MACROECONOMIC DYNAMICS OF INCOME GROWTH: EVIDENCES FROM ARDL BOUND APPROACH, GMM AND DYNAMIC OLS

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ABSTRACT

Using the annual data from 1980 through 2015, and applying the Autoregressive Distributed Lag (ARDL) Bound Approach, Dynamic OLS (DOLS) and Generalized Method of Moments (GMM) methodologies, this paper attempts to identify some major macroeconomic drivers of income growth in South Carolina. The ARDL Bounds testing approach, proposed by Pesaran, Shin, and Smith (2001) has several advantages compared to widely used Johansen and Juselius (1990) cointegration technique. One advantage is that it lends itself to estimating the long-run relationship without requiring the pretesting of the presence of unit root. Also, the error-correction modeling by the ARDL cointegration procedure facilitates both short-run and the long-run causality. The long-run results show that capital investment, export, government expenditure, and new business have significant positive effect on the growth of income. The short run dynamic results confirm that capital investment, export, government expenditure and new business establishment have significant and positive impact on income growth. The long term estimates indicate that a 1% increase in capital investment, export, government expenditures, and new business would increase income growth by 7.71, 33.7, 16.89, and 28.4 percent respectively. Also, GMM and Dynamic OLS estimates find capital investment, export, government expenditures and new business have significant and positive impact on income growth. The results imply a commitment to export promotion, capital investment, government expenditures and new business are important ingredients for successful state growth strategy.

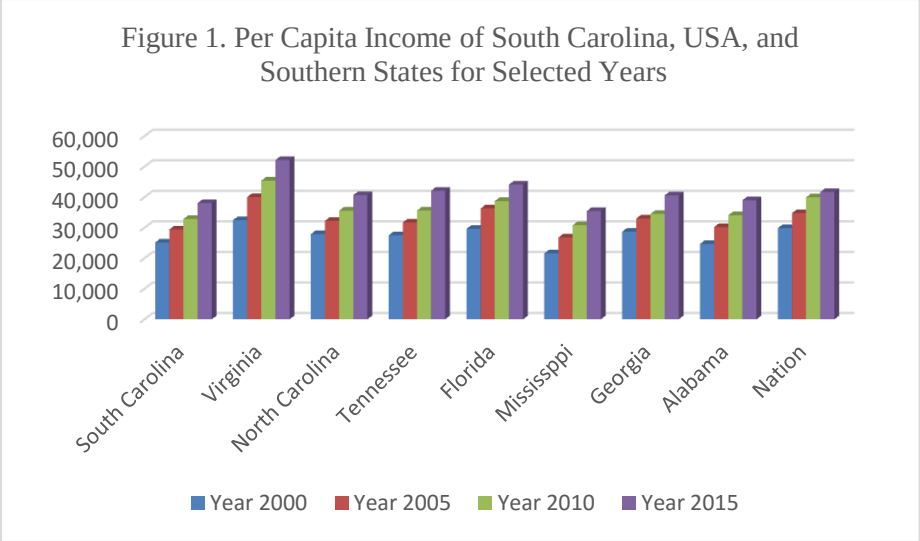
Keywords: Income Growth, ARDL Bound Approach, DOLS, GMM.

INTRODUCTION

The per capita income of South Carolina lags behind the nation and most of the Southern states (Figure 1). While Georgia, Florida, North Carolina, Tennessee, Virginia, and the US average reached $40,000 or more in 2015, Alabama, Mississippi, and South Carolina are behind the national average. According to the Bureau of Economic Analysis, the population of South Carolina was closer to 5 million in 2015 and ranked 23rd in the nation (BEA, March 2016). The same report indicates that the State had per capita personal income of $38,041. This is ranked 47th in the US. Since 2009 the per capita personal income of South Carolina as a percent of the United States has been declining.

This trend and disparity of economic well-being of the state should be of great concern to economic policy makers who are designing economic development strategies. In developing strategies, it is important to know and understand the dynamic causalities or the factors that influence per capita income so that intervention can take place to reverse trends by promoting and enhancing programs that will boost the economic well-being of the state.

Figure 1. Per Capita Income of South Carolina, USA, and Southern States for Selected Years



Source: Bureau of Economic Analysis (www.bea.gov).

