A SEQUENTIAL PANEL SELECTION METHOD (SPSM) TO REGRESSION ESTIMATES: AN APPLICATION TO THE REVENUE-EXPENDITURE RELATIONSHIP IN SOUTH AFRICAN PROVINCES

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Abstract - This paper extends the sequential panel selection method (SPSM) to the case of regression estimates as a means exploiting the power properties presented by panel estimates whilst retaining the heterogeneity advantages offered country-specific estimates. As an application we apply this technique to investigate the expenditure-revenue relationship for 12 South African provinces using the annual data spanning from 2000 to 2016. We find that the SPSM method can be effectively used to segregate the provinces with sustainable budgets from those with less sustainable budgets while preserving the power advantages presented by pane estimation techniques.

Index Terms - Sequential panel selection method (SPSM); ordinary least squares (OLS), panel ordinary least squares (POLS) revenue-expenditure, South Africa.

I. INTRODUCTION

One of the most pressing issues econometricians face when investigating economic issues using time series analysis for developing countries, such as African and Latin American countries, is the lack of long spans of time series economic variables. To deal with these sample size problems, many econometricians have turned to panel-based techniques in which increased sample sizes advantages associated with a large number of countries or regions and this circumvents problems of low power properties associated with individual country estimates.

Note setting aside the positive attributes of panel estimates, on constant worry with panel-based frameworks is their generalization of a single regression finding for a host of countries or regions which are characterized by multidimensional differences. Recently Chortareas and Kapetanois (2011) formally address this concern by introducing the sequential panel selection method (SPSM). In a nutshell, this technique carefully integrates the magnified power properties associated with 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 investigating the purchasing power parity (PPP) for 25 OECD countries. Similarly, subsequent studies subsequently applied the SPSM approach have monotonously done so for unit root purposes.

In our study we extend the SPSM approach to the case of simple regression analysis. For demonstration purposes we make an application to the revenue-expenditure relationship for 9 South African provinces. We consider this task relevant since available data on government expenditure and government revenue for South African provinces are obtainable on an annual basis between 2001 and 2016. Secondly, a number of previous works have studied this relationship from an aggregated country perspective hence ignoring the possibility 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 the methodology of the study, section 3 the data and empirical findings and section 4 concludes the study.

II. METHODOLOGY

The revenue-expenditure relationship for each individual South African province can be represented by the following bi-variate regression equation:

$$REV_t = \alpha + \beta\, EXP_t + e_t \quad (1)$$

Where rev_t is a measure of provincial revenue and exp_t is a measure of provincial expenditure. The rule of thumb is that fiscal budgets are sustainable if $\beta = 1$ whereas if $\beta < 1$, then provincial budgets are unsustainable with the degree of unsustainability increasing as β approaches 0. The panel version of regression (1) can be specified as follows:

$$REV_t = \alpha + \beta\, EXP_t + e_t \quad (2)$$

In order to econometrically carry out the SPSM

procedure, we firstly produce a series of individual coefficient estimates for each of the individual provinces which yields a series of β coefficients i.e. β_{j1}, β_{j2}, …., β_{jM}, with associated t-statistics, $t_i = (t_{j1}, t_{j2}, \ldots, t_{jM})$. Our objective is to estimate a binary object, ∂, which takes the value of 1 if the panel coefficient β form equation (2) is significant and positive and 0 otherwise. Thereafter we implement the following 3-stage algorithm to separate the positive estimates from the negative and/or insignificant estimates.

Stage 1: Initially estimate panel regression (2) with all individual provinces included in the estimation.

Stage 2: Perform a decision rule in which the t-statistic associated is computed and set $\partial = 0$ if the test statistic is insignificant whereas we set $\partial = 1$ if the t-statistic is statistically 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 t-statistic and remove it from the panel and re-estimate regression (2) on a reducing panel. We then return to stage 2 and repeat the process.

