{d\max} \delta_{2j} \ln trd_{t-j} + \sum_{i=1}^{k} o_{1i} \ln crd_{t-i} + \sum_{j=k+1}^{d\max} o_{2j} \ln crd_{t-j} + \lambda_{1t} \quad (14)$$

$$\ln k_t = \beta_0 + \sum_{i=1}^{k} \beta_{1i} \ln k_{t-i} + \sum_{j=k+1}^{d\max} \beta_{2j} \ln k_{t-j} + \sum_{i=1}^{k} \theta_{1i} \ln y_{t-i} + \sum_{j=k+1}^{d\max} \theta_{2j} \ln y_{t-j} + \sum_{i=1}^{k} \vartheta_{1i} \ln eng_{t-i} + \sum_{j=k+1}^{d\max} \vartheta_{2j} \ln eng_{t-j} + \sum_{i=1}^{k} \nu_{1i} \ln trd_{t-i} + \sum_{j=k+1}^{d\max} \nu_{2j} \ln trd_{t-j} + \sum_{i=1}^{k} \tau_{1i} \ln crd_{t-i} + \sum_{j=k+1}^{d\max} \tau_{2j} \ln crd_{t-j} \lambda_{2t} \quad (15)$$

$$\ln eng_t = \gamma_0 + \sum_{i=1}^{k} \gamma_{1i} \ln eng_{t-i} + \sum_{j=k+1}^{d\max} \gamma_{2j} \ln eng_{t-j} + \sum_{i=1}^{k} \varphi_{1i} \ln y_{t-i} + \sum_{j=k+1}^{d\max} \varphi_{2j} \ln y_{t-j} + \sum_{i=1}^{k} \mu_{1i} \ln k_{t-i} + \sum_{j=k+1}^{d\max} \mu_{2j} \ln k_{t-j} + \sum_{i=1}^{k} \kappa_{1i} \ln trd_{t-i} + \sum_{j=k+1}^{d\max} \kappa_{2j} \ln trd_{t-j} + \sum_{i=1}^{k} \xi_{1i} \ln crd_{t-i} + \sum_{j=k+1}^{d\max} \xi_{2j} \ln crd_{t-j} + \lambda_{3t} \quad (16)$$

$$\ln trd_t = \pi_0 + \sum_{i=1}^{k} \pi_{1i} \ln trd_{t-i} + \sum_{j=k+1}^{d\max} \pi_{2j} \ln trd_{t-j} + \sum_{i=1}^{k} \rho_{1i} \ln y_{t-i} + \sum_{j=k+1}^{d\max} \rho_{2j} \ln y_{t-j} + \sum_{i=1}^{k} \omega_{1i} \ln k_{t-i} + \sum_{j=k+1}^{d\max} \omega_{2j} \ln k_{t-j} + \sum_{i=1}^{k} \psi_{1i} \ln eng_{t-i} + \sum_{j=k+1}^{d\max} \psi_{2j} \ln eng_{t-j} + \sum_{i=1}^{k} \zeta_{1i} \ln crd_{t-i} + \sum_{j=k+1}^{d\max} \zeta_{2j} \ln crd_{t-j} + \lambda_{4t} \quad (17)$$

$$\ln crd_t = \sigma_0 + \sum_{i=1}^{k} \sigma_{1i} \ln crd_{t-i} + \sum_{j=k+1}^{d\max} \sigma_{2j} \ln crd_{t-j} + \sum_{i=1}^{k} \varpi_{1i} \ln y_{t-i} + \sum_{j=k+1}^{d\max} \varpi_{2j} \ln y_{t-j} + \sum_{i=1}^{k} \chi_{1i} \ln k_{t-i} + \sum_{j=k+1}^{d\max} \chi_{2j} \ln k_{t-j} + \sum_{i=1}^{k} \lambda_{1i} \ln eng_{t-i} + \sum_{j=k+1}^{d\max} \lambda_{2j} \ln eng_{t-j} + \sum_{i=1}^{k} \beta_{1i} \ln trd_{t-i} + \sum_{j=k+1}^{d\max} \beta_{2j} \ln trd_{t-j} + \lambda_{5t} \quad (18)$$

where the series are defined in (14)–(18). The null hypothesis of no-causality is rejected when the p-values fall within the desired 1–10% of level of significance. Hence, in (14), Granger causality running from$k$,eng, trd and crd to y, implies$\eta_{1i} \neq 0 \forall i$, $\varphi_{1i} \neq 0 \forall i$,

Table 5
ARDL co-integration results.

