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How to Increase the Growth Rate in South Africa?

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Abstract

Given the concern about the low growth rates in African countries, this paper deals with the issue of how to increase the said growth rates by using South Africa as a case study. This paper attempts to answer this question by examining the determinants of total factor productivity (*TFP*) and productivity growth. We utilise the theoretical insights from the Solow (1956) growth model and its extension by Mankiw, Romer and Weil (1992). Our empirical methodology is based on the London School of Economics Hendry's General to Specific Instrumental Variable method and Gregory and Hansen's (1996a; 1996b) structural break technique. Our findings imply that variables like human capital, trade openness, foreign direct investment, financial efficiency, democracy and financial reforms improves *TFP* and productivity growth in South Africa. Importantly, the key determinants appear to be democracy and financial liberalisation.

Keywords: Solow model; total factor productivity; productivity growth

JEL Numbers: O10; O15

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1. Introduction

Despite the recent global economic turmoil, South Africa remains the economic powerhouse of Africa. The economy dominates the continent in terms of its industrial output and mineral and electricity production. South Africa had a per capita income of US$3764 in 2008 and its average rate of growth of output (*GDP*) from 1967 to 2008 was nearly 3 percent with large fluctuations until the late 1990s. During 1999-08 period, the South African economy experienced tremendous economic expansion, and during this upswing, the average output growth was nearly 4 per cent. Although the level of per capita income is higher than other African countries, its growth rate is very minimal. Based on World Bank data, the average annual per capita income change over the sample period of 1967 to 2008 was just 0.68 per cent. If South Africa wishes to double its per capita income over the next 25 years, this rate needs to be increased to at least 2.8 per cent.[2] To this end, the issue at hand is how to increase the growth rate in South Africa? This paper attempts to answer this question by examining the determinants of total factor productivity (*TFP*) and productivity growth in South Africa. We utilised the theoretical insights from the Solow (1956) growth model and its extension by Mankiw, Romer and Weil (1992).[3]

The pioneering works on growth by Solow (1956; 1957) have produced immense interest on examining the determinants of growth in an economy. In the neoclassical growth model (*NCGM* henceforth) of Solow (1956), factor accumulation can only explain about half the variations in the growth rate. What remains, known as the Solow residual, is attributed to the growth in technical progress or *TFP*. In many empirical studies, *TFP* is captured with a trend variable, however strictly speaking, it is not known what factors determine *TFP* and this is our measure of ignorance of the determinants of growth. Empirically, specifications with a significant trend signify that the unknown determinants of growth are trended.

Subsequently, various frameworks have been developed to analyse the key determinants of *TFP*. A ground breaking study by Mankiw, Romer and Weil (1992) (*MRW* henceforth) have

[2] Similarly, it can also be said that if the current rate of increase of per capita income continues, it will take South Africa 102 years to double its per capita income to $7528 (constant 2000 US$).

[3] Many studies have used these frameworks to analyse the determinants of growth, for instance see Rao (2010) for Asian countries, Rao and Rao (2009) for Fiji, Rao and Tamazian (2010) for India, Rao and Hassan (2010) for Bangladesh and Rao and Vadlamannati (2010) for African countries.

extended the Solow model by integrating an explicit process of human capital accumulation. In this framework, they have derived a convergence equation relating the increments of output to investment rates for both physical and human capital. A similar approach was also taken by Casseli (2004) and Young (1995). The recently developed endogenous growth models (*EGM* henceforth) of Romer (1986), Lucas (1988) and Barro (1991, 1999) have also attempted to explain the key determinants of growth. In our view, both the *EGM* and extended Solow model of *MRW* offer significant insights for *TFP,* however from an empirical viewpoint the former model requires a long sample size and are therefore more relevant for cross sectional and panel data analysis where the number of observations is ample. Further, country specific time series models based on the *EGMs* are complicated to estimate and need non-linear dynamic econometric methods; see Greiner, Semler and Gong (2004).[4]

This paper is organised as follows: Section 2 provides a brief review of the relevant studies on *TFP* and productivity growth in Africa. Section 3 and 4, respectively, details the model specification and empirical results. Section 5 concludes.

2. Brief Literature Review

Several studies have examined the output gap (i.e. capacity utilisation), rather than *TFP* or growth determinants for South Africa. In light of the history and structural properties of the South African economy, it is important to understand the variations in the output gap and employment. However, our study focuses on the determinants of *TFP* and growth, and as such Table 1 summarises the key findings of a few recent empirical studies related to *TFP* in African countries.

