The Growth Trade-off between Direct and Indirect Taxes in South Africa: Evidence from a STR Model

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The tax system forms the backbone to the functioning of the South African fiscal authorities and it is has been recently questioned whether alterations in the existing tax mix could promote economic growth. Using quarterly data from 1990:Q1 and 2015:Q2, this study investigated the effects of direct and indirect taxes on economic growth for South Africa using the recently developed smooth transition regression (STR) model. Our findings suggest an optimal tax of 10.27 percent on the indirect tax-growth ratio, of which below this rate indirect taxes are positively related with economic growth whereas direct taxes are negatively related with growth. Above the optimal tax rate, taxation bears no significant relationship with economic growth. We therefore suggest that policymakers place a greater burden on indirect taxes and yet ensure that the contribution of indirect taxes to economic growth does not exceed the threshold of 10.27 percent.

Key Words: direct taxes, value-added tax (VAT), optimal tax, economic growth, South Africa, smooth transition regression (STR) model
JEL *Classification:* C22, C51, H21, H30, O4

Introduction

In wake of the global financial crisis of 2007–2009, most economies worldwide are in their recovery phases in the aftermath following the collapse of the US financial system. The global financial crisis took a major toll on key macroeconomic performance indices in countries across the globe with South Africa bearing no exception to this rule. In attempts to boost economic growth, policymakers worldwide are focusing on tax reform policy as a vehicle towards attaining this goal. For the specific case of South Africa, speculation has run high concerning the intentions of fiscal authorities to increase government expenditure by shifting the burden from direct taxes (i.e. personal income and corporate taxes) to indirect taxes (i.e. value added tax (VAT) and other consumption taxes such as goods and services tax (GST), excise duties and custom duties).

Apparently this tax reform policy comes recommended by the Davis Tax Committee and so far, these reforms have been advocated for based on two primary arguments. Firstly, it is contended that the current structure of the tax system in the country cannot foster higher economy growth due to heavy reliance on corporate and income taxes. In other words, if policymakers were to continue relying on direct taxes for purposes of increasing government revenue, then such tax increases would exert adverse effects on economic growth. Secondly, by increasing indirect taxes, less tax burden will be borne by individuals and corporations thus creating a conducive climate for domestic savings and foreign investments in the country.

Given the relative importance which tax policy plays towards economic development, a number studies have taken the initiative of investigating the trade-off effects of taxes on economic growth for South Africa. To the best of our knowledge, there have been four case studies conducted thus far for South Africa and these are the works of De Wet, Schoeman, and Koch (2005), Koch, Schoeman, and Van Tonder (2005), Schoeman and van Heerden (2009) and Saibu (2015). Collectively, these studies rely on a wide range of econometric methods applied to empirical data. For instance, De Wet, Schoeman, and Koch (2005) estimate an augmented neo-classical growth model using OLS estimators; Koch, Schoeman, and Van Tonder (2005) use a two-stage Data Envelopment Analysis (DEA) to estimate an augmented neo-classical growth model; whereas Schoeman and van Heerden (2009) and Saibu (2015) make use of OLS in estimating Scully's (1996; 2000) tax-optimizing model. Overall, the consensus drawn over these studies points to a negative tax-growth relationship for the South African economy. Whilst these studies provide a good basis for investigating the tax-growth relationship in South Africa, we observe that the authors' use of linear estimation in their empirical analysis leaves the studies prone to criticisms of not addressing possible nonlinear relations existing between the time series variables. This is a cause for genuine concern given the increasing amount of evidence in the literature in support of nonlinear dynamic structure of macroeconomic data (Dackehag and Hansson 2012; Stoilova and Patonov 2013; Nantob 2014; Hunady and Orviska 2015). These nonlinear studies generally imply that the conventional linear models are misspecified. Moreover, the time span covered by previous South African studies encompasses a number of important political events and tax policy reforms, which furthers the case for possible nonlinear relationships between time series of economic variables.