This paper investigates the dynamic short-run and long-run relationship among the growth in per capita income, and macroeconomic variables such as export, capital investment, government expenditure and new business establishment. The panel unit root, ARDL cointegration, dynamic OLS (DOLS), and Generalized Method of Moments (GMM) estimation methodologies are applied for the period 1980-2015. To the best of our knowledge, similar empirical studies are not available. The remainder of the paper provides a brief review of directly related literature followed by empirical methodologies and data, results, discussion and conclusions.

LITERATURE REVIEW

The theory of economic growth and development suggests that the long term per capita income growth is dependent on the growth of macroeconomic variables such as capital investment, the productivity of human resources, government expenditure, new business establishments, the level of export activities and other economic activities. Solow (1957) provides a framework of long-term determinants of economic growth as a function of growth in capital and labor. According to Elmendorf and Mankiw (1998), reduced domestic investment over a period of time will result in a smaller domestic capital stock, which in turn implies lower output and income. In addition, reduced net foreign investment over a period of time means that domestic residents will own less capital abroad (or that foreign residents will own more domestic capital). In either case, the capital income of domestic residents will fall.

The need for South Carolina to improve the quality of its workforce in order to compete in the global, knowledge-based economy was examined by Shannon (2007). The study finds several factors that hinder the state to improve the quality of its workforce include the lack of broad effective leadership and communication or strong relationships with economic development organizations. The need to speed-up economic development in South Carolina is examined by Harrell (2006). The study suggests that the state must redouble its economic development efforts to stimulate job growth. The article outlines three steps. First, the need is to aggressively recruit companies to South Carolina. This will help in creating better jobs. Next is to identify and implement ways to help large and small South Carolina companies thrive. Finally, the state must transform research universities into economic engines. It is

going to take the cooperation of government and business leaders to transform the state to a knowledge-based economy.

Hammond and Thompson (2006) found little role for public capital investment in either metropolitan or non-metropolitan regions, but that manufacturing investment tended to spur growth in non-metropolitan regions, in contrast to results for metropolitan regions. Further, the study finds some evidence which suggests that human capital investment (measured by college-level educational attainment) may not have a significant positive impact on growth in non-metropolitan labor market areas, in contrast to metropolitan areas. However, these results are only suggestive. The issue of global competition and public policy response is analyzed by Barkley, Henry and Nair (2006). The study suggests the creation of a geographic concentration of innovative activity (regional innovation systems [RIS]) that will enhance metropolitan economic development through knowledge spillovers, product development, and new firm spin-offs. This article identifies three RIS in the thirteen southern states based on cluster analysis of twenty indicators of innovative and entrepreneurial activity.

The impact of policy to attract investors plays crucial role. For example, Miley and Associates (2010) make a note of the great impact of Boeing and BMW's investments on manufacturing employment and gross state product. The study indicates that these two investments have significant impact on South Carolina's manufacturing jobs, and incomes of the people. Similarly, Kuker (2011) offers an analysis of incentives to the Boeing Company of South Carolina such as the House Bill 3130 that provides benefits including tax exemptions and economic development bonds enjoyed by the Airbus SAS and Boeing.

Woodward (2013) uses South Carolina's economic development experience as a case study of significant challenge in regional development. The study urges caution regarding development incentives as a regional strategy and suggests that stronger agglomeration and cluster-based strategies are better suited to promote economic development. Meacham (2010) examines economic development policies created in North and South Carolina to attract aircraft industry manufacturing facilities.

METHODOLOGY

Cointegration- ARDL Bounds Testing Approach

This study uses the ARDL bounds testing approach introduced by Pesaran and Shin (1999) and extended by Pesaran, Shin and Smith (2001) to investigate the co-integration relationship among capital investment, export, government expenditure, new business and income growth. This test has several advantages over previous co-integration tests, such as the residual-based technique by Robert and Granger (1987) and Full Maximum Likelihood (FML) test based on Johansen (1988, 1991) and on Johansen and Juselius (1990). First, unlike other co-integration techniques, the ARDL bounds testing approach does not impose the restrictive assumption that all the variables under study must be integrated of the same order. The ARDL approach can be applied to test the existence of a co-integrating relationship among variables regardless of whether the underlying repressors are integrated of order one [I(1)], order zero [I(0)], or fractionally integrated.