Utilising the panel data estimation methods, Bjurek and Durevall (1998) estimated the *TFP* growth rates for 31 different manufacturing sectors for Zimbabwe over the period 1980 to 1995. They found that there was no growth in *TFP* during the period of structural adjustment

[4] Solow (2000), Parente (2001) and Easterly, Levine and Roodman (2004) also noted some practical problems of the *EGMs*.

Table 1: Studies on Total Factor Productivity in Africa

Study	Country	Period/ Methodology	TFP Determinants	Other Findings
Bjurek and Durevall (1998)	Zimbabwe	1980-1995/ Panel data regressions	Growth in imports (+ve), growth in foreign aid (+ve), inflation growth (-ve), foreign business cycle lagged 1 period (-ve) and rainfall (+ve)	Positive correlation between mark-up and productivity
Jonsson and Subramanian (2001)	South Africa	1970-1997/ JML	Tariffs (-ve) and capital intensive sectors (+ve)	Trade liberalisation significantly augments long-run growth
Onjala (2002)	Kenya	1960-1995/ OLS	Agricultural sector (+ve) and manufacturing sector (+ve)	Lack of evidence to support the link between *TFP* growth and trade policy
Arora and Bhundia (2003)	South Africa	1980-2001/ JML	Trade openness (+ve) and share of private investment (+ve)	Significant increase in growth of real GDP post-apartheid
Du Toit, Koekemoer, and Ground (2004)	South Africa	1970-2000/ Kalman filter	R&D expenditure (+ve), patents (+ve), trade openness (+ve), international position index (+ve) and number of science and engineering graduates (+ve)	South Africa exhibited decreasing returns to scale with respect to capital and labour inputs
Aghion, Braun and Fedderke (2006)	South Africa	1970-2004/ Panel data regressions	Competition policy (+ve)	A reduction of mark-ups have positive effects on employment in South Africa
Fedderke and Bogetic (2006)	South Africa	1970-2000/ Panel data regressions	R&D expenditure (+ve), net exports (+ve), increased industry concentration (-ve) and infrastructure measures (+ve)	Infrastructure is vital for growth, both directly (labour productivity) and indirectly (*TFP*)
Akinlo (2006)	34 Sub-Saharan African countries	1980-2002/ Cross sectional regressions	Extertnal debt (-ve), inflation rate (-ve), agricultural value added-GDP ratio (-ve), lending rate and local price deviation (–ve), human capital (+ve), export-GDP ratio (+ve), credit (+ve), FDI-GDP ratio (+ve), manufacturing value added-GDP ratio (+ve) and liquid liabilities-GDP ratio (+ve)	The Sub-Saharan African countries should allow for greater openness
Ogunleye and Ayeni (2008)	Nigeria	1970-2003/ JML	Export growth (+ve)	The Granger causality support causality in both ways between export growth and *TFP*
Mugume and Anguyo (2009)	Uganda	1987-2008/ GETS	Government expenditure on infrastructure (+ve), terms of trade (+ve), reforms (+ve) and inflation (-ve)	External shocks are vital in explaining growth

Notes: *JML, OLS* and *GETS* means Johansen maximum likelihood, ordinary least squares and general to specific, respectively. The signs +ve and –ve, respectively, implies that the variables have positive and negative impact on *TFP*.

program (1991-1995). Overall, their findings imply that growth of imports, foreign aid, rainfall and mark-ups have a positive impact on *TFP* in Zimbabwe. Jonsson and Subramanian (2001) used the Johansen's maximum likelihood (*JML*) method to estimate the dynamic gains from trade for South Africa over the period 1970-1997. They asserted that trade liberalisation has contributed significantly to South Africa's long run growth potential via its impact on *TFP* growth.[5] Other studies on the South African economy seem to support that several macroeconomic variables are useful for *TFP* growth.[6] For instance, Arora and Bhundia (2003) found that trade openness and share of private investment are the key determinants of *TFP* in South Africa. Du Toit, Koekemoer and Ground (2004) asserted that *TFP* growth is positively influenced by R&D expenditure, patents, trade openness, international position index and number of science and engineering graduates. More recently, Aghion, Braun and Fedderke (2006) and Fedderke and Bogetic (2006) used panel data estimation methods to analyse the *TFP* for South Africa. While Aghion, Braun and Fedderke (2006) found that product market competition is beneficial for *TFP* growth, Fedderke and Bogetic (2006) attained a number of factors that stimulate *TFP* amongst which infrastructure seems to have both direct and indirect impacts on the long run growth.