In our study, we contribute to the literature by modelling nonlinear trade-off effects of direct and indirect taxes on economic growth for South African using quarterly data collected between 1990:Q1 and 2015:Q2. Theoretically, we follow in pursuit of De Wet, Schoeman, and Koch (2005) who augment Feder's (1983) two-sector production function into a steady-state growth estimation equation. Empirically, we rely on the newly developed smooth transition regression (STR) framework in order to model out the nonlinear trade-off effects of direct and indirect taxes on economic growth. Given the wide range of available nonlinear econometric models in the literature, we consider the STR model as being most appropriate for the following reasons. Firstly, the STR model encompasses other competing nonlinear econometric models such as the threshold autoregressive (TAR), the Exponential Autoregressive (EAR) and the Markov-Switching (MS) models, which are models that can be derived as extremities of the STR regression. Secondly, the STR model assumes a smooth transition between regime coefficients which is a feature of the econometric model which makes it theoretically appealing. Lastly, the STR model allows the econometrician to choose both the appropriate switching variable and the type of transition function unlike other regime-switching econometric models (Phiri 2016).

Against this backdrop, we structure the remainder of the article as follows. The literature review is presented in the next section of the paper. In the third section we outline the methodology used in the study whereas the data and empirical results are given in the fourth section. We conclude the study in the form of policy implications and possible avenues for future work.

Literature Review

For simplicity sake, the current available literature on the tax-growth nexus can be broadly segregated into two main strands of empirical works. First and foremost are those panel data studies which make use of log-linear estimates of augmented transformations of Solow's (1965) neoclassical and Lucas's (1988) endogenous growth models. Prominent examples of pioneers belonging to this cluster of studies include Kormendi and Meguire (1985), King and Rebelo (1990) and Barro (1990) who all set path for a wave of other empirical studies which also relied on cross-sectional data for empirical use. For a greater part of it, these earlier panel data studies reveal an inverse tax-growth relationship (Engen and Skinner 1992; Wright 1996; Lee and Gordon 2005; Folster and Henrekson

2001; Romero-Avila and Strauch 2008), even though some exceptional studies showed a positive relationship (Koester and Kormendi 1989; Devaranjan, Swaroop, and Zou (1996) and Agell, Ohlsson, and Thoursie 2006) and a couple of other papers have found no significant relationship between the variables (Levine and Renelt 1992; Easterly and Rebelo 1993; Mendoza, Razin, and Taser 1994).

A major criticism of the aforementioned studies lies in their inability to efficiently account for cross-country differences in their empirical analysis. A perceptible demonstration of this inefficiency is found for the US economy where the panel data studies of Koester and Kormendi (1989) and Devaranjan, Swaroop, and Zou (1996) advocate for a positive correlation between tax and growth for panel data inclusive of US data whereas the single case studies of Mertens and Ravn (2013), Barro and Redlick (2011) and Romer and Romer (2010) all find a negative tax-growth relationship for the same country. Another issue which can be raised concerns the failure of these studies to differentiate between distortionary and non-distortionary taxes. As is discussed in Karagianni, Pempetzoglou, and Saraidaris (2013), differentiating between distortionary and non-distortionary forms of taxation is important because the use of average tax rates is an inappropriate tax indicator due to it is strong correlation with public spending. To circumvent this issue, researchers have opted to use a 'tax structure mix' as a means of measuring the effect of tax policy on economic growth. This tax structure mix is combination of both direct and indirect taxes which is used in the estimation of growth equations.

So far the consensus drawn from the literature is that corporate, income and other forms of direct taxes are more distortionary towards economic growth whereas indirect taxes, such as VAT, are either positively correlated or uncorrelated with growth (Skinner 1987; Lee and Gordon 2005; Arnold 2008; Widmalm 2009; Dackehag and Hansson 2012; Bujang, Hakim, and Ahmad 2013).

