The Economic Research Guardian – Vol. 8(1)2018
Semi-annual Online Journal, www.ecrg.ro
ISSN: 2247-8531, ISSN-L: 2247-8531
Econ Res Guard 8(1): 25-39

A Sequential Panel Selection Approach to Cointegration Analysis: An Application to Wagner's Law for South African Provincial Data

Xolisa Vayi
Department of Economics, Nelson Mandela University, Port Elizabeth, South Africa
E-mail: xolisa.vayi@mandela.ac.za

Andrew Phiri
Department of Economics, Nelson Mandela University, Port Elizabeth, South Africa
E-mail: phiricandrew@gmail.com

Abstract
The main aim of this study is to extend the recently introduced sequential panel selection method (SPSM) to a cointegration framework which is particularly used to investigate Wagner's law for 9 South African provinces. We particularly apply the SPSM to the PMG and ARDL cointegration frameworks which we apply to annual data spanning from 2001 to 2016. The main findings show that when applying single country/region estimates we fail to find evidence of cointegration whereas within panel regressions, cointegration effects are present for the entire dataset. In further applying the SPSM we observed significant Wagner's effects for panels inclusive of Gauteng, Eastern Cape and Kwazulu-Natal provinces and when these provinces are excluded from the panels, cointegration effects are unobserved.

Keywords: Sequential Panel selection method (SPSM), cointegration, Wagner's law, Provincial analysis, South Africa

JEL classification: C22, C23, C52, H70

1. Introduction

There exists an upheld tradition in the econometrics literature of combining cross-section and time series techniques in investigating numerous important macroeconomic relationships (see Maddala, 1987 for discussion). One notable fallacy with these 'panel' time series econometric models is their generalization of a single regression estimate for a host of countries or regions which are characterized by multidimensional differences. Recently Chortareas and Kapetanois (2011) propose the sequential panel selection method (SPSM) which integrates the size power advantages of panel estimates with the heterogeneity advantages associated with individual sample estimates. Nevertheless, we note that Chortareas and Kapetanois (2009) strictly apply the SPSM to unit root procedures in their empirical investigations. Similarly, studies which have subsequently applied the SPSM approach have monotonously done so for unit root purposes (see Li et al (2014), Lee (2014) and Chang et al. (2015) and Anyikwa et al. (2018)).

In our study we extend the SPSM approach to the case of a cointegration regression analysis. As far as we are concerned our study becomes the first in the literature to implement this method. For demonstration purposes we make an application to Wagner's law for 9 South African provinces. We consider this task relevant for a number of reasons. Firstly, the relationship between government expenditure and economic growth is relevant in South Africa's current economic context, in which the economy is struggling to recuperate from the repercussions of the 2009-2010 global recession period, with GDP growth being recently being recorded at 0.8 percent. In this instance, much emphasis has been put on fiscal policy as a vital catalyst for economic recovery through increased government spending aimed at fostering economic growth. Validating Wagner's law for the economy will validate government's effectiveness in improving economic growth levels, whereas an absence of Wagner's law would indicate that increased government size will do nothing for the economy's growth but incur increasing public debt levels. Secondly, our study takes a disaggregated approach on Wagner's law. This is noteworthy since previous works on Wagner's law in South Africa have studied this relationship from an aggregated country perspective hence ignoring the possible differences existing within provincial budgets (Ansari et al. (1997), Ziramba (2008), Ogbonna (2009), Menyah and Wolde-Rufael (2012), Chipaumire et al. (2014), Odhiambo (2015) and Phiri (2017)). Lastly, since provincial data currently available on government expenditure and economic growth for South African provinces is limited to annual data spanning from 2001 to 2016, our use of the SPSM approach to cointegration is well justified.

Having provided a background to our study, the rest of our study is arranged a follows. Section 2 presents an overview of government spending and economic growth in South Africa. Section 3 then presents the methodology of the study, section 4 the data and empirical findings whilst the study is concluded in section 5 of the paper.

2. An overview of government spending and growth in South Africa

In South Africa, it is stated by the law (in the Constitution) that taxation and government expenditure be the drivers of budgetary policies (Calitz et al. 2014). The government has a legal obligation to formulate a fiscal policy that provides and maintains public funding. Otherwise, failure to comply with this obligation is deemed unconstitutional (Calitz et al. 2014). This is clearly illustrated in the Bill of Rights of South Africa where each citizen has the right to basic services such as housing, healthcare, food, water, social security, and education. Policymakers in South Africa, especially those in government are tasked with the act of balancing limited resources with unlimited needs. The South African government has had to invest tremendously in bridging the gap that exists in different regions, developing social responsibility projects that support and sustain communities, and most importantly creating and investing in capital infrastructure that is growth promoting.