Second, conventional co-integration methods estimate the long-run relationships within the context of a system of equations, the ARDL method employs only a single reduced form equation (Pesaran & Shin, 1999). Third, the ARDL technique generally provides unbiased estimates of the long-run model and valid t statistics – even when some of the regressors are

endogenous (Odhiambo, 2007; Odhiambo, 2010). Fourth, while other co-integration techniques are sensitive to the size of the sample, the ARDL test is suitable even when the sample size is small. Thus, the ARDL test has superior small sample properties compared to the Johansen and Juselius (1990) co-integration test. Consequently, the approach is considered very suitable for analyzing the underlying relationship and it has been increasingly used in empirical research in recent years. Based on the previous studies and the availability of data, the following double-log model is specified.

$$LNPI_t = \beta_0 + \beta_1 LCINt + \beta_2 LSEXt + \beta_3 LSGE_t + \beta_4 LNBE_t + \mu_t \quad (1)$$

Where, $LNPI_t$ = natural log of Personal Income; $LCIN_t$ = natural log of capital investment, $LSEX_t$ = natural log of South Carolina export, $LSGE_t$ = Natural log of South Carolina government expenditure, and $LNBE_t$ = Natural log of new business. A priori expected signs of coefficients are $\beta_1>0$, $\beta_2>0$ and $\beta_3>\beta_4>0$. An ARDL representation of equation (1) is

$$\begin{aligned}\Delta LNPI_t = {} & \beta_0 + \beta_1 \mathrm{T} + \sum_{i=1}^{p} \beta_2 \Delta \mathrm{LNPI}_{t-i} + \sum_{i=1}^{p} \beta_3 \Delta \mathrm{LCIN}_{t-i} + \sum_{i=1}^{P} \beta_4 \Delta \mathrm{LSEX}_{t-i} \\ & + \sum_{i=1}^{P} \beta_5 \Delta \mathrm{LSGE}_{t-i} + \sum_{i=1}^{P} \beta_6 \Delta \mathrm{LNBE}_{t-i} + \gamma_1 \mathrm{LNPI}_{t-1} + \gamma_2 LCIN_{t-1} \\ & + \gamma_3 \mathrm{LSEX}_{t-1} + \gamma_4 \mathrm{LSGE}_{t-1} + \gamma_5 \mathrm{LNBE}_{t-1} \end{aligned} \quad (2)$$

Where Δ is the first difference, the parameters β_{ij} are the short-run parameters and γ_{ij} are the long run multipliers respectively in equation (2). The null and alternative hypotheses are:

$$H_0: \gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = 0$$
$$H_1: \gamma_1 \neq \gamma_2 \neq \gamma_3 \neq \gamma_4 \neq \gamma_5 \neq 0$$

Once the selected long run model is estimated, then the short run dynamic elasticities of the variable within the framework of the errors-correction representation of the ARDL model is estimated as follows in equation 3.

$$\Delta LNPI_t = \beta_0 + \beta_{1i}^{P} \Delta LNPI_{t-i} + \sum_{i=0}^{p} \beta_2 \Delta LCIN_{t-i} + \sum_{i=0}^{p} \beta_3 \Delta LSEX_{t-i} + \sum_{i=0}^{p} \beta_4 \Delta LSGE_{t-i}$$
$$+ \sum_{i=1}^{P} \beta_5 \Delta \mathrm{LNBE}_{t-i} + \Phi ECM + \mu_t \quad (3)$$

Where Φi is the speed of adjustment and ECM_{t-i} is the residual obtained from equation (2)

Dynamic OLS (DOLS)

The ARDL co-integration test is complimented with the dynamic OLS (DOLS) estimates. The panel Dynamic Ordinary Least Squares (DOLS) methodology will provide the estimation of the statistic long-run relation augmented by leads and lags. This will improve the efficiency of the long-run estimates but does not provide guidance on the short-run behavior. The following model is estimated:

$$LNPI_t = \delta_0 + \delta_1 LCIN_t + \delta_2 LSEX_t + \delta_3 LSGE_t + \delta_4 LNBE_t + \varepsilon_t \quad (4)$$

GMM method

This paper also uses the GMM methodology developed by Arellano and Bond (1991) and Arellano and Bover (1995). The advantage of this methodology is that it points out the

econometric problems caused by unobserved effects and endogeneity of the independent variables in lagged–dependent-variable models such as income growth. This methodology allows the relaxing of strong erogeneity of the explanatory variables by allowing them to be correlated with current and previous realizations of the error term. The following model is estimated:

$$\Delta LNPI_t = \alpha_0 + \alpha_1 \Delta LCIN_t + \alpha_2 \Delta LSEX_t + \alpha_3 \Delta LSGE_t + \alpha_4 \Delta LNBE_t + \varepsilon_t \qquad (5)$$

RESULTS

Data and Sources

Annual data from 1980 through 2015 are employed. Personal income (NPI) capital Investment (CIN), export (SEX), government expenditure(SGE) and New Business (NBE) data from Bureau of Economic Analysis, SC Department of Commerce, Bureau of Economic Analysis, US Census Bureau and SC Department of Commerce respectively.