The second identifiable strand of empirical works in the literature vouch for a nonlinear relationship between taxes and economic growth and this group of studies can be further sub-divided into two groups. The first sub-group of studies are those who followed in pursuit of a series of articles written by Scully (1995; 1996; 2000; 2003) who developed both theoretical and empirical specification for computing the optimal tax rate which results in growth maximization. Belonging to this sub-group of studies are the works Chao and Grubel (1998), Hill (2008), Keho (2010), Schoeman and van Heerden (2009) and Saibu (2015). We note that Chao and Grubel (1998) estimate an optimal tax rate of 34 percent for Canadian data. On the other hand, Hill (2008) estimates optimal tax rates ranging from 9 percent to 29 percent of GDP across different states in the US. Meanwhile, Keho (2010) estimates an optimal tax rate of 22.3 percent for Ivory Coast using data collected between 1960 and 2006 whereas Saibu (2015) estimates optimal tax rates for Nigerian as well as for South Africa for data collected between 1964 and 2012. For the former country the optimal rate is found to be 30 percent whereas for the later the optimal rate is 15 percent. However, using data collected from 1960 to 2006, Schoeman and van Heerden (2009) find an optimal tax rate of 21.94 percent for South Africa. What is important to note is that the optimal tax rates documented in the literature differ, not only across different countries, but also for the same country as can be witnessed in the study of Schoeman and van Heerden (2009) in comparison to that of Saibu (2015) for the case of South Africa. Nevertheless, this particular sub-group of studies remains relevant to literature seeing that they can be used to guide policymakers in amending discrepancies between the current or prevailing tax-growth ratio and the estimated optimal tax-growth rate.

And even with the progressive nature of these studies in capturing the optimal level of tax, the underlying empirical model has been further deemed as being flawed on account of using a functional form which produces spurious estimates of the optimal level of tax (Hill 2008; Kennedy 2000). This flaw lead to the emergence to the second sub-group of nonlinear studies who empirically capture nonlinearity in the tax-growth relationship by employing two measures of government tax in their growth equations, namely the ratio of tax returns to GDP as well as the square of tax returns expressed as ratio of GDP. The former term is intended to measure the tax-growth relationship at low tax levels whereas the later term measures this relationship at high tax levels. Notably, under this method of capturing nonlinearities in the tax-growth relationship, a specific optimal tax rate cannot be identified. Studies which have used to this method to quantify nonlinearities in the tax-growth relationship include Dackehag and Hansson (2012), Stoilova and Patonov (2013), Nantob (2014), and Hunady and Orviska (2015). On one hand, the studies of Dackehag and Hansson (2012) and Nantob (2014) show that low levels of tax are positively correlated with economic growth whilst high levels of tax exert negative effects on growth. On the other hand, the study of Stoilova and Patonov (2013) find that low tax rates hamper economic growth whereas high levels of taxation are beneficial towards growth. Once again, the inconclusiveness of the empirical studies is demonstrated and thus warrants further deliberation into the subject.

Empirical Framework

Of recent, a growing number of sophisticated nonlinear econometric models have been introduced into the academic literature. Among these models, is the smooth transition regression (STR) model as introduced by Luukkonen, Saikkonen, and Terasvirta (1988) and modified by Terasvirta (1994). In comparison to other competing state-dependent non-linear time series models such as the threshold autoregressive (TAR), Exponential Autoregressive (EAR) and the Markov Switching (MS) models, the STR model holds a high level of appeal because unlike these other nonlinear models the transition between regime states is endogenously determined. Furthermore, the STR encompasses these other nonlinear econometric models. In its baseline form, the STR model can be formulated as follows:

$$y_t = \beta_0' x_t + \beta_1' x_t G(z_t; \gamma, c) + \varepsilon_t \qquad \varepsilon_t iid\, N(0, h_t^2), \tag{1}$$

where y_t is a scalar, β_0' and β_1' are parameter vectors; x_t represents the vector of explanatory variables, c is the transition variable, γ is the threshold estimate and $G(z_t; \gamma, c)$ is a transition function which assumes the following logistic function:

$$G(z_t; \gamma, c) = \frac{1}{1 + \exp\left\{-\gamma \prod_{k=1}^{k} (z_t - c_k)\right\}}, \tag{2}$$

where z_t is the transition or threshold variable whereas γ and c are the true threshold estimate and the transition parameter, respectively. For empirical purposes we restrict the STR model to the cases for $k = 1$ (LSTR-1) and $k = 2$ (LSTR-2). In firstly testing for linearity in equation (1), we impose the constraint $H_0'\colon \beta_1 = 0$ on the regression. However, since the LSTR model contains unidentified nuisance parameters under the null hypothesis of linearity, conventional tests will produce nonstandard distributions (Davies 1977). As suggested by Luukkonen, Saikkonen, and Terasvirta (1998), one method of circumventing this problem, involves replacing the transition function $G(z_t; \gamma, c)$ by its first order Taylor expansion around $\gamma = 0$, which results in the following auxiliary function:

$$y_t = \mu_t + \beta_o'^{*} x_t + \beta_1'^{*} x_t z_t + \beta_2'^{*} x_t z_t^2 + \beta_3'^{*} x_t z_t^3 + \varepsilon_t^{*}, \tag{3}$$

where the parameter vectors β_1^*, β_2^*, β_3^* are multiples of γ and $\varepsilon_t^* = \varepsilon_t + R_3\beta_1' x_t$, with R_3 being the remnant portion of the Taylor expansion. Hereafter, the null hypothesis of linearity is tested as $H_0: \beta 1 = \beta 2 = \beta 3 = 0$ and this may be tested via an LM test such that the Taylor series does not affect asymptotic distribution theory. Once the null hypothesis of linearity is rejected, one must decide on whether to fit an LSTR-1 or LSTR-2 model to the data. Terasvirta (1994) suggests using a decision rule based upon a sequence of tests in equation (3). Particularly, the author proposes testing the following null hypotheses:

$$\begin{aligned} &\text{I.} \quad H_{04}^*: \beta_3^* = 0 \\ &\text{II.} \quad H_{03}^*: \beta_2^* = 0 | \beta_3^* = 0 \\ &\text{III.} \quad H_{02}^*: \beta_1^* = 0 | \beta_3^* = \beta_2^* = 0. \end{aligned} \tag{4}$$

The decision rule for selecting either a LSTR-1 or LSTR-2 model is thus as follows. Select a LSTR-2 specification if H_{02}^* has the strongest rejection, otherwise, we select the LSTR-1 specification. Once an appropriate LSTR specification has been chosen, the next step in the modelling process is to obtain initial values for estimation purposes and these are obtained by performing a grid search with a log-linear grid in γ and a linear grid in c. The starting values are those which minimize the residual sum of squares (RSS) over the grid search and thereafter the STR parameters are estimated by a nonlinear optimization routine that maximizes the log-likelihood.

In turning to our theoretical model, we follow in pursuit of De Wet, Schoeman, and Koch (2005) who present an augmentation of Feder's (1983) two-sector production function model for empirical purposes. In particular, the authors exploit the possibility of government sector impacting economic growth through two channels namely; through revenue collections and through efficient allocation of resources. Their empirical growth model is specified as:

$$\begin{aligned} \frac{\dot{Y}}{Y} = {} & \theta_1 \left[\frac{I}{Y}\right] + \theta_2 \left[\frac{\dot{L}}{L}\right] + \theta_3 \left[\frac{\dot{T}_d}{T}\right] + \theta_4 \left[\frac{\dot{T}_{id}}{T}\right] + \left[\left(\frac{\delta}{1+\delta}\right) - \theta_3\right]\left[\frac{\dot{T}_d}{T}\right] \\ & + \left[\left(\frac{\delta}{1+\delta}\right) - \theta_4\right]\left[\frac{\dot{T}_{id}}{T}\right] + \varepsilon_t, \end{aligned} \tag{5}$$

where $\dot{Y}/Y$ measures output growth (GDP), I/Y measures the ratio of fixed capital formation to GDP, $\dot{L}/L$ measures the growth in the labour force, $\dot{T}_d/T$ measures the growth in direct tax as a ratio of total taxes,

$\dot{T}_{id}/T$ measures the growth rate in indirect tax as a ratio of total taxes, $\dot{T}_d/Y$ measures the growth of direct taxes as a share of total income, and $\dot{T}_{id}/Y$ measures the growth of indirect taxes as a share of total income.