After the 1994 elections, there was a huge shift in public expenditure and the new democratic government had to cater to millions under limited resources. Over the last couple of decades or the democratic ANC government has implemented a number of large scale expenditure programmes (i.e. the Reconstruction and Development Programme (RDP), Growth, Employment and Redistribution

(GEAR), Accelerated and Shared Growth Initiative for South African (ASGISA), the National Development Plan (NDP) and the New Growth Path (NGP) aimed at addressing the social imbalance inherited from the former Apartheid regime. The national budget has being the most common tool for income redistribution which to no surprise, led to fiscal deficits (Phiri. 2017) and in 2012, current expenditure, social benefits paid and services on public debt accounted for 92.3 percent of general government expenditure. Overall, with the size and composition of the public sector in South Africa have grown significantly over the last few decades (from R66.3 billion in 1960 to R473.6 billion in 2012), it is quite surprising that this has not been mirrored onto improved economic growth rates for the country.

From an academic standpoint, the current empirical evidence on Wagner's law for South Africa is far from reaching a consensus. Whilst the previous studies of Ogbonna (2009), Menyah and Wolde-Rufael (2012), Odhiambo (2015) and Phiri (2017) validate Wagner's effect for South African data, in which a larger government size is accompanied with increased economic growth, on the other hand, the works of Ansari et al. (1997), Ziramba (2008) and Chipaumire et al. (2014) fail to find any significant Wagner effects for South Africa. We note the ambiguity observed in these previous findings may be due to three reasons. Firstly, the different authors use different empirical methods such as the Engle-Granger (1987) cointegration method (Ansari et al. (1997)), the vector error correction method (Chipaumire et al. (2014)) the autoregressive distributive lag model (Ziramba (2008), Ogbonna (2009), Menyah and Wolde-Rufael (2012) and Odhiambo (2015)) and the momentum threshold autoregressive model (Phiri (2017)). Secondly, each of these authors use different time periods i.e. Ansari et al. (1997) use 1957 – 1990; , Ziramba (2008) use 1960-2006; Ogbonna (2009) use 1950-2008; Menyah and Wolde-Rufael (2012) use 1950-2007; Chipaumire et al. (2014) use 1990-2010; Odhiambo (2015) use 1970 – 2013 and Phiri (2017) use 1994 – 2016. Lastly, the aforementioned authors take an aggregated approach in reaching their various conclusions on Wagner's law for South Africa. However, as mentioned by Narayan et al. (2008), the use of provincial data is advantageous towards investigating Wagner's law since provincial data is consistent with the peace and stability assumption since provincial budgets do not incur military spending items. Moreover, relying on sub-national data implies the exploitation of cross-sectional dimension while minimizing the effects of cultural and institutional differences as well as influences of state expenditure in dealing with changes in the international economic conditions, all which are important assumption underlying Wagner's law.

3. Empirical framework

3.1. Wagner's specification

The academic literature indicates the existence of six versions of Okun's law, namely the (1) Peacock-Wiseman (1961) version; (2) Pryor (1969) version; (3) Goffman (1968) version; (4) Musgrave version (1969); (5) Gupta version (1967); and (6) Mann (1968) version. These versions are respectively specified below in regressions (1) to (6) for South African individual provinces:

$$G = f(Y) \quad (1)$$

$$C= f(Y) \quad (2)$$

$$G = f(Y/P) \quad (3)$$

$$G/Y = f(Y/P) \quad (4)$$

$$G/P = f(Y/P) \quad (5)$$

$$G/Y = f(Y) \quad (6)$$

Where G stands for real government expenditure, C stands for government consumption expenditure, Y stands for real GDP, G/Y is share of government spending in GDP, P is population such that Y/P is per capita GDP, and G/P is government spending per capita. Using log-linear functional form for each version, where t is the time subscript and e is the random error term, the following ARDL specifications can be specified for empirical purposes:

$$\Delta g_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i}\, g_{t-i} + \sum_{i=1}^{p} \alpha_{2i}\, y_{t-i} + \phi_{1i} g_{t-i} + \phi_{2i} y_{t-i} + \xi_t \quad (7)$$

$$\Delta c_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i}\, c_{t-i} + \sum_{i=1}^{p} \alpha_{2i}\, y_{t-i} + \phi_{1i} c + \phi_{2i} y_{t-i} + \xi_t \quad (8)$$

$$\Delta g_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i}\, g_{t-i} + \sum_{i=1}^{p} \alpha_{2i}\, y/p_{t-i} + \phi_{1i} g_{t-i} + \phi_{2i} y/p_{t-i} + \xi_t \quad (9)$$

$$\Delta g/y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i}\, g/y_{t-i} + \sum_{i=1}^{p} \alpha_{2i}\, y/p_{t-i} + \phi_{1i} g/y_{t-i} + \phi_{2i} y/p + \xi_t \quad (10)$$

$$\Delta g/p_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i}\, g/p_{t-i} + \sum_{i=1}^{p} \alpha_{2i}\, y/p_{t-i} + \phi_{1i} g/p_{t-i} + \phi_{2i} y/p + \xi_t \quad (11)$$

$$\Delta g/p_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i}\, gp_{t-i} + \sum_{i=1}^{p} \alpha_{2i}\, y_{t-i} + \phi_{1i} g/p_{t-i} + \phi_{2i} y + \xi_t \quad (12)$$