Stationarity Tests

In order to examine the integrating level of variables, DF-GLS, Philips–Peron, and Parron (1997) tests are employed. The results are reported in Table 1. The results reported in Table 1 show that after differencing the variables, all variables were confirmed to be stationarity. The ARDL test does not require the pretesting of variables, the test gives guidance as to whether ARDL is applicable or not. ARDL is applicable to the analysis of variables which are integrated of order zero {1(0)} or one {1(1)}. It is clear from the tests that variables are stationary after first difference. So, the ARDL bounds test can be done satisfactorily.

Table 1. Stationarity for all Variables

Dickey-Fuller Generalized Least Square (DF-GLS)				
Variable	Levels		First Difference	
	Without Trend	With Trend	Without Trend	With Trend
LNPI	-0.3480	-0.1460	0.9477	-5.0013***
LCIN	-2.4649**	-3.1217**	-6.6577**	6.4570***
LSEX	0.6613	-2.4574	-9.9163***	-10.3932***
LSGE	-0.6662	-0.3773	-0.2763	-3.0990*
LNBE	0.6288	1.4584	-3.4958***	-3.5058**
Philips-Perron (PP)				
LNPI	-0.5047	0.8561	1.0025	-2.1832*
LCIN	0.0608	-3.1217	-7.0303***	-7.1090***
LSEX	0.0311	-12.5930	-4.8075	-12.9013
LSGE	-3.6921***	-2.4710	-2.4771	-3.7701
LNBE	-0.3791	-2.4298	-5.9969***	5.9417***
Ng-Perron				
LNPI	0.7936	0.2646	1.0020	2.1715**
LCIN	-2.0468	-2.3646	-2.5172**	-2.7638*
LSEX	-1.6216	-6.4419**	-1.0092	6.4419***
LSGE	0.5861	0.2646	-1.0020	-2.1832
LNBE	-2.3855	-0.3557	-0.3618	11.2668***

Note: *, ** and *** denote stationarity at 10%, 5% and 1% significance levels.

Estimates of Unrestricted ARDL Model

Table 2 presents the unrestricted ARDL model estimates of equation (2). The model is referred to as unrestricted equilibrium correction model. The long-run parameters and respective standard errors are estimated using OLS. The table shows values of long-run (γ) and short run (β) with their t-statistics. The coefficients of income growth lagged 1 period (LNPI(-1)), capital investment (LCIN), export (LSEX) and Government Expenditure (LSGE), and new business (LNBE) have positive and significant impact on economic growth.

Table 2: Unrestricted Estimates of ARDL Model (1, 0, 0, 0, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNPI(-1)	0.775503	0.076141	10.18503	0.0000
LCIN	0.017326	0.007660	2.261954	0.0314
LSEX	0.075683	0.030402	2.489382	0.0188
LSGE	0.037907	0.021375	1.773443	0.0867
LNBE	0.063772	0.039352	1.620569	0.1159
C	0.675419	0.323159	2.090049	0.0455
R^2	0.999249	Schwarz criterion		-4.886694
Adjusted R^2	0.999120	F-statistic		7721.386

Co-integration and ARDL-ECM Bound Test

The long-run relationship among the variables in the general model is examined using the ARDL bounds testing procedure. The first step is to obtain the order of lags on the first differenced variables in equations (2) by using the Schwartz Bayesian Criterion. This is followed by the application of a bound F-test to equation (2) to establish a long-run relationship between the variables under study. The results of the bounds F-test are reported in table 3.

Table 3: ARDL Bounds Test for Cointegration

Null Hypothesis: No long-run relationships exist		
Test Statistic	Value	k
F-statistic	57.46270	4
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.2	3.09
5%	2.56	3.49
2.5%	2.88	3.87
1%	3.29	4.37

The results of the F-test suggest that there exists a long-run relationship among LNPI, LCIN, LSEX, LSGE and LNBE. Therefore, the empirical findings lead to the conclusion that a long run relationship among income growth, capital investment, export, government expenditure and new business exist.