For the Kenyan economy, Onjala (2002) examined the link between trade policy and *TFP* for the period 1960-1995. His Ordinary Least Squares (*OLS*) estimates of *TFP* showed that *TFP* growth contributed more to agriculture, than to the manufacturing sector. Moreover, he found inconsistent evidence to support the link between *TFP* growth and trade policy. Ogunleye and Ayeni (2008) estimated the link between *TFP* and export growth for Nigeria over the period 1970-2003. By utilising the *JML* method, they attained a significant positive relationship

[5] In particular, the capital intensive sectors of production lift the *TFP* growth while tariffs are detrimental.

[6] There are a few studies that examined other aspects of growth in South Africa. For instance, Du Toit and Moolman (2003) proposed a measure of potential output and output gap (capacity utilisation) and their impact was analysed in an extended supply-side model of the South African economy. Their results for potential output imply that the potential for the South African economy to grow is seemingly deteriorating due to rising labour costs and a continuous increase in unemployment. Arestis, Luintel and Luintel (2005) found that the financial sector has a significant impact on real per capita output in South Africa. More recently, Bonga-Bonga (2009) asserted that the Cobb-Douglas specification outperforms the Constant Elasticity of Substitution specification in-sample as well as out-of-sample in forecasting the aggregate production function in South Africa for the period 1970-2006.

between *TFP* and export growth. The Granger causality tests imply that there is a bi-directional causality between *TFP* and export growth. A similar conclusion was made by Haddad et al. (1996) for Morocco except that causality is only from export growth to *TFP*.

Mugume and Anguyo (2009) employed the General to Specific (*GETS*) method to estimate the *TFP* function for Uganda over the period 1987-2008. They argued that government expenditure on infrastructure, terms of trade and reforms have increased the *TFP*. Using a cross sectional method and data from 1980-2002, Akinlo (2006) estimated the determinants of *TFP* for 34 Sub-Saharan African countries. His results suggest that human capital, export-GDP ratio, credit to the private sector, manufacturing development, foreign direct investment and liquid liabilities have a significant positive effect on *TFP*.[7] However, inflation rate, population growth, lending rate and local price deviation from purchasing power parity and the share of agricultural value-added-GDP ratio have negative effects on *TFP*.

Although these and other earlier empirical studies offer significant insights on African economies economic performance, their empirical approach is equivocal. First, most studies used standard cross sectional, time series or panel data techniques but failed to consider structural changes in the cointegrating vector. Since the early 1980s many countries, including South Africa, have undergone significant structural changes and, therefore, it has become necessary to test for structural breaks in cointegrating relationships. Second, many existing empirical studies contain a short sample period and this may significantly distort the power of the standard tests and lead to misguided conclusions. Therefore our paper partly fills these gaps in the empirical literature by utilising updated data for South Africa over the period 1967-2008. We shall examine the structural changes in the long run output function using the Gregory and Hansen (1996a; 1996b) method. Further, we apply the London School of Economics (*LSE*) Hendry's General to Specific Instrumental Variable method to estimate the productivity growth equations. It is well known that this method addresses the endogeneity bias and captures the dynamic adjustments efficiently.

[7] Similarly, Tahari et al. (2004) argued that good quality institution, human capital development, a favourable macroeconomic policy environment, trade liberalisation, and diversification of the economic base from agriculture to manufacturing and services can positively influence *TFP* growth in Sub-Saharan Africa.

3. Model Specification

The traditional macro framework employed in time series studies is the Solow growth model. Under this setup, the rate of growth of output, in the non-steady state, depends on the rates of growth of factors of production (capital and labour) and the technology residual. Therefore assuming constant returns to scale, we specify the Cobb-Douglas production function as follows:

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \quad (1)$$

Take the logs of the variables in (1) to get:

$$\ln Y_t = \ln A_t + \alpha \ln K_t + (1-\alpha)\ln L_t \quad (2)$$

The per worker output can be expressed as:

$$\ln(Y/L)_t = \ln A_t + \alpha \ln(K/L)_t \quad (3)$$

where Y is output, A is stock of knowledge, K is stock of capital, (Y/L) is per worker output, (K/L) is per worker capital stock and L is labour force. The variable of interest is the per worker income y^*. The steady state output per worker can be expressed as:[8]

$$y^* = \left[\frac{s}{d+n+g}\right]^{\frac{\alpha}{1-\alpha}} \times A \quad (4)$$

$$\ln y^* = \frac{\alpha}{1-\alpha}\ln\left[\frac{s}{d+n+g}\right] + \ln A$$

where d is depreciation rate, s is proportion of output saved and invested, n is growth of labour force and g is growth of the stock of knowledge.