Dependent variable	Break period	Computed F-statistic
ln y	$TB_y=1$: 2000-2011	6.1654***, **
ln k	$TB_k=1$: 2004-2011	2.7706
ln eng	$TB_{eng}=1$: 2005-2011	1.3602
ln trd	$TB_{trd}=1$: 1994-2011	0.4176
ln crd	$TB_{crd}=1$: 1979-2011	2.8800
N	Critical Bounds at 1% level	
40	LB=4.763	UB=6.200
45	LB=4.628	UB=5.865
Critical bounds at 5% level		
40	LB: 3.512	UB=4.587

Notes: Critical values for lower bound (LB) and upper bound (UB) are from Narayan [59], Critical values for the bounds test: case IV: unrestricted intercept and restricted trend, p. 1989; $k=4$.

*** Significance at 1% levels with sample size referenced at $n=45$.
** Significance at 5% levels with sample size referenced at $n=40$.

Table 6
Bayer–Hank combines cointegration.

Lag length	EG	Johansen	Banerjee	Boswijk	EG–Johansen	EG–J–Banerjee–Boswijk
$k=2$	−4.348* (0.055)	36.280** (0.025)	−3.243 (0.204)	19.613* (0.054)	13.159**	22.153**

Notes: EG–Johansen critical value at 1%, 5% and 10% equals to 15.845, 10.576 and 8.301; EG–J–Baerjee–Boswijk critical value at 1%, 5% and 10% equals to 30.774, 20.143 and 15.938 respectively.

* 10% level of significance.
** 5% level of significance.

Table 7
Diagnostic tests from the ARDL (1,2,0,1,0) lag estimates.

Test types	LM version	*p*-value	*F* version	*p*-Value
Serial correlation	$\chi^2(1)=0.4878$***	0.485	$F(128)=0.3546$***	0.556
Functional form	$\chi^2(1)=1.2984$***	0.255	$F(1,28)=0.9643$***	0.335
Normality	$\chi^2(2)=0.7326$***	0.693		
Heteroscedasticity	$\chi^2(1)=0.0472$***	0.828	$F(1, 37)=0.0448$***	0.833

Notes:

*** Rejection of null hypothesis of presence of respective test types at 1% level of significance.

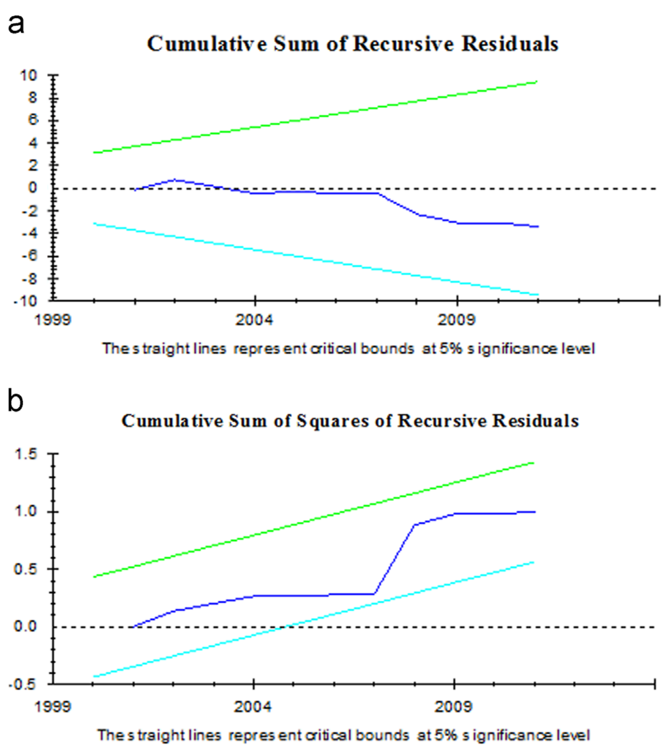

Fig. 1.