The above result is a step forward to the estimation of long-run coefficients which are reported in Table 4. The long-run estimated coefficients of capital investment, new business are significant at 5% level and the coefficients of export and government expenditure are significant at 1% level. The result of long run estimated coefficients show that a one percent

increase in capital investment, export, government expenditure, and new business is expected to lead to 7.7, 33.7, 16.9 and 28.4% increase in income growth respectively.

Table 4: Long Run ARDL Cointegration Model (1, 0, 0, 0, 0, 0)

Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCIN	0.077178	0.038567	2.001160	0.0548**
LSEX	0.337123	0.055582	6.065287	0.0000*
LSGE	0.168852	0.055046	3.067470	0.0046*
LNBE	0.284069	0.136569	2.080036	0.0465**
C	3.008589	1.369972	2.196096	0.0362**

Note: Asterisk *, ** Show significance levels at the 1%, and 5% level

Diagnostic Tests:

Adjusted R^2	0.9900
JB Normality Test	0.8811(0.6436)
Breusch-Godfrey Serial Correlation F-Test:	1.07288(0.3561)
Breusch-Pagan-Godfrey Heteroscedasticity F-Test	0.2840 (09163)

In Table 4, the results of the estimated long-run ARDL cointegration model (1, 0, 0, 0, 0), selected automatically by Schwarz criterion (SIC) out of 2500 models are reported. The SIC criterion automatically determined the lag to be one. The bottom portion of Table 4 displays the results of the diagnostic tests of the selected ARDL (1, 0, 0, 0, 0) model. The coefficient of adjusted degree of freedom, $R^{2,}$ is 99%, explaining the variation in income growth by changes in LCIN, LSEX, LSGE, and LNBE. The JB test for normality indicates that the residual are normality distributed. Breusch-Godfrey Serial Correlation F-test and the Breusch-Godfrey Heteroskedasticity F-test fail to reject the null-hypothesis of no serial correlation and no heteroscedasticity of the residuals.

Table 5 is drawn from Table 4 to emphasize the estimated coefficients are also the elasticities of the macroeconomic variables with respect to income growth. The results indicate the elasticities of capital investment, export, government expenditure, and new business with respect to income growth are 0.0771, 0.3370, 0 .1689, and 0.2840 respectively. The results imply that a one percent increase in capital investment, export, government expenditures, and new business establishment would be expected to increase income growth by 7.71, 33.7, 16.89, and 28.4 percent respectively.

Table 5: Elasticity Estimates with Respect to Income Growth

Capital Investment	0.0771**
Export	0.3370*
Government Expenditure	0.1689*
New Business	0.2840**

Note: Asterisks *, ** Show significance levels at the 1%, and 5% level

In table 6, the results of the estimated ARDL short-run error-correction model is presented. The coefficients of ΔLCIN, Δ LSEX, ΔLSGE and ΔLNBE exhibited a positive sign and are significant at 1%, 1%, 5% and 8% respectively. The coefficient of error-correction term, ECT (-1), is significant at the 1% level and exhibits the expected negative sign. The error-correction term, besides confirming the existence of cointegration based on the ARDL model,

shows that 21% of the disequilibria in the income growth arising out of past shocks will be corrected in the current period, although the speed of adjustment is relatively slower.

Table 6: The ARDL Cointegrating Short-run Error-Correction Model (1, 0, 0, 0, 0)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Δ(LCIN)	0.023127	0.007344	3.149005	0.0038
Δ (LSEX)	0.090181	0.033685	2.677231	0.0121
Δ (LSGE)	0.036554	0.018622	1.962915	0.0593
Δ (LNBE)	0.067334	0.037216	1.809284	0.0808
ECT(-1)	-0.217650	0.019819	-10.981679	0.0000

Parameter stability tests

One of the requirements for well-specified ARDL model is the presence of stability of parameter. One should always employ the cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMQ) as suggested in Brown, Durbin, and Evans (1975). Figures 2 and 3 report plots of the CUSUM and CUSUMSQ graphs. It can be seen that the plot of CUSUM and CUSUMQ stay within the critical 5% bounds. This confirms the long-run relationships among variables and thus indicates the stability of coefficients.

