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Testing the Balanced Growth Hypothesis: Evidencefrom Bangladesh

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Abstract:*In this paper we investigate, using the Johansen's cointegration procedures, the relevance of balanced growth hypothesis in Bangladesh, a least developed country. We find that major macroeconomic variables, viz. output, consumption and investment share a common stochastic trend in the sample period. The parametric restrictions consistent with strict balanced growth in the closed economy model is weakly supported within the Johansen framework. However, the same framework rejects balanced growth in the open economy model of Bangladesh. Direct stationarity tests outside the Johansen framework suggest non-stationarity of some great ratios indicating the absence of strict balanced growth in both closed and open economy model of Bangladesh.*
Keywords:*Balanced growth, Great ratios, Unit root, Stationarity, Cointegration.*

I. Introduction

Balanced growth hypothesis originating from neo-classical growth models of Solow (1956) and Swan (1956) predict a steady-state growth path for an economy along which all real macroeconomic variables grow at the same rate. Despite the difficulties of the steady-state growth path to exist in the real world due to restrictive assumptions, the hypothesis is simple and has many theoretical implicationsattractinghuge attention from scholars to examine the hypothesis theoretically and empirically. The stochastic version of the balanced growth hypothesis described by King et al. (1991) implies that the 'great ratios', mainly consumption:output, investment:output and capital:output ratios should be stationary without any trend. Ample empirical studies have investigated the great ratios, mostly for developed countries. Most of the studies found non-stationarity of great ratios and did not find evidence in favour of balanced growth hypothesis in industrialized countries except for US data analysed by King et al.(1991). Developing countries almost remain outside of the empirical investigation of balanced growth hypothesis. However, those countries have already passed a moderately long period of developing process which should be scrutinized with proper econometric methods. An attempt was taken by Li and Daly (2008) to test the relevance of the hypothesis in China. Motivated by the work of Li and Daly (2008), in this paper we examine the validity of balanced growth hypothesis in a least developed country, Bangladesh using both univariate and multivariate analyses. In univariate analyses, tests of stationarity are performed on the constructed great ratios and in multivariate analyses Johansen's cointegration procedure is applied to investigate the presence of cointegration among consumption, investment and output. Though, most of the studies are based on closed economy model, we consider open economy in addition of closed economy model to check relevance of balanced growth hypothesis in Bangladesh.

The remaining of the paper is outlined as follows. In section two the theoretical background and econometric representation is presented. Empirical literature review is outlined in section three, whereas the sources and characteristics of data is discussed in section four. Section five includes testing the balanced growth hypothesis in the closed economy model. Testing the same hypothesis in the open economy model is the topic of section six. Section seven concludes.

II. Theoretical Background And Econometric Representation

The Solow-Swan (1956) growth model based on some restrictive assumptions predicts that major macroeconomic variables like real output, consumption and investment will grow at the same rate $(n + g)$ where n is the labour force growth rate and g is the exogenous technological progress rate. Consequently, the growth rates of per capita output, consumption and investment are determined only by the exogenous technological progress which is assumed to be a constant rate, g. This implies that the ratios of consumption and investment to output will remain constant along the long run growth path which constitutes the core proposition of balanced growth hypothesis.

If we consider technological progress as a stochastic process the growth path of all macroeconomic variables will be stochastic following the same stochastic trend of technological progress. In the log-linear version of the stochastic growth model the logarithms of output, consumption and investment will share that common trend. In econometric perspective this implies that those variables should be non-stationary with the same order of integration. Then, it should be possible to construct two cointegrating equations in a three variables space and three cointegrating equations in a four variable space. These cointegrating relations should ensure that the logarithms of consumption/output and investment/output 'great ratios' are stationary in the closed economy model which is entailed by the stochastic balanced growth hypothesis. In the open economy model, trade/output ratio along with the other great ratios, should be stationary. In summary, the econometric version of the balanced growth hypothesis requires two facts:

(1) An appropriate number of cointegrating equation or cointegration rank in the VECM representation. It is two in a three variable space and three in a four variable space.