[8] See Romer (2006) and Sorensen and Whitta-Jacobsen (2005) for derivation of the steady state output per worker.

Several useful inferences can be drawn from the Solow model. First, when the economy is in a steady state mode and the parameters are constant, per worker income will grow at the rate of technical progress. Second, government policies aimed at raising the investment ratio will have only permanent level effects. Any policy that attempts to raise *g* will have growth effects. Third, the Solow model also has informative implications for the convergence hypothesis; see Rao and Hassan (2010) for more details.[9]

4. Empirical Results

4.1 Data and Structural Break Tests

We first test for the time series properties of *Y, K, L,* (*Y/L*) and (*K/L*) with the Augmented Dicky-Fuller (*ADF*) and Elliot-Rothenberg-Stock (*ERS*) tests.[10] Both the tests indicate that the level variables are I(1) and their first differences are I(0). We therefore contend that the level variables are non-stationary and their first differences are stationary. This paper utilises annual data for South Africa over the period 1967 to 2008. Data were obtained from the International Financial Statistics (2010) and World Development Indicators (2010) databases. Definitions of the variables are provided in the Appendix.

Next we applied the Gregory and Hansen (1996a; 1996b) method (*GH* henceforth) to test for cointegration between the variables. The *GH* method tests for the null of no cointegration with structural breaks against the alternative of cointegration. Unlike the Perron (1997) and Bai and Perron (2003) tests, this technique determines breaks endogenously in the cointegrating equation. The four standard models advocated by *GH* are based on different assumptions about structural breaks, for instance, (1) level shift; (2) level shift with trend; (3) regime shift where both the intercept and the slope coefficients change and (4) regime shift where intercept, slope coefficients and trend change. The *GH* results are presented in Table 2.

[9] A key prediction of Solow model is that the income levels of poor countries will tend to catch up with the income levels of rich countries as long as they have similar characteristics; see Rao and Hassan (2010) for a comprehensive discussion.

[10] The unit root test results are not reported to conserve space but can be obtained from the authors upon request.

Table 2: Cointegration tests with structural breaks

ln $(Y/L) = \beta + \alpha\ln(K/L) + \varepsilon$				
	Break Year	***GH* Test Statistic**	**5% Critical Value**	**H_0 of no Cointegration**
(1)	1994	-5.123	-3.53	Reject
(2)	1985	-7.290	-6.67	Reject
(3)	1994	-3.420	-3.53	Accept
(4)	1994	-4.112	-3.53	Reject

The *GH* results imply that there is a long run relationship between per capita output and per capita capital stock. However, the endogenously determined break date in (1) implies that there is a level shift in 1994. The break date in (2) implies a level shift with trend in 1985. The results of (3) are ambiguous because the null hypothesis of no cointegration is not rejected. The break date in (4) is not different from (1) and (3) and this implies a regime shift in which intercept, trend and slope coefficients change. In light of the developments in the South African economy, we argue that these break dates are plausible. A break in 1994 is expected because this may highlight the advent of democracy which improved general economic performance in many ways, for instance, enhanced competitiveness in the markets, increased job creation, development of trade promotion policies, etc. Another break date is 1985 and this is also expected for two reasons. First, this break could be drawing on the impact of the gold market boom in 1980 and second this may represent the implementation of financial reforms. The latter is more plausible because many developing countries, including South Africa, introduced financial reforms during the 1980s. Therefore, we develop two dummy variables, *DUM94* and *DUM85* respectively, to capture the effects of democracy and financial market liberalisation on growth.