Where the small letter represents the log transformation of the series, Δ is a first difference operator, α_0 is the intercept term, the parameters $\alpha_1, \ldots, \alpha_2$ and $\phi_1, \ldots, \phi_2$ are the short-run and long-run elasticities, respectively, and ξ_t is a well-behaved error term. The bounds test for cointegration can be implemented straightforward by testing the null hypothesis of no cointegration (i.e. $\phi_1 = \phi_2 = 0$), which is tested against the alternative hypothesis of ARDL cointegration effects (i.e. $\phi_1 \neq \phi_2 \neq 0$). Only if the F-statistic exceeds the upper critical bound, then cointegration effects are validated and the following unrestricted error correction model (UECM) representation of the ARDL regressions (8) can be modelled:

$$\Delta g_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i}\, g_{t-i} + \sum_{i=1}^{p} \alpha_{2i}\, y_{t-i} + \eta\, ect_{t-1} + \xi_t \quad (13)$$

$$\Delta c = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i}\, g_{ct-i} + \sum_{i=1}^{p} \alpha_{2i}\, y_{t-i} + \eta\, ect_{t-1} + \xi_t \quad (14)$$

$$\Delta g_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i}\, g_{t-i} + \sum_{i=1}^{p} \alpha_{2i}\, y/p_{t-i} + \eta\, ect_{t-1} + \xi_t \quad (15)$$

$$\Delta g/y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i}\, g/y_{t-i} + \sum_{i=1}^{p} \alpha_{2i}\, y/p_{t-i} + \eta\, ect_{t-1} + \xi_t \quad (16)$$

$$\Delta g/p_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i}\, g/p_{t-i} + \sum_{i=1}^{p} \alpha_{2i}\, y/p_{t-i} + \eta\, ect_{t-1} + \xi_t \quad (17)$$

$$\Delta g/p_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i}\, gp_{t-i} + \sum_{i=1}^{p} \alpha_{2i}\, y_{t-i} + \eta\, ect_{t-1} + \xi_t \quad (18)$$

Where ect_{t-1} is the error correction term, which is measures the speed of adjustment back to equilibrium subsequent to a shock to the system.

3.2. Sequential panel selection method to cointegration

The academic literature indicates To conduct the SPSM to cointegration we rely the pooled mean group (PMG) panel estimation of Pesaran et al. (1999) which is a generalized panel extension of the ARDL model outlined in the previous section. In it's generalized form the panel model can be specified as:

$$Y_{it} = \alpha_0 + \alpha\delta_{1i}X_{it} + \alpha_{2i}X_{i,t-1} + \psi_i Y_{i,t-1} + e_{it} \quad (19)$$

And associated equilibrium error correction representation is given as:

$$\Delta Y_{it} = \alpha_0 + \delta_{1i}\Delta X_{it} + \phi_{1i} Y_{i,t-1} - \theta_{0i} - \theta_{1i}X_{i,t-1} + e_{it} \quad (20)$$

Where $\theta_{0i} = \frac{\alpha_i}{1-\psi_i}$, $\theta_{1i} = \frac{\delta_{0i}+\delta_{1i}}{1-\psi_i}$ and $\phi_i = (\psi_i - 1)$. The above described panel cointegration framework is coupled with the panel cointegration test of Kao (1999). In outlining the Kao (1999) cointegration test, we assume the residual terms obtained from a panel regression, e_{it}, can be expressed as:

$$e_{it} = \rho\, e_{it} + \sum_{j=1}^{n} \Phi_j \Delta e_{it-j} + v_{itp} \quad (21)$$

And from equation (19) the null hypothesis of no cointegration is given as:

$$H_0: \rho = 1 \quad 22)$$

Kao (1999) suggests that the no cointegration null hypothesis can be tested using the following modified ADF-type test statistic:

$$t_{kao} = \frac{t_{adf} + \sqrt{6N}\,\sigma_v/(2\sigma_{ov})}{\sqrt{\sigma_{ov}^2/(2\sigma_v^2) + 3\sigma_v^2/(10\sigma_{ov}^2)}} \sim N(0,1) \quad (23)$$