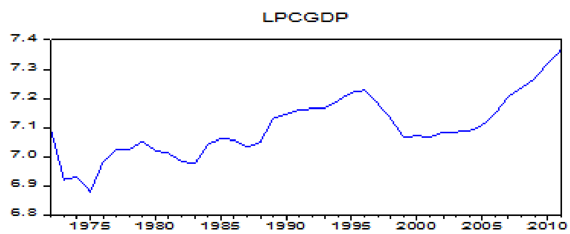
(2) An appropriate parametric restrictions in the cointegrating vectors that ensure stationarity of the great ratios. In the output: consumption: investment space the correct parametric restrictions are (1 -1 0) and (1 0 -1) that ensure stationarity of the great ratios. In the output: consumption: investment: trade space the parametric restrictions become (1 -1 0 0) (1 0 -1 0) and (1 0 0 -1).

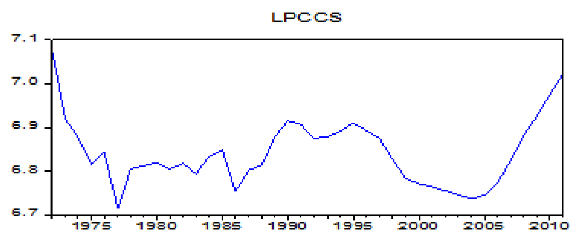
III. Empirical Literature Review

The well-known and widely cited research work of King et al. (1991) test the balanced growth hypothesis on US data using real consumption and investment for the period1949:Q1 to 1988:Q4 employing time series methods and find evidence for the balanced growth hypothesis. However, Whelan (2005), using upgraded data and real consumption and investment like King et al. (1991), demonstrates that the balanced growth hypothesisis rejected for the US if the data span is extended to 2004. He argues that an alternative balanced growth hypothesis, proposing stationarity of the ratio of nominal consumption to nominal investment is evident in a two-sector model of US economy. The balanced growth hypothesis is evaluated for Australia by Ji and Park (2011) incorporating public sector and open economy sector leading rejection of great ratios' stationarity. Kemper et al. (2009) test the implications of the balanced growth hypothesis for Germany using unit roots and cointegration techniques allowing for structural breaks in early 1970s. They find that the long-run growth path of Germany is consistent with the balanced growth hypothesis if the structural break is allowed. Attfield and Temple (2010), also allowforstructural breaks and demonstrate, using nominal variables that the balanced growth hypothesis is consistent with both the US and UK.Morana (2003), using data for the period 1957 to 2001 shows that the long-run growth path of Japan supports the balanced growth hypothesis. Harvey et al. (2003) examine the stationarity of great ratios in the G7 countries conducting univariate unit root tests and cointegration analysis. They find almost no evidence of stationarity for consumption:output and investment:output great ratios for G7 countries. The implications of the balanced growth hypothesis are tested for a developing country, China by Li and Daly (2008). They conclude that balanced growth is rejected if a structural break in the reform period 1978 is not included. However, if the structural break is modelled some evidences are found for the balanced growth for the pre-break period, but not for the post-break period. Hossain and Chung (1999), applying multivariate cointegration analysis, investigate the implications of the neo-classical growth model for Australia, New Zealand, South Korea and Taiwan. They find that in each country there is a common long-run stochastic trend. However, stationarity of the great ratios are not supported by the data of those countries. Serletis and Krichelinvestigate the long-run implications of the neoclassical growth model for ten OECD countries – Canada, France, Germany, Italy, the Netherland, Norway, Switzerland, Japan, the UK and the USA. Their findings suggest that consumption-output ratio is stationary only in Canada, Japan and Netherlands, whereas the investment-output ratio is stationary only in Canada.

IV. Data: Sources And Characteristics

All necessary raw data for the variables used in this study are obtained from Penn World Table 8.0. Though data are available for the period 1959-2011 we use data for the period 1972-2011. We include data only for the post-independent period of Bangladesh to avoid possible structural break in the year of independence, 1971. We made some transformations to raw data to obtain logarithms of per capita output (LPCGDP), per capita consumption (LPCCS), per capita investment (LPCI) and per capita volume of international trade (LPCO). The time series properties of the variables are explored in the following diagram.