Figure 2: CUSUM test for stability

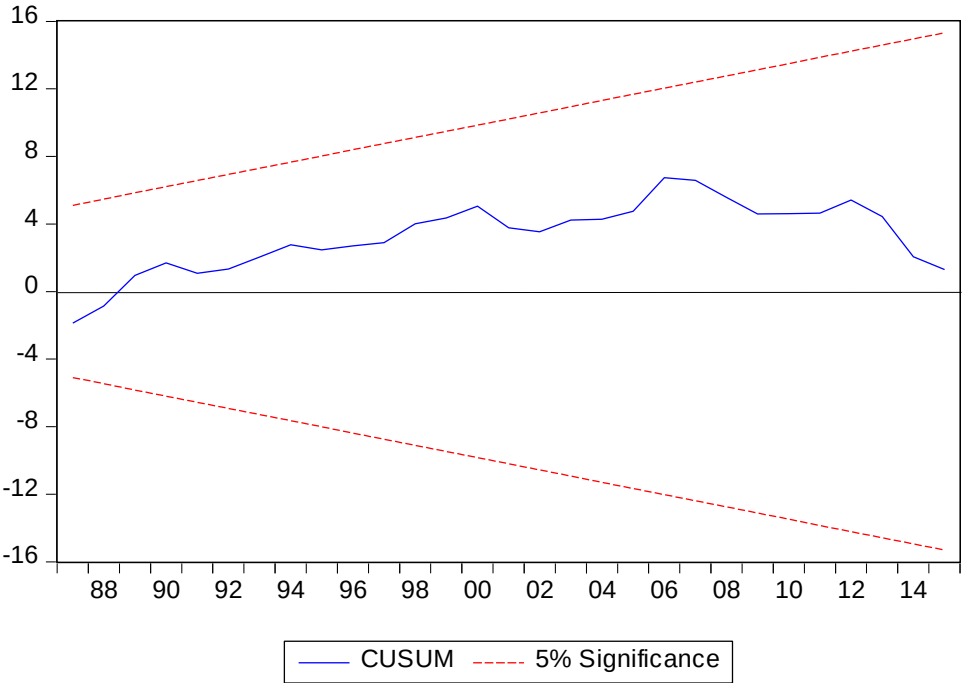
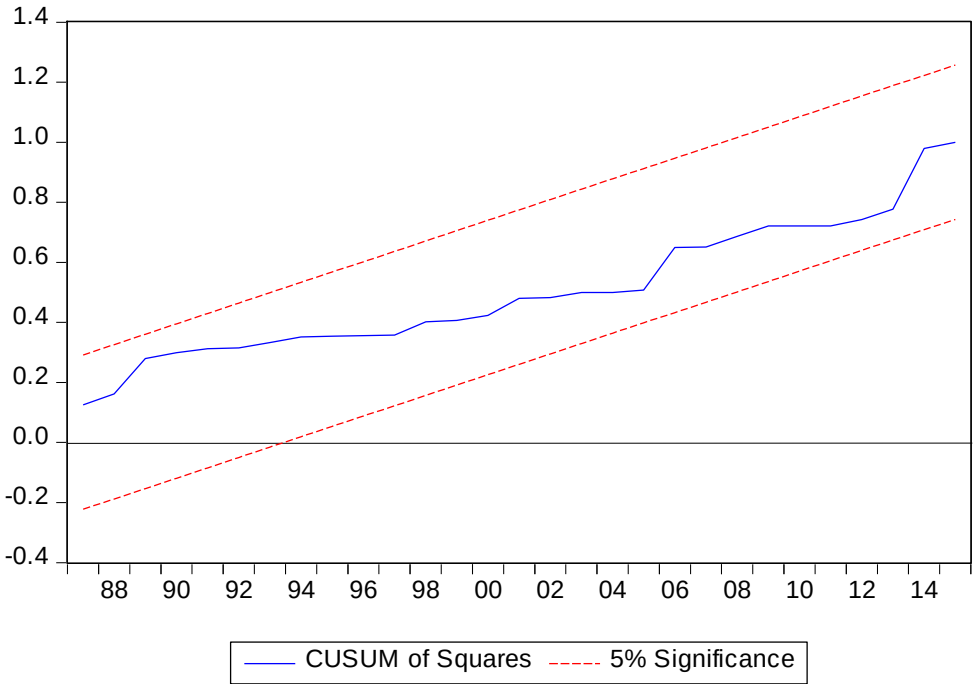