Where $t_{adf} = \frac{(\rho-1)[\sum_{i=1}^{N}(e_i^{'}Q_i e_i)]^{\frac{1}{2}}}{s_v}$. In order to econometrically carry out the SPSM procedure to cointegration analysis, we firstly produce a series of individual F-statistics, $F_i = (F_{j1}, F_{j2}, \ldots, F_{jM})$ after carrying out the ARDL bounds test for cointegration on the individual provinces. We then specify our binary object function, ∂, which takes the value of 1 if the panel t_{kao} test statistic rejects the null hypothesis of no cointegration and zero otherwise. We then implement the following 3-stage algorithm to separate the cointegration from non-cointegrated series.

Stage 1: Initially estimate the PMG regression with all individual provinces included in the estimation.

Stage 2: Perform a decision rule in which the Kao test statistic given in equation (13) associated is computed and set $\partial = 0$ if the test statistic is insignificant or else we set $\partial = 1$ if the test statistic is significant. Only if $\partial = 1$ is true that we continue to the next stage, otherwise we stop the procedure.

Stage 3: We identify the individual province which produces a β coefficient with the highest absolute value of the F-statistic and remove it from the panel and re-estimate the PMG on a reducing panel. We then return to stage 2 and repeat the process.

4. Data and results

Our data has been sourced from Quantec online statistical database and consists of total government expenditure, population and economic growth for the nine South African provinces i.e. Western Cape (WC), Eastern Cape (EC), Northern Cape (NC), Free State (FS), Kwa-Zulu Natal (KZN), North West (NW), Gauteng (GP), Mpumalanga (MPL) and Limpopo (LIM).

All data are collected on annual frequency from 2001 to 2016 in their raw form and for empirical purposes the series are converted into their natural logarithms. Moreover, using our empirical data we construct three additional variables; those being; i) government share of GDP (g/y), ii) income per capita (y/p) and iii) government spending per capita (g/p).

Owing to data constraints we do not use Pryor (1969) version and hence we only estimate 5 versions of Wagner's law. Also prior to estimation of our panel regressions, we perform conventional panel unit root tests of Levin et al. (2002) and Im et al. (2002) and the reported results in Table 1 indicate that none of the series is integrated of an order higher than I(1), which is a property of the time series which allows compatible of the variables with our designated methodology.

Table 1 - Unit root test results

Series	LLC		IPS	
	Intercept	Intercept and trend	Intercept	Intercept and trend
g	0.33 [-6.60]***	-1.60* [-5.25]***	3.99 [-4.30]***	-0.32 [-2.26]**
y	-4.78*** [-5.63]***	2.06 [-6.14]***	-1.43* [-3.90]***	3.81 [-3.95]***
g/y	1.49 [-8.02]***	-0.36 [-7.16]***	4.02 [-5.66]***	1.11 [-4.08]***
y/p	-4.41*** [-4.90]***	2.31 [-5.95]***	-1.51* [-3.55]***	4.17 [-3.70]***
g/p	-4.40*** [4.90]***	2.31 [-5.95]***	-1.51* [-3.55]***	4.17 [-3.70]***

Notes: significance codes "***", "**", "*" are 1%, 5% and 10% critical levels, respectively. Test statistics for first difference reported in [].

Our empirical analysis is summarized in the following three steps. In the first step, we compute the F-statistics bounds tests for all individual provinces for all 5 estimated versions of Wagner's law and this amounts to the estimation of 45 individual ARDL regressions. As can be easily observed from the results reported in Table 2, all produced F-statistics fail to exceed their respectively 10 percent upper critical levels hence implying that we cannot rely ARDL framework for empirical purposes. Encouragingly enough, this also implies that out suggested SPSM framework for panel cointegration can be utilized as an alternative.

Table 2 - "Bounds" test for cointegration for individual provinces

Province	G = f(Y)	G = f(Y/P)	G/Y = f(Y/P)	G/P = f(Y/P)	G/Y = f(Y)
WC	1.04	0.80	1.07	0.87	1.26
EC	2.55	2.69	2.37	2.81	2.26
FS	1.14	1.03	1.21	1.09	1.30
GP	3.74	1.78	1.29	2.17	2.67
LIM	1.06	0.83	1.49	0.96	1.76
NW	0.62	0.22	0.54	0.18	1.09
KZN	1.99	1.82	1.71	1.94	1.83
MPL	1.26	0.92	0.87	0.99	1.19
NC	1.23	0.87	1.28	0.94	1.56

The 10% critical values for bounds test are as follows: I(0) – 3.02, I(1) – 3.51.