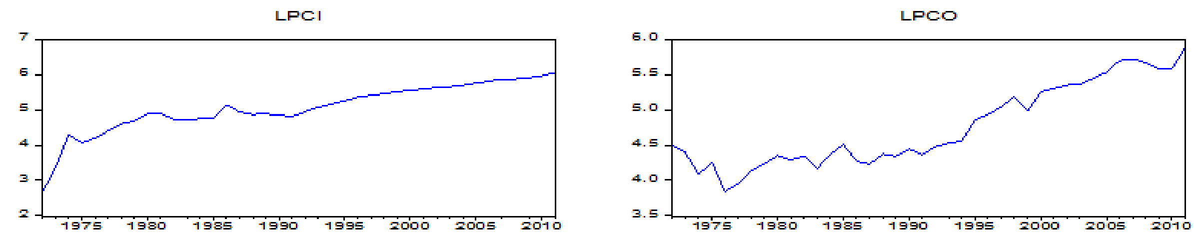


Figure 1 Time sequence plot of LPCGDP, LPCCS, LPCI and LPCO

All the variables have upward trends though the trend is less obvious for LPCCS. LPCGDP and LPCCS have more volatility than the other two series and have downturns followed by upturns in 2000. This might be the result of political regime change in that period. All the series follow business cycle and there is no obvious outlier in any series. Graphical inspection shed a light on a common stochastic trend among LPCGDP, LPCI and LPCO. LPCS exhibits a different trend to some extent. However, we need to adopt formal tests for less ambiguous inference regarding the common long run stochastic trend among the variables. The precondition of a common stochastic trend is that all variables should have the same order of integration.
We have applied three unit root tests to identify the order of integration of the variables under consideration. The unit root tests we have applied are ADF, DF-GLS and KPSS tests. The test results are presented in table 1.

Table 1 Unit Root Test Results

Variable	ADF Test Statistics		DF-GLS Test Statistics		KPSS Test Statistics	
	Levels	1^{st} Diff	Levels	1^{st} Diff	Levels	1^{st} Diff
LPCGDP	−0.7397 (−2.9411)	−6.4087* (−2.9411)	−1.1781 (-1.9499)	-2.2470* (-1.9499)	0.6593 (0.4630)	0.2331* (0.4630)
LPCCS	−1.4377 (−2.9411)	−6.5018* (−2.9411)	-1.0353 (-1.9499)	-0.9811 (-1.9501)	0.0740* (0.4630)	0.4113* (0.4630)
LPCI	−4.4269* (−2.9411)	−5.7470* (−2.9411)	-0.3166 (1.9496)	-0.6370 (-1.9504)	0.7678 (0.4630)	0.3782* (0.4630)
LPCO	0.2590 (−2.9411)	−7.3382* (−2.9411)	0.2554 (-1.9496)	-7.0987* (-1.9499)	0.7021 (0.4630)	0.2673* (0.4630)

Note: For ADF and DF-GLS tests, H_0 is Non-stationarity, * indicates rejection of H_0 at 5% level of significance. For KPSS test, H_0 is stationarity, *indicates acceptation of H_0 at 5% level of significance. Figures below the test statistics are the 5% critical values.

All the unit root tests indicate that LPCGDP and LPCO are stationary at the first differences. The test results are contradictory in the cases of LPCCS and LPCI. ADF test suggests that LPCCS is stationary at first differences. In contrary, DF-GLS test rejects stationarity of LPCCS at levels or first differences, whereas KPSS test indicates stationarity even at levels of LPCCS. Three tests suggest three different stationarity conditions for LPCCS. The situation is almost the same for LPCI. ADF test indicates stationarity at levels, DF-GLS test indicates non-stationarity even at first differences and KPSS test suggests stationarity at first differences. Since, no unit root test method is expected to produce perfect results and our test results are contradictory, we like to accept the moderate results, stationarity of LPCCS and LPCI at first differences. This allows us to consider all the variables under consideration as I(1). Moreover, if a variable is not I(1) it will be reflected in the cointegration tests and the variables with different order of integration should not be cointegrated.