4.2 TFP and its Determinants

We utilise Solow's (1957) growth accounting procedure to compute *TFP*. Growth accounting is useful because it breaks growth into components that can be attributed to the growth of factor accumulation and *TFP*. As noted earlier, *TFP* is also called the Solow residual and this is an indication of the level of ignorance with regard to understanding all the determinants of growth. We estimated equation (2) with *OLS* and attained the profit share of output (α) as (0.358). This calculated parameter is next used in the growth accounting exercise to estimate *TFP*, as follows:

$$TFP \equiv \Delta \ln Y - 0.358 \Delta \ln K - (1 - 0.358) \Delta \ln L \qquad (5)$$

During the period 1967-08, average output growth was nearly 3 percent and factor accumulation and *TFP* grew, respectively, at nearly 89 per cent and 11 per cent. During the 1970s, *TFP* growth was negative (nearly -15 per cent) and rapidly increased during the 1980s (nearly 14 per cent). In the decade prior to 1994, output growth averaged less than 1 per cent per year. Since 1999, the average *TFP* has grown by nearly 10 per cent. In all these time periods, factor accumulation has been the major factor for growth in South Africa.

Next we examine the factors that determine *TFP* for South Africa. We have selected 10 potential variables that affect *TFP* which include (with their notation and expected signs in parentheses): foreign direct investment to *GDP* ratio (*FDIY, +ve*), current government spending to *GDP* ratio (*GY, -ve*), *M2* to *GDP* ratio as a proxy for the development of the financial sector (*M2Y, +ve*), remittances by emigrant workers to *GDP* ratio (*REMY, +ve*), trade openness proxied with the ratio of imports plus exports to *GDP* (*TO, +ve*), carbondioxide emissions (ln*CO2, -ve*), index of human capital (*H, +ve*), two dummy variables (*DUM94, +ve* and *DUM85, +ve*) to capture the effects of democracy and financial reforms, respectively and time trend (*T*) to capture the effects of other trended but ignored variables which may have positive or negative effects. The *ADF* and *ERS* unit root tests for these variables indicated that they are I(1) in levels.[11]

The cointegrating equations of *TFP* are estimated with *OLS* and the results are reported in Table 3. Our objective is to determine which of the aforementioned 10 variables have a significant impact on *TFP*. First we estimated the *TFP* function without *DUM95* and *DUM85* and the result is presented in column (1) of Table 3. Here all the estimated coefficients are significant at the 5% level, except *TO*, *FDIY* and *M2Y*. The estimated variables also have the expected signs. Second, when *DUM94* was added, *TO* and *FDIY* became significant at the 5% level, see column (2). The estimates of *FDIY* have also increased mildly. Column (3) introduced *DUM85* and excluded *DUM95*. While the estimates of financial efficiency (*M2Y*) became significant, *TO* and *FDIY* estimates became insignificant at the 5% level. Column (4)

[11] The *ADF* and *ERS* unit root test results for potential variables are not reported to conserve space but can be obtained from the authors.

incorporates both the dummy variables, *DUM94* and *DUM85*, with all other explanatory variables and all the estimates are significant at the 5% level. There are three important implications from these findings. First, democracy and financial reforms are necessary to improve *TFP*. Second, policy makers should focus on policies that enhance human capital, trade openness, foreign direct investment and financial efficiency because these variables also increase *TFP*. Third, the government should attempt to reduce carbon dioxide emissions because this seems to have a significant negative impact on *TFP*.

Table 3: Determinants of TFP

	(1)	(2)	(3)	(4)
Intercept	-0.014 (3.19)*	-0.040 (4.51)*	0.286 (2.17)*	0.254 (1.75)**
T	0.012 (5.35)*	0.015 (3.59)*	0.010 (3.62)*	0.011 (1.83)**
TO_t	0.227 (1.88)**	0.228 (3.86)*	0.302 (1.70)**	0.295 (4.76)*
$\ln H_{t-1}$	0.411 (2.42)*	0.525 (2.61)*	0.440 (3.42)*	0.453 (3.40)*
$FDIY_{t-1}$	0.434 (1.34)	0.654 (3.93)*	0.349 (1.21)	0.380 (4.76)*
$FDIY_{t-2}$	0.280 (1.20)	0.550 (4.38)*	0.163 (0.98)	0.218 (5.17)*
$\ln CO2_{t-2}$	-0.495 (2.77)*	-0.546 (3.02)*	-0.441 (3.93)*	-0.417 (3.77)*
$M2Y_t$	0.013 (1.59)	0.014 (1.43)	0.019 (2.58)*	0.019 (2.55)*
$M2Y_{t-1}$	0.109 (1.11)	0.117 (1.33)	0.132 (5.14)*	0.133 (5.11)*
DUM94		0.033 (1.98)*		0.014 (2.64)*
DUM85			0.105 (2.69)*	0.098 (2.35)*
$\bar{R}^2$	0.428	0.484	0.507	0.543
SEE	0.033	0.032	0.029	0.027
$\chi^2(sc)$	0.004 [0.99]	0.073 [0.79]	0.387 [0.53]	0.382 [0.54]
$\chi^2(ff)$	0.203 [0.65]	0.203 [0.65]	0.250 [0.62]	0.196 [0.66]
$\chi^2(n)$	1.722 [0.19]	1.631 [0.20]	0.355 [0.55]	0.023 [0.88]
$\chi^2(hs)$	2.662 [0.10]	2.609 [0.11]	0.013 [0.91]	0.993 [0.32]