In the second step of our empirical process, we proceed to implement the SPSM to cointegration discussed in the previous section of the paper. To achieve this we firstly arrange the individual F-statistics obtained in Table 2, from the statistics with the highest rejection (largest F-statistic) to that of the lowest statistic (smallest F-statistic). Note that this has been done for all provinces and for all 5 estimated versions of Wagner's law which are reported in Table 3. Also note that the optimal lags for each of the regressions has been selected based on the minimization of Schwarz information criterion. Then afterwards, we compute the associated Kao (1999) panel statistics for all 5 versions of Wagner's law, firstly for the entire panel (as indicate by sequence 1), and then on a reducing balance, where we firstly remove the province which produces the highest individual F-statistic, which in our case is Gauteng for the Peacock-Wiseman (1961) and Mann (1968) versions of Wagner's law and the Eastern Cape for the remaining versions.

We then re-calculate the Kao (1999) test statistic for the reduced panel and then remove the provinces with the second largest F-statistic, which is now Eastern Cape for Peacock-Wiseman (1961) and Mann (1968) versions, Gauteng for the Gupta version (1967) version and KZN for the Goffman (1968) and Musgrave (1969) versions. Even though by description we are only supposed to carry out the process until the panel Kao cointegration test static fails to detect any cointegration effects, we decide to carry out this procedure throughout all diminishing panel sets for completeness and confirmation sake.

After completing the entire procedure, as reported in Table 3, we observe that panels inclusive of GP, EC and KZN produces significant cointegration effects whereas when these provinces are removed from the panel, the remaining panel regressions indicate no significant cointegration effects. However, we are quick to note that the results obtained for the Musgrave (1969) and Gupta (1967) versions are not as optimistic as none of the computed Kao (1999) statistics can reject the null hypothesis of no panel cointegration whereas that for the Mann (1968) version is only significant with Gauteng included in the panel sample and insignificant once this province is removed from the panel. It is therefore only for the Peacock-Wiseman (1961) version and (2) Pryor (1969) versions that all three provinces (GP, EC and KZN) are found to contribute to the finding of significant Wagner effects in the panel.

Table 3- Kao's (1999) panel cointegration tests on sequential panels

	G = f(Y)		G = f(Y/P)		G/Y = f(Y/P)		G/P = f(Y/P)		G/Y = f(Y)	
Sequence	max F-stat	Kao statistic	max F-stat	panel estimate	max F-stat	panel estimate	max F-stat	panel estimate	max F-stat	panel estimate
1	**GP**	**-2.43 (0.00)*** **	**EC**	**-1.99 (0.47)**	EC	-0.13 (0.45)	EC	-0.34 (0.33)*	**GP**	**-1.61 (0.05)***
2	**EC**	**-1.84 (0.00)*** **	**KZN**	**-1.96 (0.02)** **	KZN	-0.03 (0.49)	GP	-0.32 (0.36)	EC	-1.17 (0.12)
3	**KZN**	**-1.55 (0.06)***	**GP**	**-1.95 (0.02)** **	LIM	0.06 (0.47)	KZN	-0.03 (0.49)	KZN	-0.88 (0.19)
4	MPL	-1.22 (0.11)	FS	-0.59 (0.29)*	GP	0.22 (0.41)	FS	0.16 (0.44)	LIM	-0.45 (0.32)
5	NC	-0.57 (0.28)	MPL	-0.60 (0.19)	NC	0.56 (0.29)	MPL	0.54 (0.29)	NC	-0.10 (0.46)
6	FS	0.02 (0.49)	NC	-031 (0.38)	FS	1.26 (0.10)	LIM	0.97 (0.17)	FS	0.25 (0.40)
7	LIM	0.52 (0.30)	LIM	0.51 (0.30)	WC	1.62 (0.05)	NC	1.19 (0.12)	WC	0.78 (0.22)
8	WC	1.07 (0.14)	WC	1.16 (0.12	MPL	1.95 (0.02)	WC	2.15 (0.02)	MPL	0.95 (0.17)
9	NW	2.38 (0.00)	NW	3.45 (0.00)	NW	3.18 (0.00)	NW	3.39 (0.00)	NW	2.84 (0.00)

Notes: significance codes "***", "**", "*" are 1%, 5% and 10% critical levels, respectively. p-values reported in ().