V. Testing Balanced Growth In The Closed Economy Model

As the series LPCGDP, LPCCS and LPCI are assumed to be I(1) there is a possibility of cointegration among the variables. If there is any cointegration there will be a VECM representation of the series according to Granger Representation Theorem. In this VECM representation if the number of cointegration rank, r is 2, the necessary condition of balanced growth will be satisfied. We apply Johansen cointegration method (1988 and 1991) to check the number of cointegration rank. The Johansen approach begins by assuming that the joint behaviour of a set of n I(1) variables can be adequately described by a reduced form VAR of suitable order, viz:

$$X_t = d + \Pi_1 X_{t-1} + \Pi_2 X_{t-2} + \ldots + \Pi_k X_{t-k} + \varepsilon_t$$

This level VAR can be rearranged as a Vector Error Correction Model. In a VECM a levels term appears only at one particular lag - we shall choose this to be t-1, and all other terms are in first differences, viz:

$$\Delta X_t = \Pi X_{t-1} + \Gamma_1 \Delta X_{t-1} + \Gamma_2 \Delta X_{t-2} + \ldots + \Gamma_{k-2} \Delta X_{t-(k-2)} + \Gamma_{k-1} \Delta X_{t-(k-1)} + (d + \varepsilon_t)$$

Non-trivial cointegration occurs when ΠX_{t-1} is stationary and Π is neither a null matrix nor a full-rank matrix, i.e. when $0 < r = rank\ (\Pi) < n$. The Johansen procedure focuses on estimating the rank, r of matrix Π.

The value of r or the number of cointegrating equations is determined with a likelihood ratio (LR) test, using either the trace test or the maximum eigenvalue test. Both of these tests are based upon the eigenvalues, denoted λ_i (i=1,2,3,….,n), of the nxnΠ matrix. The rank of the Π matrix is equal to the number of non-zero eigenvalues,λ_i. The trace test is based upon a sequence of hypothesis tests. Firstly, the null hypothesis $H_0: r = 0$ is tested against the alternative$H_1: r \geq 1$. Secondly, the null hypothesis $H_0: r = 1$ is tested against the alternative $H_1: r \geq 2$ and so on. The test statistic is

$$LR_{trace}\left(r_{H_0}\right) = -T\sum_{i=r_{H_0+1}}^{n} \ln(1 - \hat{\lambda}_i)$$

Where, $r_{H_0}$is the number of cointegrating equations under the null hypothesis. The critical values for each hypothesis are taken from Mackinnon, Haugh and Michelis (1999). The maximum eigenvalue test for cointegration is also based upon a sequence of hypothesis tests. Firstly, the null hypothesis $H_0: r = 0$ is tested against the alternative $H_1: r = 1$. Secondly, the null hypothesis $H_0: r = 1$ is tested against the alternative $H_1: r = 2$ and so on. The test statistic is

$$LR_{max}\left(r_{H_0}\right) = -T\ln(1 - \hat{\lambda}_{r_{H_0}})$$

Where, $r_{H_0}$is the number of cointegrating equations under the null hypothesis. The critical values for each hypothesis are also taken from Mackinnon, Haugh and Michelis (1999).

We estimate an unrestricted VAR for the series LPCGDP, LPCCS and LPCI with lag length 7. We chose lag length 7 because all lag length criteria including FPE, AIC, SIC and HQ criteria suggest lag length 7. Any other lag length less than 7 introduces autocorrelation at different lags. The VAR with lag length 7 is free from serial autocorrelation at any lag which is a precondition of Johansen procedure. Moreover, the VAR with lag length 7 has very high goodness of fit and residual normality.

We, then applied Johansen’s Likelihood Ratio test to estimate the number of cointegrating vectors. Summary of the test result is presented in table 2 below.