The coefficients θ_1, θ_2, θ_3 and θ_4, measure the effects of investment on economic growth, labour on economic growth, direct taxes on economic growth and indirect taxes on economic growth, respectively. On the other hand, the coefficient $[(\delta/(1+\delta)) - \theta_3]$ is an efficiency measures between direct taxes and the real economy, whereas the coefficient $[(\delta/(1+\delta))-\theta_4]$ is an efficiency measure between indirect taxes and the real economy. If either $[(\delta/(1+\delta))-\theta_3] > 0$ or $[(\delta/(1+\delta))-\theta_3] > 0$ occurs, then resources collected by the public sector are used more efficiently by the government than the resources in the rest of the real sector (De Wet, Schoeman, and Koch 2005). The opposite is only possible if the coefficients θ_3 and θ_4 are of a greater absolute value than the coefficients $[(\delta/(1+\delta)) - \theta_3]$ and $[(\delta/(1+\delta)) - \theta_4]$. In referring back to equations (1) through (4), we can transform the linear growth regression (4) into the following STR estimation model:

$$\begin{aligned}\frac{\dot{Y}}{Y} &= \theta_1\left[\frac{I}{Y}\right] + \theta_2\left[\frac{\dot{L}}{L}\right] + \theta_3\left[\frac{\dot{T}_d}{T}\right] + \theta_4\left[\frac{\dot{T}_{id}}{T}\right] + \left[\left(\frac{\delta}{1+\delta}\right) - \theta_3\right]\left[\frac{\dot{T}_d}{T}\right] \\ &+ \left[\left(\frac{\delta}{1+\delta}\right) - \theta_4\right]\left[\frac{\dot{T}_{id}}{T}\right] + \theta_1'\left[\frac{I}{Y}\right] + \theta_2'\left[\frac{\dot{L}}{L}\right] + \theta_3'\left[\frac{\dot{T}_d}{T}\right] \\ &+ \theta_4'\left[\frac{\dot{T}_{id}}{T}\right] + \left[\left(\frac{\delta'}{1+\delta'}\right) - \theta_3'\right]\left[\frac{\dot{T}_d}{T}\right] + \left[\left(\frac{\delta'}{1+\delta'}\right) - \theta_4'\right]\left[\frac{\dot{T}_{id}}{T}\right] \\ &\times G(z_t;\gamma,c) + \varepsilon_t. \end{aligned} \tag{6}$$

Having formulated our estimation model, we thus outline the modelling and estimation process of the formulated STR regression as follows. Firstly, we test linearity against the LSTR alternative by using each of the explanatory variables as a possible transition variable. Once linearity is rejected, we use the decision criteria to choose between LSTR-1 and LSTR-2 specification and choose the model with the highest rejection. Secondly, we carry out a three-dimensional grid search over the values of z_t, γ and c for the STR regression. The optimal values are the ones which minimize the residual sum of squares (RSS). Thirdly, we estimate the chosen model using a Newton-Raphson algorithm to maximize the conditional maximum likelihood function. Lastly, we perform diagnostic tests (i.e. ARCH effects, tests of no error autocorrelation and parameter consistency) on the estimated model.

TABLE 1 Summary of Time Series

SARB code	Description of time series
KBP6006S	Percentage change in gross domestic product ($\dot{Y}/Y$)
KBP6282L	Percentage change in ratio of gross fixed capital formation to GDP (I/Y)
KBP7008L	Total employment in private sector (L)
KBP459M	Total net national government tax revenue (T)
KBP4578M	National government tax revenue: taxes on goods and services – value added tax (T_{id})
KBP4578M	National government tax revenue: total taxes on income, profits and capital gains (T_d)
KBP6006L	Gross domestic product (millions) (Y)

NOTES Adapted from the SARB online data base (https://www.resbank.co.za/Research/Statistics/Pages/OnlineDownloadFacility.aspx).

Data and Empirical Analysis

DATA AND UNIT ROOT TESTS

For empirical purposes, we collect all our data from the South African Reserve Bank (SARB) online database. Table 1 summarizes the raw time series as has been collected from the SARB database. Each of the time series has been collected on quarterly basis between the period of 1990:Q1 to 2015:Q2, that is with the exception of taxes on goods and services (VAT) and the taxes on income, profits and capital gains, which have been collected on a monthly basis from 1990:M1 to 2015:M6. Given the non-uniformity of the time series, we use cubic spline interpolation to convert the monthly data (i.e. taxes on goods and services (VAT) and the taxes on income, profits and capital gains) into quarterly data over the same sample period.