Notes: Absolute *t*-ratios are in the parentheses below the coefficients; *p*-values are in the square brackets for the χ^2 tests. Significance at 5% and 10% level, respectively, denoted by * and **.

4.3. Productivity Growth Functions

We shall use the London School of Economics (*LSE*) Hendry's General to Specific (*GETS*) Instrumental Variable method to estimate the productivity growth functions.[12] The implied growth equation based on the cointegration and error correction model (*ECM*) specification using the *GETS* formulation is:

$$\Delta \ln(Y/L)_t = -\lambda[\ln(Y/L)_{t-1} - (\alpha_0 + T + \alpha_1 \ln(K/L)_{t-1} + \alpha_2 Z_{t-1})] + \sum_{i=0}^{n1} \gamma 1_i \Delta \ln(K/L)_{t-i} + \sum_{i=1}^{n2} \gamma 2_i \Delta \ln(Y/L)_{t-i} + \sum_{i=0}^{n1} \gamma 3_i \Delta Z_{t-i} + \varepsilon_t \quad (6)$$

where α_0 is the intercept, T is the trend, λ is the speed of adjustment, Z is a vector of potential shift variables and ε is the error term with the usual classical properties. All equations are estimated with the *GETS* two stage non-linear least squares instrumental variable method to minimise endogeneity bias. The lagged values of the levels and first differences are used as instruments. The productivity growth equations were estimated with a lag structure of 4 periods. These were later reduced to manageable parsimonious versions as reported in Table 4. The dummy variables *DUM94* and *DUM85* are included in all regressions. In Table 4, column (1) provides the estimates of a basic productivity growth model with a trend. The estimate of the share of capital (0.38) is significant and close to the stylised estimate of 0.3. The trend term is highly significant implying that there could be additional (ignored) variables that also affect productivity growth, which are trended. Consequently, we added the variable ln*H* which is the index of human capital in (2) and the estimated coefficients changed only marginally. The significance of the trend term reduced slightly. In equation (3) the human capital index is

[12] We could have used other alternative method such as Stock and Watson's (1993) Dynamic Ordinary Least Squares (*DOLS*), Phillip and Hansen's (1990) Fully Modified Ordinary Least Squares (*FMOLS*) and Johansen's (1991) *JML*, however we think that it is convenient to use the *GETS* specification. We argue that it is not a valid criticism that *GETS* estimates I(0) and I(1) variables together. Hendry repeatedly pointed out that if the I(1) variables are cointegrated then their linear combination is I(0). Furthermore, Banarjee et al. (1993) have shown that the *GETS* approach is equivalent to the *FMOLS*, for more details see also Hendry (1995), Hendry and Doorink (1994), Rao, Singh and Kumar (2010).