Table 2 Johansen Cointegration Testin the Closed Economy Model

Selected (0.05 level*) Number of Cointegrating Relations by Model					
Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	3	3	2	2	1
Max-Eig	3	3	2	2	1
*Critical values based on MacKinnon-Haug-Michelis (1999)					

The model with intercept without trend in the cointegrating equations but linear trend in data series is most suitable for testing balanced growth hypothesis or, in other words, the constancy of great ratios. This model is associated with two cointegrating vectors according to both trace and maximum eigenvalue tests. Two cointegrating vectors in a three-variable space indicate one common long run stochastic trend among the variables which in turn is supportive of balanced growth hypothesis. However, this is not a sufficient condition of balanced growth hypothesis. The sufficient condition is the parametric restrictions (1 -1 0) and (1 0 -1) in the cointegrating vectors for (lpcgdplpccslpci) in the VECM that ensure stationarity of the great ratios. We impose these restrictions into the cointegrating vectors in the estimated VECM individually and simultaneously and conduct the LR test to check whether data allows these restrictions. The test result is presented in table 3.

As the table shows the parametric restrictions imposed either individually or simultaneously can be rejected at 5% level of significance. However, restrictions are valid at 1% level of significance as the P-values are greater than 0.01. This implies the evidence of balanced growth in Bangladesh in strict sense of the stationarity of the great ratios at 1% level of significance.

Table 3LR test of restrictions on the cointegrating vectors in the close economy model

Restrictions	$(1 - 1\ 0)$	$(1\ 0 - 1)$	$(1 - 1\ 0)$and $(1\ 0 - 1)$
LRStatistic	5.1023	6.2046	6.2461
P − value	0.02	0.012	0.04

Nevertheless, we are dealing with a small sample and Johansen procedure is not powerful in small sample. We, therefore like to test the stationarity of great ratios in alternative ways. The graphical features of the great ratios are presented below.

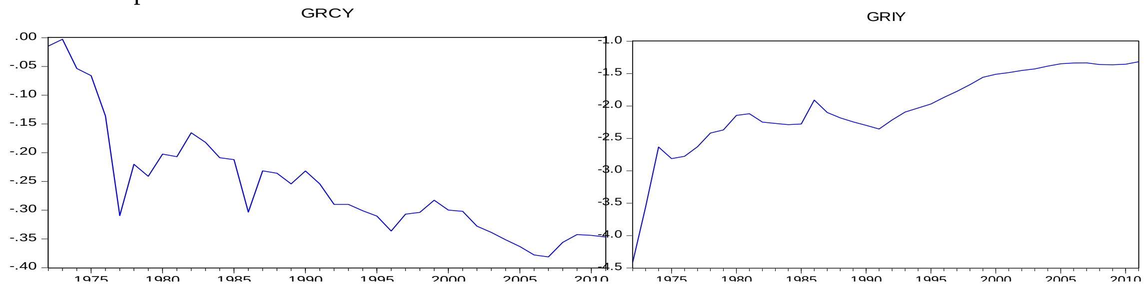


Figure 2: Graphical Features of GRCY and GRIY

GRCY shows a downward trend with high fluctuations, whereas GRIY shows an upward trend with less fluctuations. For a concrete output we checked stationarity of great ratios at their levels without any trend by directly applying ADF test. The ADF test results applied to the great ratios are presented in table 4.

Table 4 ADF Test Results on Great Ratios without Trade

Series	LagLength	τStatistic	5% Criticalτ	P(τ)
GRCY	0	−2.5434	−2.9390	0.11
GRIY	0	−5.3401	−2.9390	0.00

The table shows that one can reject the null hypothesis that logarithm of investment-output ratio (GRIY) has a unit root at 5% level of significance. However, the null hypothesis that logarithm of consumption-output ratio (GRCY) has a unit root cannot be rejected at any level of significance, i.e. this great ratio is not stationary. We also checked the stationarity of GRCY with a trend and still found unit root. These direct ADF test results do not support balanced growth in Bangladesh in the strict sense of constant means for all great ratios which is apparently conflicting with the conclusion of Johansen procedure.