As a first step in our empirical analysis, we need to examine the time series variables for their integration properties. Given that the time series covers periods which are prone to structural breaks, it is advisable to test for unit roots using methods which account for structural breaks. Therefore, conventional unit root tests such as the Augmented Dickey Fuller (ADF) and Phillips and Perron (PP) tests are inappropriate for the study. We thus consider using the unit root tests of Zivot and Andrews (1992) with a structural break existing under the alternative hypothesis of a stationary time series process. The unit root tests are performed with (i) an intercept and (ii) with a trend and the optimal lag length of the tests is determined by the minimization of the AIC.

TABLE 2 Zivot and Andrews (1992) Unit Root Test

Time series	t-statistic			Breakpoint (year)		
	Intercept	Trend	Both	Intercept	Trend	Both
$\dot{Y}/Y$	−5.45***	−4.85*	−5.53***	1990	1995	1990
I/Y	−8.19***	−7.24***	−8.52***	1994	1995	1994
$\dot{L}/L$	−5.89***	−2.11	−7.06***	1994	1992	1994
$\dot{T}_d/T$	−5.59***	−7.60***	−7.57***	1995	1994	1994
$\dot{T}_{id}/T$	−11.74***	−11.40***	−11.80***	1991	1992	1991
$\dot{T}_d/Y$	−10.74***	−10.85***	−10.79***	1998	1998	1998
$\dot{T}_{id}/Y$	11.61***	−11.61***	−11.37***	1998	1998	1998

NOTES Significance levels are given as follows: ***, **, and * represent the 1%, 5% and 10% significance levels respectively. The test statistics for first differences are reported in parentheses. The critical values for the Zivot and Andrews (1992) unit root tests inclusive of an intercept only are as follows: 1%: −5.34, 5%: −4.80 and 10%: −4.58; the critical values for the unit root test inclusive of a trend are as follows: 1%: −4.93, 5%: −4.42 and 10%: −4.11 whereas the critical values for the unit root test inclusive of a trend are as follows: 1%: −5.57, 5%: −5.08 and 10%: −4.82.

Based on the unit root test results reported in table 2, all observed time series, in their levels, reject the null hypothesis of a unit root regardless of whether the unit root test regression includes an intercept, a trend or both. An exception is warranted for the unit root tests performed with trend on the growth in labour force variable. However, this is merely an exceptional result than the norm. Another thing worth noting form the unit root test results reported in table 2 is that the various structural break points detected in the time series correspond to the political shift of South Africa towards a democratic economy as witnessed in 1994. Notably, the tax recommendations of the Katz commission where introduced and implemented during the period of 1994 to 1998 which saw significant changes in the personal income tax system. The detected structural breaks correspond to this period of tax reforms within the country. All-in-all, we conclude that all utilized time series appear to be stationary in their levels (i.e. integrated of order I(0)) and this satisfies a preliminary condition for estimating the STR model without the fear of obtaining spurious regression results.

Selection, Estimation and Evaluation of STR Model

Prior to the estimation of the STR model, we need to conduct linearity tests in order to determine an appropriate transition variable for estima-

TABLE 3 Linearity Tests

Trans. var.	Tests statistics				Decision
	F	F4	F3	F2	
I/Y	$4.3438e^{-1}$	$1.5583e^{-1}$	$6.8692e^{-1}$	$5.6340e^{-1}$	Linear
$\dot{L}/L$	$3.6582e^{-1}$	$2.8636e^{-1}$	$2.4223e^{-1}$	$6.7763e^{-1}$	Linear
$\dot{T}_d/T$	$1.8651e^{-1}$	$7.4984e^{-1}$	$2.3839e^{-1}$	$5.8844e^{-2}$	Linear
$\dot{T}_{id}/T$	$2.9371e^{-1}$	$8.2546e^{-1}$	$6.7247e^{-1}$	$2.6595e^{-2}$	Linear
$\dot{T}_d/Y$	$2.7808e^{-3}$	$4.0006e^{-3}$	$5.7885e^{-2}$	$3.0139e^{-1}$	LSTR(1)
$\dot{T}_{id}/Y$	$1.4412e^{-2}$	$3.2655e^{-2}$	$6.2697e^{-1}$	$1.6723e^{-2}$	LSTR(1)#

NOTES The *F*-tests for nonlinearity are performed for each possible candidate of the transition variable and the variable with the strongest test rejection (i.e. the smallest *p*-value) is tagged with symbol #.

