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A SEQUENTIAL PANEL SELECTION APPROACH TO COINTEGRATION ANALYSIS: AN APPLICATION TO WAGNER'S LAW FOR SOUTH AFRICAN PROVINCIAL DATA

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ABSTRACT: This study extends 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 between 2001 and 2016. We note 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 since available data on government expenditure and economic growth for South African provinces is limited to annual data spanning from 2001 to 2016. Secondly, a number of previous works have studied this relationship from an aggregated country perspective (Ansari et al. (1997), Ziramba (2008), Ogbonna (2009), Menyah and Wolde-Rufael (2012), Chipaumire et al. (2014) and Odhiambo (2015)) hence ignoring the possible differences existing within provincial budgets. And with the economy struggling to recuperate from the repercussions of the 2009-2010 global recession period, much emphasis has been put on fiscal policy as a vital catalyst for economic recovery.

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 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, 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. We note the ambiguity observed in these previous findings may be due to the aggregated approach taken by the aforementioned authors 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 Wagners 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 specifications

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) (2)

G = f(Y/P) (3)

G/Y = f(Y/P) (4)

G/P = f(Y/P) (5)

G/Y = f(Y) (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:

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

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

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

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

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

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

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 α_1, …, α_2 and ϕ_1, …, ϕ_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:

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

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

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

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

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

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

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

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}, …, 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	-1.60*	3.99	-0.32
	[-6.60]***	[-5.25]***	[-4.30]***	[-2.26]**
y	-4.78***	2.06	-1.43*	3.81
	[-5.63]***	[-6.14]***	[-3.90]***	[-3.95]***
g/y	1.49	-0.36	4.02	1.11
	[-8.02]***	[-7.16]***	[-5.66]***	[-4.08]***
y/p	-4.41***	2.31	-1.51*	4.17
	[-4.90]***	[-5.95]***	[-3.55]***	[-3.70]***
g/p	-4.40***	2.31	-1.51*	4.17
	[4.90]***	[-5.95]***	[-3.55]***	[-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**	**EC**	**-1.99**	EC	-0.13	EC	-0.34	**GP**	**-1.61**
		(0.00)***		**(0.47)**		(0.45)		(0.33)*		**(0.05)***
2	**EC**	**-1.84**	**KZN**	**-1.96**	KZN	-0.03	GP	-0.32	EC	-1.17
		(0.00)***		**(0.02)****		(0.49)		(0.36)		(0.12)
3	**KZN**	**-1.55**	**GP**	**-1.95**	LIM	0.06	KZN	-0.03	KZN	-0.88

		(0.06)*		**(0.02)****		(0.47)		(0.49)		(0.19)
4	MPL	-1.22	FS	-0.59	GP	0.22	FS	0.16	LIM	-0.45
		(0.11)		(0.29)*		(0.41)		(0.44)		(0.32)
5	NC	-0.57	MPL	-0.60	NC	0.56	MPL	0.54	NC	-0.10
		(0.28)		(0.19)		(0.29)		(0.29)		(0.46)
6	FS	0.02	NC	-031	FS	1.26	LIM	0.97	FS	0.25
		(0.49)		(0.38)		(0.10)		(0.17)		(0.40)
7	LIM	0.52	LIM	0.51	WC	1.62	NC	1.19	WC	0.78
		(0.30)		(0.30)		(0.05)		(0.12)		(0.22)
8	WC	1.07	WC	1.16	MPL	1.95	WC	2.15	MPL	0.95
		(0.14)		(0.12		(0.02)		(0.02)		(0.17)
9	NW	2.38	NW	3.45	NW	3.18	NW	3.39	NW	2.84
		(0.00)		(0.00)		(0.00)		(0.00)		(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 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**	**EC**	**3.38**	EC	2.11	EC	3.11	**GP**	**2.19**
		(0.00)***		**(0.00)*****		(0.00)***		(0.00)***		**(0.00)*****
2	**EC**	**2.60**	**KZN**	**3.90**	KZN	2.48	GP	3.48	EC	2.16
		(0.00)***		**(0.00)*****		(0.00)***		(0.00)***		(0.00)***
3	**KZN**	**2.65**	**GP**	**4.79**	LIM	3.06	KZN	3.22	KZN	2.12
		(0.00)***		**(0.00)*****		(0.00)***		(0.00)***		(0.00)***
4	MPL	2.62	FS	4.67	GP	3.05	FS	3.73	LIM	2.03
		(0.00)***		(0.00)***		(0.00)***		(0.00)***		(0.00)***
5	NC	2.54	MPL	4.56	NC	2.73	MPL	3.66	NC	2.01
		(0.00)***		(0.00)***		(0.01)**		(0.00)***		(0.00)***
6	FS	2.44	NC	4.61	FS	2.60	LIM	3.74	FS	1.99
		(0.00)***		(0.01)**		(0.02)**		(0.01)**		(0.00)***
7	LIM	2.39	LIM	4.31	WC	2.52	NC	3.74	WC	2.07
		(0.00)***		(0.02)**		(0.03)*		(0.01)**		(0.00)***
8	WC	2.37	WC	4.30	MPL	2.50	WC	3.51	MPL	2.77
		(0.00)***		(0.02)**		(0.09)*		(0.02)**		(0.01)**
9	NW	2.93	NW	3.82	NW	2.39	NW	3.39	NW	3.62
		(0.00)***		(0.24)		(0.38)		(0.22)		(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**	**EC**	**-1.83**	EC	-2.69	EC	-1.83	**GP**	**-1.92**
		(0.00)***		**(0.00)*****		(0.00)***		(0.00)***		**(0.00)****
2	**EC**	**-2.07**	**KZN**	**-1.70**	KZN	-2.55	GP	-1.68	EC	-2.07
		(0.00)***		**(0.00)*****		(0.00)***		(0.00)		(0.00)***