In the final step of our empirical procedure, we then estimate the long-run coefficients, the short-run coefficients and the error correction terms for our PMG regressions performed for all versions of Wagner's law. These estimates are respectively reported in Tables 4, 5 and 6 and as previously mentioned the optimal lag selection as determined by the Schwarz information criterion is (1,0) for all models. To also ensure robustness of our estimated regressions we use the Newly-West heteroscedasticity and autocorrelation consistent (HAC) estimators. Recall, that according to our rule of thumb, regression estimates are supposed to be produced only for 'panels' which passed the cointegration tests reported in Table 3, and yet, for completeness sake we report all regression estimates on the entire samples of reducing panels. However, to ensure the ease of interpretation, we report the estimates of panels which passed the cointegration tests in bold. A can be observed from Table 4, all long-run regressions for the panels of GP, EC and KZN from the Peacock-Wiseman (1961) and Pryor (1969) version as well as those inclusive of the GP for the Mann (1968) version, all produce positive estimates which are significant at all critical levels. These positive long-run estimates are comparable to those previously obtained in the studies of Ogbonna (2009), Menyah and Wolde-Rufael (2012), Odhiambo (2015) and Phiri (2017).

In turning to the associated short-run coefficients and error correction terms for these significant panels as reported in Tables 4 and 5, respectively, we firstly highlight that all panels obtain negative and highly statistically significant estimates for the short-run coefficients. Similar findings of a negative coefficient estimate are found in the study of Chipaumire et al. (2014). Moreover, all 'significant' panel regressions produce error correction terms which have the correct negative and statistically significant estimates hence implying reversion back to steady-state equilibrium in the face

The Economic Research Guardian – Vol. 8(1)2018
Semi-annual Online Journal, www.ecrg.ro
ISSN: 2247-8531, ISSN-L: 2247-8531
Econ Res Guard 8(1): 25-39

of an exogenous shock to the system.

What can be collectively drawn from our empirical exercise is that while Wagner's law only holds for South African provinces over the long-run, such effects o not exist over the short-run where government size is negatively correlated with economic growth or it's variant measures. However, our analysis also shows that Wagner's law only holds if the GP, EC and KZN provinces are included in the panels, hence implicating that these provinces are responsible for any observed Wagner's law at aggregated levels.

What is further important to realize from our empirical exercise, is that if we had relied strictly on individual ARDL regressions, we would have come to the conclusion of no evidence of Wagner's effect at provincial level, seeing that none of the obtained F-statistics testing cointegration managed to reject the "no cointegration" null hypothesis. On the other hand, if we strictly relied on panel regression estimates for the entire provinces we would have concluded that fiscal budgets are mutual sustainable across the provinces. We therefore consider our empirical exercise as some-what of a success.

Table 4 - Long-run estimates

	G = f(Y)		G = f(Y/P)		G/Y = f(Y/P)		G/P = f(Y/P)		G/Y = f(Y)	
Sequence	max F-stat	panel estimate	max F-stat	panel estimate	max F-stat	panel estimate	max F-stat	panel estimate	max F-stat	panel estimate
1	**GP**	**2.64 (0.00)*** **	**EC**	**3.38 (0.00)*** **	EC	2.11 (0.00)***	EC	3.11 (0.00)***	**GP**	**2.19 (0.00)*** **
2	**EC**	**2.60 (0.00)*** **	**KZN**	**3.90 (0.00)*** **	KZN	2.48 (0.00)***	GP	3.48 (0.00)***	EC	2.16 (0.00)***
3	**KZN**	**2.65 (0.00)*** **	**GP**	**4.79 (0.00)*** **	LIM	3.06 (0.00)***	KZN	3.22 (0.00)***	KZN	2.12 (0.00)***
4	MPL	2.62 (0.00)***	FS	4.67 (0.00)***	GP	3.05 (0.00)***	FS	3.73 (0.00)***	LIM	2.03 (0.00)***
5	NC	2.54 (0.00)***	MPL	4.56 (0.00)***	NC	2.73 (0.01)**	MPL	3.66 (0.00)***	NC	2.01 (0.00)***
6	FS	2.44 (0.00)***	NC	4.61 (0.01)**	FS	2.60 (0.02)**	LIM	3.74 (0.01)**	FS	1.99 (0.00)***
7	LIM	2.39 (0.00)***	LIM	4.31 (0.02)**	WC	2.52 (0.03)*	NC	3.74 (0.01)**	WC	2.07 (0.00)***
8	WC	2.37 (0.00)***	WC	4.30 (0.02)**	MPL	2.50 (0.09)*	WC	3.51 (0.02)**	MPL	2.77 (0.01)**
9	NW	2.93 (0.00)***	NW	3.82 (0.24)	NW	2.39 (0.38)	NW	3.39 (0.22)	NW	3.62 (0.24)

Notes: significance codes "***", "**", "*" are 1%, 5% and 10% critical levels, respectively. p-values reported in ().