tion usage. The purpose of the suggested linearity tests is two-fold. Firstly, we use the linearity tests to inform us on which candidate transition variable is most suitable for modelling nonlinear behaviour among the time series. Secondly, we use the *p*-values from the linearity tests to determine whether the selected transition variable should be used to model the STR regression as either an LSTR-1 or LSTR-2 model. Pragmatically, we carry out the linearity tests by conducting a sequence of F-tests and compute their corresponding *p*-values. The decision rule is to choose the model which produces the lowest *p*-values. For the chosen model, we also conduct supplementary tests for no remaining nonlinearity. The results of the linearity tests are reported in table 3 whereas the results of the tests for no remaining nonlinearity are presented in table 4.

The linearity test results reported in table 3 reveal that the null hypothesis of linearity can be rejected for only two candidate variables, those being, the growth of direct taxes as a share of total income ($\frac{T}{d}/Y$) and the growth of indirect taxes as a share of total income ($\dot{T}_{id}/Y$). However, given smaller *p*-values associated with the growth of indirect taxes as a share of total income ($\dot{T}_{id}/Y$), we consider this time series the most suitable transition variable for building our LSTR model. Also given that the F3 statistic produces the highest rejection associated with the ($\dot{T}_{id}/Y$) variable, we decide upon fitting an LSTR-1 to the data. Furthermore, the results of the tests of no remaining linearity, as performed on the chosen LSTR-1 model and reported in table 4, shows no evidence of remaining nonlinearity for the regression model.

Having conducted our linearity tests as well as the tests of no remaining

TABLE 4 Tests of no Remaining Nonlinearity

F-statistics	F	F4	F3	F2
p-value	$1.0809e^{-1}$	$1.6560e^{-1}$	$6.1657e^{-2}$	$6.5915e^{-1}$

nonlinearity, we proceed to estimate the LSTR-1 model with the growth of indirect taxes as a share of total income ($\dot{T}_{id}/Y$) being the transition variable. The parameter estimates of the selected LSTR-1 model are reported in table 5. We note that the threshold value of the transition variable is estimated to be 0.1027, which implies that the regimes are dependent upon whether $\dot{T}_{id}/Y < 0.1027$ (i.e. lower regime) or $\dot{T}_{id}/Y \geq 0.1027$ (i.e. upper regime). The relatively high transition parameter estimate of 10.00 indicates a rather abrupt change in moving from one regime state to another. In the lower regime of the STR model, we find that direct taxes have a significantly negative impact on economic growth whereas indirect taxes exert a significantly positive effect on growth. One can note that these results are an improvement over those presented in De Wet, Schoeman, and Koch (2005) who find a similar result of a negative effect of direct taxes on economic growth and yet find an insignificant effect of indirect taxes on economic growth. Thus, by effect, our estimation results support the notion that government revenue collections could be improved, by shifting reliance from direct to indirect taxes. From a practical perspective, this could involve lowering personal income taxes and simultaneously spreading as well as increasing consumption taxes such as VAT and GST. This could also imply that tax administrators would increase the enforcement of the collection of indirect taxes through the implementation of appropriate audit tools.

Furthermore, in the lower regime of the model, the coefficients on the relative efficiency variables, $\dot{T}_d/Y$ and $\dot{T}_{id}/Y$, are significant with the coefficient on the $\dot{T}_d/Y$ variable being positive, thus implying that resources collected by the public sector can be used more efficient by the government than resources collected in the rest of the real sector. Once again, this result is an improvement over that reported in De Wet, Schoeman, and Koch (2005), who find no efficiency effects associated with public revenue collection.

Another finding worth pointing out concerns the growth in the labour force ($\dot{L}/L$), of which under the lower regime produces a statistically significant and positive coefficient which turns negative and insignificant in the upper regime of the model. Notably, Phiri (2014) finds a similar finding of regime switching behaviour between employment and economic growth for South African data.

Also note that the coefficient on the investment variable produces a significantly negative estimate in the lower regime and remains negative and yet insignificant in the upper regime of the model. This negative coefficient on the investment variable contradicts conventional growth theory and yet for the case of South Africa is a plausible result for the following two reasons. Firstly, a greater part of South Africa's investments are not 'Greenfield investments' which would contribute to infrastructure development and job creation but are rather mergers and acquisitions (Fortainer 2007). The second reason is that the current high levels of public spending and budget deficits crowd out the positive effects of investment in the South African economy (Biza, Kapingura, and Tsegaye 2015).