$\delta_{1i} \neq 0 \forall i$,and $o_{1i} \neq 0 \forall i$, respectively. Similarly, in (15), *y*, *eng*, *trd* and *crd* Granger causes *k* if $\theta_{1i} \neq 0 \forall i$, $\vartheta_{1i} \neq 0 \forall i$, $\nu_{1i} \neq 0 \forall i$, and $\tau_{1i} \neq 0 \forall i$, respectively; in (16) *y*, *k*, *trd* and *crd* Granger causes *eng* if $\phi_{1i} \neq 0 \forall i$, $\mu_{1i} \neq 0 \forall i$, $\kappa_{1i} \neq 0 \forall i$,and $\xi_{1i} \neq 0 \forall i$, respectively; in (17), *y*, *k*, *eng*, and *crd* Granger causes *trd* if $\rho_{1i} \neq 0 \forall i$, $\omega_{1i} \neq 0 \forall i$, $\psi_{1i} \neq 0 \forall i$, and $\varsigma_{1i} \neq 0 \forall i$, respectively; and finally in (18) *y*, *k*, *eng*, and *trd* Granger causes *crd* if $\varpi_{1i} \neq 0 \forall i$, $\chi_{1i} \neq 0 \forall i$, $\lambda_{1i} \neq 0 \forall i$, and$\beta_{1i} \neq 0 \forall i$, respectively.

From the unit root results (Tables 2 and 3), we note that the maximum order of integration is 1 ($d_{max}=1$), and the optimal lag length (k) chosen is 2 (Table 4). Hence the maximum lags (l) that can be used to carry out the non-causality tests is 3 ($l = d_{max} + k \leq 3$). Hence, we take $l = 2$ and note that this lag-length also ensures that the causality model is dynamically stable, that is, the inverse roots of the AR (auto-regressive) characteristics polynomial lies within the positive and negative unity, $|I_R| \leq 1$. The results are presented in Table 9.

We note a bi-directional causation between trade openness and output per worker ($\ln y \rightarrow \ln trd: \chi^2=10.3198$; $\ln y \leftarrow \ln trd: \chi^2=10.3319$) at 5% level of statistical significance; and a unidirectional causality running from energy per capita to output per worker ($\ln eng \rightarrow \ln y: \chi^2=12.8108$), capital per worker to output per worker ($\ln k \rightarrow \ln y: \chi^2=18.2214$) and capital per worker to trade openness ($\ln k \rightarrow \ln trd: \chi^2=14.6222$) at 1% level of statistical significance, respectively. Subsequently, the causality results indicate a mutually reinforcing (feedback) effect between trade openness and output; capital productivity (investment) and energy per capita cause output [44]; and capital productivity cause trade activities. We do not find any causality between financial development and economic growth and/or trade openness. While our findings show no causality between financial development and trade openness similar to Menyah et al. [58], however, it differs in regard to a unidirectional causality detected in the latter which runs from financial development to economic growth in South Africa. Moreover, our study supports a bi-directional causality between trade openness and output per worker whereas Menyah et al. [58] find a unidirectional causality from trade openness to economic growth. In examining the combined or 'conjoint' effect, we note that the 'combined force' of capital productivity, energy and trade openness jointly cause output per worker ($\ln k \times \ln eng \times \ln trd \rightarrow \ln y: \chi^2=31.2599$); and output per worker and

Table 8
Estimated long run coefficients and error correction representation.