III. DATA AND EMPIRICAL FINDINGS

Our data has been collected from Quantec online statistical database and consists of total government revenue and total government expenditure 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 Rand value and for empirical purposes the series are converted into logarithmic form. Also prior to estimation of our panel regressions, we perform conventional panel unit root tests of Levin et al. (2002) and Breitung (2002) and report the results in Table. Note that both tests are performed with an intercept and trend.

Table 1 reports the LLC unit root test performed with an intercept and trend. As can be observed both time series variables are levels stationary, at significance levels of at least 10 percent, which is a property of the time series which allows compatible of the variables with the panel ordinary last squares (POLS) estimation technique.

Table 1: Panel unit root tests

	Rev	Exp
Levin, Lin, Chu	-1.76 (0.03)*	-1.66 (0.04)*
Breitung	-2.29 (0.01)**	-1.73 (0.04)*

Significance codes: "", "*" are the 5% and 10% critical levels, respectively. P-values reported in parentheses.**

Table 2 presents the empirical findings after performing the SPSM approach to our regression estimates. In order to ensure robustness of our regressions we estimate our OLS and POLS regressions with a robust variance-covariance matrix. We begin the estimation process by providing the individual provincial estimates from regression (1) and we report the results in the left hand side of the Table 2 in order of the province which produces the β coefficient associated with the highest t-statistic all the way through to the province which produces the β coefficient associated with the lowest t-statistic. Based on the obtained sequences from the individual provinces, we then proceed to estimate the panel regression (2), firstly with the entire panel, and then on a reducing panel with the provinces with the highest t-statistics being sequentially removed after each panel estimation.

In our case, the entire panel produces a β coefficient of 1.00 which is highly significant with an associated t-statistic of 746.82. Note that this evidence points to fiscal budgets being perfectly sustainable for all provinces. We then remove Mpumalanga from the dataset, since this province produces the highest individual t-statistic of 400.54 and re-estimate the panel regression. Take note that the β coefficient estimate remains the same, in the sense of being of value 1 and highly significant, yet note that the t-statistic is of a lower value at 356.37. We then continue the process, by sequentially removing Western Cape from the panel, then Free State, then Kwazulu Natal, then Northern Cape, then Limpopo, and finally Gauteng. In summarizing the findings after running through the whole sequence, is that fiscal budgets are sustainable for the panel of Mpumalnga, Western Cape, Free State, KwaZulu Natal, Northern Cape and Limpopo provinces. The remaining three provinces, North West, Gauteng and the Eastern Cape provinces, produce β coefficients which point to a less sustainable fiscal budgets compared to the rest of the provinces. What is important to realize is that if we had relied strictly on panel regressions estimates, then we would have come to the conclusion that fiscal budgets are mutual sustainable across the provinces. On the other hand, if we relied on the individual OLS estimates for each of the provinces we would have lost a substantial amount of power in the regression due to small sample size. Moreover, the provinces with lowest fiscal sustainability associated with OLS estimates are different from those obtained from the more powerful panel estimates.

Table 2: Empirical estimates

Panel estimates			Provincial estimates		
coefficient	t-statistic		series	coefficient	t-stat
1.00	746.82		MPL	1.00	400.54
1.00	597.74		WC	1.01	356.37
1.00	560.62		FS	0.99	226.32
1.00	516.15		KZN	1.00	194.00
1.00	488026		NC	1.00	172.77
1.00	430.06		LIM	1.01	170.92
0.99	379.35		NW	1.00	149.02
0.99	309.52		GP	1.00	114.95
0.98	91.42		EC	0.98	91.42

Significance codes: "", "*" are the 5% and 10% critical levels, respectively.**

CONCLUSION

In our study we extend the SPSM method and implement it within the setting of regression estimates. 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. Even though this technique has been currently applied to simple OLS/POLS setting, this procedure can be easily extended by researchers to a more comprehensive multivariate cointegration framework.

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