VI. Balanced Growth In The Open Economy Model

International trade is an important part of every economy today. Bangladesh is not an exception in anyway. Considering trade explicitly is likely to enhance reliability of any macroeconomic behavioural analysis. We, thus include trade openness defined as the summation of export and import volumes into our cointegration analysis to test the balanced growth hypothesis in Bangladesh. The necessary condition of balanced growth is 3 cointegrating vectors in the variable space LPCGDP LPCCS LPCI LPCO. The stationarity of three great ratios is the sufficient condition of balanced growth.

As we know from previous analysis that all the four variables are integrated of order one, we can apply Johansen method to estimate the number of cointegrating rank. We construct an unrestricted VAR of lag length 6 with the four variables. We chose lag length 6 as it is recommended by FPE and SIC. Moreover, only this lag length makes the VAR free from autocorrelation. The estimated VAR has very high goodness of fit in all individual equations and residual normality. Based on this VAR we apply Johansen cointegration test. The test result is presented in table 5.

Table 5 Johansen Test of Cointegrationin the Open Economy Model

Selected (0.05 level*) Number of Cointegrating Relations by Model					
Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	No Trend	Trend	Trend
Trace	4	4	3	3	3
Max-Eig	4	4	3	3	2
*Critical values based on MacKinnon-Haug-Michelis (1999)					

The model with intercept without any trend in the cointegrating equations and linear trends in the data series is suitable for our present purpose. Both the trace and maximum eigenvalue test suggest that the cointegration rank is 3. In a four variable space this number of rank indicates a common long run stochastic trend among the variables. Thus, the necessary condition of balanced growth is again satisfied.

The sufficient condition is the parametric restrictions (1 -1 0 0) (1 0 -1 0) and (1 0 0 -1) in the cointegrating vectors for (lpcgdplpccslpcilpco) in the VECM that ensure stationarity of the great ratios. We impose these restrictions into the cointegrating vectors individually and simultaneously and conduct the LR test for binding restrictions. The test result is presented in table 6.

Table 6 LR test of restrictions on the cointegrating vectors in the open economy model

Restrictions	$(1-1\ 0\ 0)$	$(1\ 0-1\ 0)$	$(1\ 0\ 0-1)$	All Restrictions
$LRStatistic$	3.0645	9.7000	9.7280	54.5778
$P-value$	0.08	0.00	0.00	0.00

The first restriction imposing stationarity restriction on GRCY is supported by the LR test within Johansen cointegration framework which is conflicting with the previous direct ADF test result. All other restrictions are invalidated by the LR test. This finding rules out the strict sense of balanced growth in Bangladesh in the open economy model.

Direct ADF test also suggests the absence of balanced growth in the open economy model of Bangladesh. We have already found, outside the Johansen framework that consumption-output ratio is not stationary. We also found that the trade-output ratio is non-stationary which further invalidates balanced growth.

VII. Conclusion

We have applied Johansen cointegration method to test whether balanced growth hypothesis is supportive for Bangladesh economy or not. We have found that all major macroeconomic variables have a common long run stochastic trend as suggested by the proper cointegration rank in the VECM representation of the series. This long run characteristic is evident either we include international trade or not.

However, the validity of the parametric restrictions consistent with balanced growth is not unambiguous. We have found some validity of balanced growth within the Johansen framework if we do not include international trade in the analysis. In the same framework balanced growth is ruled out if we include trade. On the other hand, the direct assessment of stationarity of the great ratios applying ADF test method does not support balanced growth either in closed or open economy. Though one great ratio investment/output is stationary the other two great ratios viz. consumption/output and trade/output are found to be non-stationary according to ADF test result. These results imply that Bangladesh economy does not follow balanced growth in strict sense whether we include international trade or not. However, the existence of proper cointegration ranks in the VECM representations indicates that there are some regularities in the growth processes of major macroeconomic aggregates in Bangladesh.

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