Figure 3: CUSUM Square Test for Stability



Dynamic OLS (DOLS)

To complement the ARDL co-integration test, the dynamic OLS (DOLS) is estimated. The panel Dynamic Ordinary Least Squares (DOLS) methodology will provide the estimation of the statistic long-run relation augmented by leads and lags. This will improve the efficiency of the long-run estimates but does not provide guidance on the short-run behavior. The estimated results are reported in Table 7. The coefficients of capital investment, export, government expenditure, and new business all are positive and significant at 1% level, suggesting that in the long run they will lead the income growth rate.

Table 7: Dynamic Least Squares (DOLS)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCIN	0.036034	0.010955	3.289147	0.0046
LSEX	0.384571	0.016767	22.93633	0.0000
LSGE	0.090381	0.027484	3.288519	0.0046
LNBE	0.784813	0.104364	7.519939	0.0000
C	-2.203768	0.955527	-2.306339	0.0348
R^2	0.999540	Adjusted R^2		0.999080

GMM Estimates

The results of the GMM estimates are reported in Table 8. The coefficients of capital investment, export, and new business are positive and significant at 1% level suggesting that they will lead the income growth rate. Thus, both dynamic OLS cointegration and GMM estimates lead to almost identical conclusion. However, in the GMM estimates, the estimated coefficients of explanatory variables are usually taken to represent short-term impact, whilst dynamic OLS (DOLS) estimates provide information on the long-run. Also, capital investment is positive in both models and significant in dynamic OLS.

Table 8: Generalized Method of Moments (GMM)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCIN	0.036394	0.038079	0.955764	0.3466
LSEX	0.312275	0.040315	7.745824	0.0000
LSGE	0.217029	0.042517	5.104481	0.0000
LNBE	0.537722	0.023875	22.52227	0.0000
R^2	0.995186	J-statistic		1.548240
Adjusted R^2	0.994720			

DISCUSSION

This paper, for the first time in the literature, has applied the ARDL bound approach, dynamic OLS, and GMM method to empirically identify major macroeconomic drivers of personal income growth in South Carolina during the period of 1980-2015. ARDL bound approach and dynamic OLS (DOLS) show that major drivers of income growth in South Carolina are capital investment, export, government expenditures and new business. The study shows all the variables are stationary at level or after first difference. Hence, they are integrated of order I (1). Together they form a long-run link exhibiting an integrating relationship among LNPI, LCIN, LSEX, LSGE and LNBE. The coefficients of all variables in ARDL short-run estimates and GMM estimates are positive and significant with the exception of LCIN in the GMM model. The coefficient of error-correction, ECT (-1) is significant at 1% level and has negative sign as expected.

The elasticities of capital investment, export, government expenditures, and new business establishment with respect to income growth are 0.077, 0.337, 0.1689, and 0.284 respectively. In other words, the result imply that one percent increase in capital investment, export, government expenditures, and new business establishment would be expected to increase by 7.7, 33.7, 16.9, and 28.4 percent respectively.

CONCLUSION

This paper investigates the dynamic short-run and long-run relationship among the growth in per capita income, and macroeconomic variables such as export, capital investment, government expenditure and new business establishment. The panel unit root, ARDL bound cointegration, dynamic OLS (DOLS), and Generalized Method of Moments (GMM) estimation are applied for the period 1980-2015. The long-run results show that capital investment, export, government expenditure, and new business have significant positive effect on the growth of income. The short run dynamic results confirm that capital investment, export, government expenditure and new business establishment have significant positive impact on income growth. The long term estimates indicate that a 1% increase in capital investment, export, government expenditures and new business would be expected to increase income growth by 7.71, 33.70, 16.89, and 28.40 percent respectively. Also, GMM estimates, which represent short run impact, find capital investment, export, government expenditures and new business have significant and positive impact on income growth. The estimated ARDL cointegration model passes the econometric diagnostic tests. Also, coefficients are stable. CUSUM and CUSUMQ tests confirm the long run stable relationship among the variables. The results imply capital investment, export, new business, government expenditures are macroeconomic drivers of economic growth. One of the policy implications of the findings in this paper is that policy makers should strategize to encourage capital

investment, attract new businesses like BMW, Boeing and Amazon.com and promote exports.

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