Panel a: Long-run: dependent variable Ly_t				*Panel b: short-run: dependent variable ΔLy_t*			
Regressor	Coefficient	Standard error	*t*-ratio	Regressor	Coefficient	Standard error	*t*-ratio
$\ln k$	0.4391	0.0313	14.0445***	$\Delta \ln k$	2.6998	0.3633	7.4317***
$\ln eng$	0.2887	0.1189	2.4281**	$\Delta \ln k_{t-1}$	−0.8671	0.3080	−2.8154***
$\ln trd$	0.0519	0.0278	1.8669*	$\Delta \ln eng_t$	0.2414	0.0896	2.6954**
$\ln crd$	−0.0393	0.0108	−3.6455***	$\Delta \ln trd_t$	0.0691	0.0256	2.7030**
Constant	2.3626	0.6293	3.7543***	$\Delta \ln crd_t$	−0.0328	0.0108	−3.0306***
$TB_{\geq 2000}$	0.0172	0.0099	1.7356*	*Constant*	1.9759	0.7879	2.5079**
				$TB_{\geq 2000}$	0.0144	0.0085	1.7016*
				ECM_{t-1}	−0.8363	0.1769	−4.7273***
Short-run dynamics test statistics							
R-squared			0.8429	R-bar-squared			0.7941
S.E. of regression			0.0112	*F*-stat. *F*(7, 31)			22.2225
Mean of dependent variable			0.0047	S.D. of dependent variable			0.0247
Residual sum of squares			0.0036	Equation log-likelihood			125.6452
Akaike info. criterion			115.6452	Schwarz Bayesian criterion			107.3274
DW-statistic			2.0864	ARDL(1,2,0,1,0)			*N*=41

Notes:

* 10% level of statsitcal significance.
** 5% level of statsitcal significance.
*** 1% level of statsitcal significance.

Table 9
Granger non-causality test.

Excluded variable	Dependent variable (χ^2)				
	ln *y*	ln *k*	ln *eng*	ln *trd*	ln *crd*
ln *y*	–	5.2225 (0.1562)	1.1090 (0.7749)	10.3198** (0.0160)	0.2279 (0.9730)
ln *k*	18.2214*** (0.0004)	–	4.139675 (0.2468)	14.6222*** (0.0022)	0.6356 (0.8882)
ln *eng*	12.8108*** (0.0051)	4.4232 (0.2192)	–	5.9725 (0.1130)	1.0659 (0.7853)
ln *trd*	10.3319** (0.0159)	4.6915 (0.1958)	1.8896 (0.5956)	–	2.9323 (0.4022)
ln *crd*	2.47238 (0.4803)	1.0864 (0.7804)	3.2295 (0.3576)	5.1129 (0.1637)	–
Combined	31.2599*** (0.0018)	12.9643 (0.3716)	12.4420 (0.4109)	38.4310*** (0.0001)	9.34425 (0.6733)

Notes: df=3; *p*-values are in the parenthesis. Significance within 1–10% level indicates presence of causality.

** 5% level of significance.

*** 1% level of significance.

capital productivity jointly cause trade activities ($\ln y \times \ln y \rightarrow \ln trd : \chi^2 = 38.4310$) at 1% level of significance, respectively.

4. Discussion

Notably, the results presented in the paper resonate with as well as contrasts to with some earlier studies in few respects. For instance, the unidirectional causation running from energy to output is similar to Odhiambo [64] and Kumar and Kumar [44]. Notably, the estimated energy elasticity coefficient is slightly lower than Kumar and Kumar [44] since we included other variables to minimize omitted variable biasness and hence the risk of over-estimating the coefficient. The negative coefficient of financial development contrast to Polat et al. [73] which find relatively high positive coefficient of financial development (0.31) in the long-run and a negative but not statistically significant coefficient in the short-run. Unlike Polat et al. [73] and Menyah et al. [58] which find that financial development cause output, and Odhiambo [64] which find reverse causality, our results show of any such causality between financial development and output. Interestingly, we note a positive coefficient of financial development both in the short-run and the long-run which is contrast to Polat et al. [73] which find a mixed outcome – positive in the short-run and negative in the long-run, with a very low error correction term. We contend that trade is an important part of South Africa's growth and development, and hence research to suss out the impact of trade needs to be assessed with care. At best, our results coincide with regard to financial development and trade openness with some recent studies [19,15].

Additionally, we have to reiterate that the poorest 30% of the population does not actively participate in the financial sector development in South Africa because most of them do not have access to financial services. One argument is that it is except microloans with over-proportional high margins unprofitable for financial institutions to offer their services to the 30% of the poorest citizens. However, we argue that appropriate financial infrastructures such as mobile technology, road and transport services, and soft infrastructures such as financial literacy, regulations, ethics of borrowing, socio-economic importance, culture of saving, etc. can greatly reduce the barriers to financial inclusivity. The weak (and/or missing) links between financial sector and small and medium enterprises therefore may be one of the reasons why financial sector is weakly correlated with and subsequently have negative impact on growth in South Africa despite the fact that the economy is classified as an upper middle income country. Additionally, it must be stated that the private credits to GDP ratio is likely above the level that the financial sector can contribute to growth measured by this indicator. Moreover, we also note that this indicator incorporates the weakness that a too high ratio leads probably to an economic decline rather than to economic growth, which in large part can be due to the credit being channeled into non-income generating and consumption activities, which coupled with growing unemployment, increases the odds of default and wastage of economic resources. A second weakness is generated by the fact that we do not know precisely the purpose or use of these credits. If they are only used for consumption purposes, then the outcome will probably be growth-retarding if not growth-reducing.