Table 5 - Short-run estimates

	G = f(Y)		G = f(Y/P)		G/Y = f(Y/P)		G/P = f(Y/P)		G/Y = f(Y)	
Sequence	max F-stat	panel estimate	max F-stat	panel estimate	max F-stat	panel estimate	max F-stat	panel estimate	max F-stat	panel estimate
1	**GP**	**-1.92 (0.00)*** **	**EC**	**-1.83 (0.00)*** **	EC	-2.69 (0.00)***	EC	-1.83 (0.00)***	**GP**	**-1.92 (0.00)** **
2	**EC**	**-2.07 (0.00)*** **	**KZN**	**-1.70 (0.00)*** **	KZN	-2.55 (0.00)***	GP	-1.68 (0.00)	EC	-2.07 (0.00)***
3	**KZN**	**-1.84 (0.00)*** **	**GP**	**-1.63 (0.00)*** **	LIM	-2.50 (0.00)***	KZN	-1.79 (0.00)***	KZN	-1.79 (0.00)***
4	MPL	-1.78 (0.00)***	FS	-1.74 (0.00)***	GP	-2.57 (0.00)***	FS	-1.73 (0.00)***	LIM	-1.74 (0.00)***
5	NC	-1.56 (0.00)***	MPL	-1.83 (0.00)***	NC	-2.73 (0.00)	MPL	-1.82 (0.00)***	NC	-1.60 (0.00)***
6	FS	-1.34 (0.00)***	NC	-1.63 (0.00)***	FS	-2.59 (0.00)***	LIM	-1.63 (0.00)***	FS	-1.69 (0.00)***
7	LIM	-1.36 (0.00)***	LIM	-1.38 (0.00)***	WC	-2.72 (0.00)***	NC	-1.82 (0.00)***	WC	-1.77 (0.00)***
8	WC	-1.50 (0.00)***	WC	-1.54 (0.00)***	MPL	-2.82 (0.00)***	WC	-1.56 (0.00)***	MPL	-1.09 (0.00)***
9	NW	-1.18 (0.00)***	NW	-1.53 (0.00)***	NW	-2.36 (0.00)***	NW	-1.51 (0.00)***	NW	-1.13 (0.00)***

Notes: significance codes "***", "**", "*" are 1%, 5% and 10% critical levels, respectively. p-values reported in ().

Table 6 - Error correction estimates

	G = f(Y)		G = f(Y/P)		G/Y = f(Y/P)		G/P = f(Y/P)		G/Y = f(Y)	
Sequence	max F-stat	panel estimate	max F-stat	panel estimate	max F-stat	panel estimate	max F-stat	panel estimate	max F-stat	panel estimate
1	**GP**	**-0.18 (0.00)*****	**EC**	**-0.12 (0.00)*****	EC	-0.14 (0.00)***	EC	-0.14 (0.00)***	**GP**	**-0.20 (0.00)*****
2	**EC**	**-0.19 (0.00)*****	**KZN**	**-0.11 (0.00)*****	KZN	-0.13 (0.00)***	GP	-0.13 (0.00)***	EC	-0.21 (0.00)***
3	**KZN**	**-0.17 (0.00)*****	**GP**	**-0.09 (0.00)*****	LIM	-0.11 (0.00)***	KZN	-0.12 (0.00)***	KZN	-0.19 (0.00)***
4	MPL	-0.15 (0.00)***	FS	-0.08 (0.00)***	GP	-0.13 (0.00)***	FS	-0.10 (0.00)***	LIM	-0.17 (0.00)***
5	NC	-0.10 (0.00)***	MPL	-0.09 (0.01)***	NC	-0.12 (0.00)***	MPL	-0.12 (0.00)***	NC	-0.18 (0.00)***
6	FS	-0.10 (0.00)***	NC	-0.07 (0.00)***	FS	-0.13 (0.00)***	LIM	-0.09 (0.00)***	FS	-0.21 (0.00)***
7	LIM	-0.11 (0.01)**	LIM	-0.07 (0.05)*	WC	-0.15 (0.00)***	NC	-0.11 (0.00)***	WC	-0.23 (0.05)*
8	WC	-0.15 (0.00)***	WC	-0.11 (0.02)**	MPL	-0.18 (0.00)***	WC	-0.13 (0.00)***	MPL	-0.14 (0.03)*
9	NW	-0.18 (0.00)***	NW	-0.13 (0.02)**	NW	-0.15 (0.00)***	NW	-0.15 (0.00)***	NW	-0.08 (0.00)***

Notes: significance codes "***", "**", "*" are 1%, 5% and 10% critical levels, respectively. p-values reported in ().

5. Conclusion

In our study we extend the SPSM method and implement it within the setting of a cointegration framework. We consider this an important contribution to literature more particularly for researchers investigating economic relationships which require the use of time series estimation techniques and yet have short associated time series data to work with. In such instances, panel time series data consisting of multiple countries or regions can be used and through the use of the SPSM technique demonstrated in this paper, one can retain the power of panel regression estimates yet retain the heterogeneity advantages presented by individual country/region estimates. Through an application of the SPSM method of cointegration to Wagner's law for South African provinces, we find that panels consisting of Gauteng, Eastern Cape and Kwazulu-Natal find significant Wagner effects whereas, when these provinces are removed from the panels, cointegration effects are absent.