In observing the coefficient estimates found in the upper regime of the model, we notice that the impact of all these growth explanatory variables become insignificant. By default, this implies that the lower regime of the estimated LSTR-1 model is most efficient and that policymakers should strive to keep the economy in such a state, that is, to keep the growth of indirect taxes as a share of total income ($\dot{T}_{id}/Y$) below 10.27 percent. The diagnostics tests performed on the estimated LSTR-1 model show that the regression residuals are well-behaved. In particular, evidence is provided for no autocorrelation, for no ARCH effects and also sufficient evidence for normality of the regression residuals.

Conclusions

With discussions of tax reforms being high on the agenda of fiscal authorities in South Africa, the main objective of this paper was to investigate the growth trade-off effects between direct and indirect taxes in the country using interpolated quarterly time series data collected from 1990:q1 to 2015:q2. While the necessity to account for nonlinearities in the estimation process has long been advocated for, we are unaware of any previous studies which have done so for the case of South Africa. Therefore, in differing from previous studies conducted for South Africa, we test for nonlinearities in the taxation-growth relationship by using the recently developed LSTR model. The theoretical framework for our case study is adopted from De Wet, Schoeman, and Koch (2005) who develop an augmented empirical model based on the Feder's (1983) two-sector production function model. The application the LSTR estimators to the theoretical model is favourable in producing a more theoretical appealing results

TABLE 5 STR Regression Estimates

independent variable	Linear part	Nonlinear part
I/Y	−0.83098 (0.00)***	−0.07133 (0.87)
$\dot{L}/L$	0.07449 (0.00)***	−0.01991 (0.62)
$\dot{T}_d/T$	−0.56565 (0.00)***	0.27585 (0.62)
$\dot{T}_{id}/T$	0.38683 (0.00)***	−0.03800 (0.96)
$\dot{T}_d/Y$	0.54695 (0.00)***	−0.24632 (0.59)
$\dot{T}_{id}/Y$	−0.46797 (0.00)***	0.27639 (0.63)
c	10.00 (0.02)**	
γ	0.1027 (0.00)***	
LM(4)	6.70 (0.00)***	
ARCH(4)	11.20 (0.03)	
J-B	0.92 (0.63)	

NOTES *t*-statistics are reported in parentheses. Significance levels are given as follows: ***, **, and * represent the 1%, 5% and 10% significance levels respectively. LM and ARCH respectively denote the Lagrange Multiplier and Ljung-Box statistics for autocorrelation whilst the J-B denotes the Jarque-Bera normality test of the regression residuals.

in comparison to estimates that could have been obtained from other nonlinear econometric models. This is because the transition between the model regimes in the STR model is conducted in a smooth manner and the rate of adjustment between both regimes can be measured. Moreover, the variable responsible for the regime switching behaviour in the LSTR model is determined intrinsically as part of the estimation process.

Indeed, our empirical results confirm the existence of a nonlinear growth trade-off effects with direct and indirect taxes for the data, with indirect taxes accounting for the regime switching behaviour in the estimated model. Interestingly enough, our results show that both direct and indirect taxes are only significantly related with economic growth when the indirect tax-growth ratio is below a threshold of 10.24 percent. Below this threshold, we observe that indirect taxes are positively related with economic growth whilst direct taxes adversely affect growth. Moreover, it is within this lower regime that we find resources collected by government can be efficiently used and that the labour growth variable has a positive effect on economic growth. By policy implication this presents a case for fiscal authorities to exploit the nonlinear tax-growth relationship to their advantage by specifically exploiting the positive relationship found between indirect taxes and economic growth below the established threshold. This, in turn, would entail a gradual shift of reliance in collecting government revenue from direct taxes to indirect taxes. And yet is should be cautioned that policymakers should take care to not breach the threshold level and avoid moving the economy into regions beyond the threshold point. Research similar to ours could also be extended to other Sub-Saharan African (SSA) countries in view of limited empirical evidence for these countries. This would an ideal for future research seeing that African countries tend to be more reliant on government revenues for social and economic welfare.

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