Moreover, it is not sufficient that the poor have access to financial services. In addition, the government may consider how the poor citizens can participate in the economic development process of South Africa to reduce the income inequality and ensure that the share of the people who live below the poverty line are given the opportunity to be part of the thriving economic prosperity of South Africa.

With regard to energy, we note that because of the fact that the electricity and energy supply is crucial for South Africa's economy and the fact that the state-governed companies and especially Eskom are not able to guarantee a continuous and sufficient supply of electricity since 2007, policies to re-regulate the market for electricity may need to be re-visited [18]. While being cautious of environmental sustainability, it is equally pertinent to note that excessive energy-electricity conservation policies may tend to have a detrimental impact on the economic growth, and therefore as balance need to be maintained. The potential of clean and eco-friendly solar (green) energy to power up and support economic activities can be looked at. In this regard, the production and consumption of electricity/energy, identifying sources of energy and innovative technologies will require putting science, and research and development at the centre of policy discussion.

Moreover, benefits arising from trade can be exploited through greater partnership with regional members both within SSA and outside (including Brazil, India, and China) whilst ensuring that small and medium enterprises are given the necessary and conducive environment. The role of appropriate institutions to guard property rights and accessibility to and channel of resources including funds to active and potentially promising business firms will be vital.

Improving capital intensity (capital per worker) and labor productivity is becoming a global concern as countries walk towards sustaining growth. South Africa as an emerging and industrializing economy is no exception. Hence, scaling up capital productivity through encouraging and attracting domestic and foreign investment in key sectors and the inclusion of information technology as a conduit of development in major areas of economic activities are critical for sustainable growth. The Government of South Africa may need to review its trade in services commitments in the area of financial sector in so far as global trade is concerned.

Despite the fact that South Africa has made commitments under the positive list approach of the General Agreement on Trade in Services (GATS) at the multilateral forum, however if one scrutinizes the schedule of commitments in the financial sector, it is noted that full commitments are not made under certain modes of supply. Specifically, under the sub-sector of banking and other financial services, South Africa has made partial commitments under certain modes, however, it still has under mode 3 (commercial presence) certain requirements that foreign investors will have to fulfill. For example in order to establish banking firm in the country, the branches of banks not incorporated in the country is required to maintain a minimum capital requirements. In the same vein, the role of financial and technology expansion need to be improved if a scale-up effect is to be materialized from trade and energy intensive sectors. Access to cost effective financial and technological services including digital banking, innovative use of technology in retail and financial services can be some few areas to look at. Moreover, re-visiting and reviewing the South Africa's micro-credit model is imperative. As much as vigilance and proactiveness is required in lending and debt recovery, of equal importance will be to ensure the necessary hard and soft financial and technology infrastructure are in place to ensure the credits are used in income-generating projects. Of course, trade openness and financial development is an important part of economic development. Hence, to ensure sustainability, economic transformations in the economy will require ongoing need to improve trade activities and strengthen international relations, and the need to promote small and medium enterprises, effective use of energy and technology, and financial inclusion.

5. Concluding remarks

This paper set out to explore the role of energy and economic growth whilst examining the role of trade and financial development in the South Africa over the sample period 1970–2011. Furthermore, by including trade openness and financial development, which are critical drivers of economic activity in the emerging market of South Africa, we also minimize the chance of over estimating the energy elasticity. The Perron [71] test is used to control for a single period structural break in series. It is noted that there exists a long-run cointegration between the variables and that capital per worker, energy and trade openness have positive associations with output per worker. We note a bi-directional causation between energy and output. Based on the outcomes, we discuss relevant policy matters.

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