Overall, three main conclusions can be drawn from our empirical analysis. Firstly, the Musgrave and Gupta versions of Wagner's law do not hold for any of the South African provinces implying that government size is not related to per capita income in any of the provinces. Secondly, an increase in government spending improves aggregate economic growth in Gauteng, Eastern Cape and Kwa-

Zulu Natal provinces whilst no such relationship holds for the remaining provinces. Lastly, fiscal authorities are advised to design different fiscal policies for the different provinces rather than relying on one aggregated policy rule applicable to all provinces. The identification of provincial specific fiscal rules can provided a suitable avenue for future research.

References

Ansari M, Gordon D, Akuamoah C (1997). Keynes versus Wagner: Public expenditure and national income for three African countries. *Applied Economics*. 29: 543-550.

Anyikwa I, Haaman N, Phiri A (2018). Persistence in suicides of G20 countries: SPSM approach to three generations of unit root tests. MPRA Working Paper No. 87790: July.

Calitz E, Du Plessis S, Siebrits F (2014). Fiscal sustainability in South Africa: Will history repeat itself? *Journal of Studies in Economics and Econometrics*. 38(3): 55-78.

Chang T, Wu T, Gupta R (2015). Are hosue prices in South Africa really nonstationary? Evidence form SPSM-based panel KSS test with Fourier function. *Applied Economics*. 47(1): 32-53.

Chipaumire G, Ngirande H, Method M, Ruswa Y (2014). The impact of government spending on economic growth: Case South Africa. *Mediterranean Journal of Social Sciences*. 5(1): 109-118.

Chortareas G, Kapetanois G (2009). Getting PPP right: Identifying mean-reverting real exchange rates in panels. *Journal of Banking and Finance*. 30(2): 390-404.

Goffman I (1968). On the empirical testing of Wagner's law: A technical note. *Public Finance*. 23(3): 359-364.

Gupta S (1967). Public expenditure and economic growth: A time series analysis. *Public Finance*. 22: 423-461.

Im K, Pesaran M, Shin Y (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics*. 115(1): 53-74.

Kao C (1999). Spurious regression and residual-based tests for cointegration in panel data. *Journal of Econometrics*. 90(1): 1-44.

Lee K (2014). Is per capita GDP stationary in China? Sequential panel selection method. *Economic Modelling*. 37: 507-517.

Levin A, Lin C, Chu J (2002). Unit root tests in panel data: asymptotic and finite sample properties. *Journal of Econometrics*. 108(1): 1-24.

Li X, Tang D (2014). CO2 emissions converge in the 50 U.S. states – Sequential panel selection method. *Economic Modelling*. 40: 320-333.

Maddala G (1987). Limited dependent variable models using panel data. *Journal of Human Resources*. 22(3): 307-338.

Mann A (1980). Wagner's law: An econometric test for Mexico 1926-1976. *National Tax Journal*. 33: 189-201.

Menyah K, Wolde-Rufael Y (2012). Wagner's law revisited: A note from South Africa. *South African Journal of Economics*. 80(2): 200-208.

Musgrave R. (1969). *Fiscal systems*. New Haven: Yale University Press.

Narayan P, Nielsen I, Smyth R (2008). Panel data, cointegration, causality and Wagner's law: Empirical evidence form Chinese provinces. *China Economic Review*. 19(2): 297-307.

Odhiambo N (2015). Government spending and economic growth in South Africa. *Atlantic Economic Journal*. 43(3): 393-406.

Ogbonna B (2009). Testing Wagner's law of government size for South Africa. *Journal of Research in National Development*. 7(2): 1596-8308.

Peacock A, Wiseman J (1961) *The growth of public expenditure in the United Kingdom*. Princeton: Princeton University Press.

Pesaran H, Shin Y, Smith R (1999). Pooled mean group estimation of dynamic heterogenous panels. *Journal of the American Statistical Association*. 94(446): 621-634.

Pesaran M, Shin Y, Smith R (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Econometrics*. 16(3): 289-326.

Phiri A (2017). Nonlinearities in Wagner's law: Further evidence from South Africa. *International Journal of Sustainable Economy*. 9(3): 231-249.

Pryor F (1969). *Public expenditures in communist and capitalist nations*. London: George Allen and Unwin.

Ziramba E (2008). Wagner's law: An econometric test for South Africa, 1960-2006. *South African Journal of Economics*. 76(4): 596-606.