Table 4: Determinants of productivity in South Africa (Dependent Variable: Δln(Y/L)$_t$)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	0.323 (3.26)*	0.187 (3.81)*	0.174 (2.58)*	0.976 (4.77)*	0.249 (2.94)*	0.189 (4.05)*	0.319 (3.17)*	0.130 (2.94)*	0.096 (1.15)
T	0.001 (9.81)*	0.009 (8.91)*	0.009 (4.78)*	0.003 (5.42)*	0.001 (5.41)*	0.002 (9.67)*	0.001 (5.56)*	0.001 (10.45)*	0.002 (7.92)*
λ	-0.323 (3.26)*	-0.274 (2.43)*	-0.270 (2.38)*	-0.250 (2.20)*	-0.331 (2.54)*	-0.306 (3.13)*	-0.318 (3.17)*	-0.324 (3.76)*	-0.209 (2.76)*
$\ln(K/L)_{t-1}$	0.380 (7.39)*	0.343 (5.34)*	0.357 (5.05)*	0.353 (9.45)*	0.372 (2.41)*	0.425 (5.74)*	0.401 (3.45)*	0.395 (6.57)*	0.383 (4.84)*
$\ln H_{t-1}$		0.312 (3.73)*							
$\ln(L\text{x}H)_{t-1}$			0.330 (7.67)*						
TO_{t-1}				0.015 (4.83)*					
$REMY_{t-1}$					0.584 (1.13)				
$FDIY_{t-1}$						0.235 (2.38)*			
$M2Y_{t-1}$							0.002 (2.68)*		
GY_{t-1}									-0.042 (1.15)
$\ln CO2_{t-1}$								-0.058 (1.85)**	
$\Delta\ln(Y/L)_{t-1}$	0.414 (2.43)*	0.352 (1.99)*	0.354 (1.98)*		0.114 (1.78)**		0.398 (2.30)*	0.414 (2.50)*	
$\Delta\ln(K/L)_t$	0.370 (3.25)*	0.376 (4.34)*	0.375 (3.24)*	0.399 (4.00)*	0.369 (5.08)*	0.369 (8.25)*	0.364 (6.50)*	0.387 (8.81)*	0.383 (2.81)*
$\Delta\ln(K/L)_{t-1}$	-0.141 (2.06)*	-0.116 (1.66)**	-0.117 (1.69)**			0.068 (2.37)*	-0.132 (1.87)**	-0.133 (2.04)*	
$\Delta\ln(K/L)_{t-2}$					0.034 (2.47)*				
$\Delta\ln(K/L)_{t-3}$					0.34 (1.67)**				
ΔTO_{t-1}				-0.015 (3.93)*					
$\Delta REMY_t$					1.771 (2.37)*				
$\Delta FDIY_t$						0.107 (2.51)*			
ΔGY_{t-1}									-0.045 (4.39)*
DUM94	0.024 (2.01)*	0.031 (2.36)*	0.033 (2.40)*	0.029 (3.02)*	0.027 (1.67)**	0.028 (2.34)*	0.037 (2.05)*	0.030 (2.36)*	0.027 (2.55)*
DUM85	0.015 (1.98)*	0.022 (2.53)*	0.022 (2.64)*	0.025 (2.88)*	0.029 (1.74)**	0.019 (2.65)*	0.017 (1.98)*	0.020 (2.98)*	0.018 (2.65)*
$\bar{R}^2$	0.914	0.918	0.917	0.937	0.918	0.916	0.913	0.926	0.935
$\overline{GR}^2$	0.857	0.895	0.900	0.915	0.899	0.902	0.887	0.910	0.912
Saragan's χ^2	5.994 (0.112)	5.768 (0.120)	4.724 (0.218)	1.276 (0.143)	2.844 (0.118)	1.907 (0.166)	3.287 (0.125)	5.024 (0.233)	3.290 (0.176)
SEE	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.002	0.002
$\chi^2(sc)$	0.022 [0.88]	0.006 [0.94]	0.004 [0.95]	1.865 [0.17]	1.172 [0.28]	4.341 [0.14]	0.005 [0.99]	1.366 [0.24]	0.197 [0.66]
$\chi^2(ff)$	8.532 [0.10]	11.887 [0.20]	10.720 [0.10]	8.872 [0.56]	6.175 [0.11]	0.714 [0.60]	9.620 [0.38]	1.884 [0.30]	3.466 [0.58]
$\chi^2(n)$	0.523 [0.77]	0.233 [0.89]	0.309 [0.86]	0.102 [0.95]	0.498 [0.78]	0.251 [0.88]	0.314 [0.86]	1.638 [0.44]	0.610 [0.74]
$\chi^2(hs)$	0.569 [0.45]	0.514 [0.47]	0.537 [0.46]	0.482 [0.49]	0.642 [0.42]	0.457 [0.50]	0.576 [0.45]	0.283 [0.60]	0.461 [0.50]

Notes: Absolute *t*-ratios are in the parentheses below the coefficients; *p*-values are in the square brackets for the χ^2 tests. Significance at 5% and 10% level, respectively, denoted by * and **.