3	**KZN**	**-1.84**	**GP**	**-1.63**	LIM	-2.50	KZN	-1.79	KZN	-1.79
		(0.00)* **		**(0.00)*** **		(0.00)***		(0.00)***		(0.00)***
4	MPL	-1.78	FS	-1.74	GP	-2.57	FS	-1.73	LIM	-1.74
		(0.00)***		(0.00)***		(0.00)***		(0.00)***		(0.00)***
5	NC	-1.56	MPL	-1.83	NC	-2.73	MPL	-1.82	NC	-1.60
		(0.00)***		(0.00)***		(0.00)		(0.00)***		(0.00)***
6	FS	-1.34	NC	-1.63	FS	-2.59	LIM	-1.63	FS	-1.69
		(0.00)***		(0.00)***		(0.00)***		(0.00)***		(0.00)***
7	LIM	-1.36	LIM	-1.38	WC	-2.72	NC	-1.82	WC	-1.77
		(0.00)***		(0.00)***		(0.00)***		(0.00)***		(0.00)***
8	WC	-1.50	WC	-1.54	MPL	-2.82	WC	-1.56	MPL	-1.09
		(0.00)***		(0.00)***		(0.00)***		(0.00)***		(0.00)***
9	NW	-1.18	NW	-1.53	NW	-2.36	NW	-1.51	NW	-1.13
		(0.00)***		(0.00)***		(0.00)***		(0.00)***		(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**	**EC**	**-0.12**	EC	-0.14	EC	-0.14	**GP**	**-0.20**
		(0.00)* **		**(0.00)*** **		(0.00)***		(0.00)***		**(0.00)*** **
2	**EC**	**-0.19**	**KZN**	**-0.11**	KZN	-0.13	GP	-0.13	EC	-0.21
		(0.00)* **		**(0.00)*** **		(0.00)***		(0.00)***		(0.00)***
3	**KZN**	**-0.17**	**GP**	**-0.09**	LIM	-0.11	KZN	-0.12	KZN	-0.19
		(0.00)* **		**(0.00)*** **		(0.00)***		(0.00)***		(0.00)***
4	MPL	-0.15	FS	-0.08	GP	-0.13	FS	-0.10	LIM	-0.17
		(0.00)***		(0.00)***		(0.00)***		(0.00)***		(0.00)***

5	NC	-0.10	MPL	-0.09	NC	-0.12	MPL	-0.12	NC	-0.18
		(0.00)***		(0.01)***		(0.00)***		(0.00)***		(0.00)***
6	FS	-0.10	NC	-0.07	FS	-0.13	LIM	-0.09	FS	-0.21
		(0.00)***		(0.00)***		(0.00)***		(0.00)***		(0.00)***
7	LIM	-0.11	LIM	-0.07	WC	-0.15	NC	-0.11	WC	-0.23
		(0.01)**		(0.05)*		(0.00)***		(0.00)***		(0.05)*
8	WC	-0.15	WC	-0.11	MPL	-0.18	WC	-0.13	MPL	-0.14
		(0.00)***		(0.02)**		(0.00)***		(0.00)***		(0.03)*
9	NW	-0.18	NW	-0.13	NW	-0.15	NW	-0.15	NW	-0.08
		(0.00)***		(0.02)**		(0.00)***		(0.00)***		(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.

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