multiplied with labour force and the estimate is highly significant. The trend term is significant but its *t*-statistic is nearly halved compared to (2). Equations (4), (5) and (6) introduce variables such as *TO*, *REMY* and *FDIY*, respectively. While *TO* and *FDIY* are significant at the 5% level, *REMY* is insignificant at conventional levels. Note that the capital share of output has slightly increased to 0.425 in (6). Equations (7) and (8) include *M2Y* and ln*CO2*. The estimates imply that *M2Y* improves productivity growth while ln*CO2* has a negative impact (although the latter is only significant at the 10% level). The capital share of output is approximately 0.4 in both cases. *GY* is introduced in equation (9) and this has an insignificant impact on productivity growth. In all equations, the two dummy variables *DUM94* and *DUM85* are significant at conventional levels and these capture the effects of democracy and financial reforms, respectively. Our findings imply that improving human capital, trade openness, foreign direct investment, financial efficiency and democracy undoubtedly increases productivity growth. Alternatively, carbondioxide emission is detrimental. These findings corroborate with the earlier results related to the determinants of *TFP* growth.

In all cases, the speed of adjustment (λ) has the expected negative sign. This implies that if there are departures from equilibrium in the previous period, the departure is reduced by about 21-33 per cent in the current period. The χ^2 summary statistics show that there is no serial correlation, functional form misspecification, non-normality of residuals and heteroscedasticity in the residuals. The Saragan's χ^2 indicates that the instruments are valid.[13] The $\overline{GR}^2$ measures the goodness of fit of the *IV* estimates and this is remarkably high.

[13] The Saragan test statistic deals with over-identifying restrictions. The null hypothesis is that the selected instruments are exogenous (uncorrelated with the error term). The rejection of the null indicates that the selected instruments are exogenous and valid.

5. Conclusions

In this paper, we examined the determinants of *TFP* and productivity growth in South Africa over the period 1967 to 2008. The theoretical insights from the Solow (1956) growth model and its extension by Mankiw, Romer and Weil (1992) were used. While the Gregory and Hansen (*GH*) test was utilised to determine the break dates, General to Specific Instrumental Variable method was employed to estimate the productivity growth equations. The *GH* tests show that there are level and regime shifts in 1994 and a level shift with trend in 1985. A break in 1994 is expected because it highlights the advent of democracy in this country. Additionally, many developing countries, including South Africa, introduced financial reforms during the mid-1980s which improved the efficiency in the financial sector. Consequently, a break in 1985 is also reasonable. Our growth accounting exercise showed that during the 1970s growth in South Africa was mainly due to factor accumulation. Since then, *TFP* has only made a small contribution to growth. In all cases, we find that the capital share of output is between 0.3 to 0.4.

Our findings imply that the potential variables like human capital, trade openness, foreign direct investment, democracy and financial reforms have significant positive impacts on *TFP* and productivity growth. Alternatively, carbon dioxide emissions seem to have adverse effects. Results also showed that the trend variable, which was highly significant when democracy and financial reforms were not included via dummy variables in the growth model, became less significant once these dummies were added. This indicates the importance of democracy and financial reforms in stimulating growth in South Africa. To further increase the growth rate in South Africa, policy makers should therefore focus on policies that enhance human capital, trade openness, foreign direct investment, and most importantly democracy and financial reforms.

Data Appendix

Variables	***Definition***	***Source***
Y	Real Gross Domestic Product	International Financial Statistics (2010)
K	Capital Stock; Derived using perpetual inventory method $K_t = .95 * K_{t-1} + I_t$. It is real gross domestic fixed investment	International Financial Statistics (2010)
L	Labour force	World Development Indicators (2010)
H	Human capital; An average of educational attainment.	Barro and Lee (2010) data set.
REMY	Workers' remittances and compensation of employees to GDP ratio.	World Development Indicators (2010)
FDIY	Foreign direct investment to GDP ratio.	World Development Indicators (2010)
M2Y	Money and quasi money (*M2*) to GDP ratio.	World Development Indicators (2010)
GY	General government final consumption expenditure to GDP ratio.	World Development Indicators (2010)
ln*CO2*	Log of carbondioxide emissions.	World Development Indicators (2010)
TO	Sum of export plus import of goods and services to GDP ratio.	World Development Indicators (2010)
DUM94	Dummy variable to capture impact of democracy. *DUM94* is constructed as 1 from 1994-2008, 0 otherwise.	Authors computations
DUM85	Dummy variable to capture impact of financial reforms and liberalization policies. *DUM85* is constructed as 1 from 1985-2008, 0 otherwise.	Authors computations

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