Testing Significance of Macroeconomic Variables in Explaining Aggregate Economic Growth: A Cross-Country Study

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March 7, 2021

Abstract The paper studies the relationship between the aggregate economic growth and the macroeconomic variables during the period 1977-2016. A first-order autocorrelation in the dependent and independent variables was detected. The residuals of the ordinary least squares (OLS) model were also affected by heteroscedasticity. By applying multiple econometric estimation techniques, the study finds that annual consumption growth, government expenditure growth, and gross savings to GDP ratio are the most statistically significant macroeconomic variables in explaining the change in aggregate economic growth.

Keywords GDP, Aggregate Growth, Stationary Distribution, Panel Data, Pooled OLS, Random Effects GLS, Fixed Effects GLS

1 Introduction

Gross domestic product (GDP) and its growth rate are considered as the most critical performance indicators of an economy. Policymakers, therefore, are mostly concerned about maintaining a stable long-term annual GDP growth rate using fiscal and monetary policy tools. The fiscal policy tools include government spending and tax. Through the fiscal policy, the government attempts to achieve target economic growth and stability by influencing the consumption and investment. On the other hand, the monetary policy includes a set of tools that central banks or monetary authority use to control the money supply through reserve ratios and interest rates. Both groups of policies are expected to influence the critical macroeconomic variables such as the con-

sumption, investment, savings, exchange rates, exports, and imports. The reason for such control through policies is to shift the direction of the economy. The aggregate economic output is primarily determined by consumption and investment of the private sector. Therefore, it is expected that macroeconomic variables influence economic growth. Therefore, the primary objective of the study is to identify and measure the statistical significance of the key macroeconomic variables that contribute to the aggregate GDP growth. This paper studies a cross-country time series data involving 100 countries for the period 1977-2016. The independent variables of the study are relevant to the closed economy aggregate demand model.

2 Literature Review

Keynes (1936) provided the concept that the productive capacity of the economy is not only determined by the aggregate demand. Macroeconomic variables such as employment and inflation are also the key determinants of an economy's productive capacity. Based on his theory, Hicks (1937) proposed a simultaneous equation model popularly known as the IS-LM framework. The framework shows how equilibrium is reached in the real good and money market simultaneously. Since the inception, the Keynesian macroeconomic thoughts and IS-LM model became the most widely discussed subject by macroeconomists and econometricians. The IS-LM model can be discussed in closed or open economy contexts. In the closed economy context, the national income is a function of consumption, investment, and government expenditure (Scarth, 1988). The exogenous variables such as government expenditure and taxation can be classified as fiscal policy variables. Variables such as interest rate and money supply can be classified as monetary policy variables. The theoretical relationships between these variables with national income is a subject widely studied in macroeconomic theories. Kuznets (1941) established a framework for national income accounting and introduced an econometric approach that can be used to conduct empirical testing on the validity of the Keynesian theory. The framework defined national income as the net value of commodities and services produced by the nation's economic system. In the national income account, the value of these commodities and services are shown separately under agriculture, mining, manufacturing, construction, transportation and public utilities, trade, finance, government, service, and miscellaneous sectors. Kuznets (1942) derived an estimated consumption function by using long-term time series data on US economy which is one of the very first empirical analysis on long-term time-series macroeconomic data. Fischer (1991) conducted a cross-country empirical study for the period 1970-1985 and found that budget deficit and inflation rate are negatively correlated with national economic growth. Garrison and Lee (1995) studied the impact of macroeconomic variables on economic growth during the period 1960-87. The study

found that inflation, budget deficits, and high levels of government consumption are negatively correlated with economic growth. However, they found weak evidence on the negative relationship of tax rates with growth. Temur et al. (2017) used the multivariate time series and panel data techniques for determining the relationship among the variables such as inflation, net public debt, interest rate, budget deficit, and exchange rate. They found that budget deficits and interest rates are positively correlated. They also found that inflation is negatively associated with public debt and interest rates. Besides the studies conducted in the macroeconomic contexts, there are many studies conducted on time series macroeconomic variables in the econometric context. For example, Dickey and Fuller (1979) developed a unit-root test to identify whether a time-series data is stationary. White (1980) provided methods for detecting heteroscedasticity and offered a solution to the problem by using heteroscedasticity-consistent standard errors. Such researches on econometric techniques related to time-series and panel distribution helped the economists to understand the macroeconomic variables better and progressed the empirical study on macroeconomic theories significantly.

3 Methodology

The study explores the relationship between aggregate economic growth and macroeconomic variables using cross-country panel data. Baum (2006) explained the linear panel regression model through the following equation,

$$y_{it} = \sum_{k=1}^{k} x_{kit}\beta_{kit} \ + \ \epsilon_{it} \ , \ i = 1, ..., N, \ t = 1, ..., T \tag{1}$$

where N is the number of individuals and T is the number of periods. In the panel models, a major concern is that the time series variables may be nonstationary. If the variables are nonstationary, regression techniques cannot be applied without transforming the variables. An appropriate stationary test for unbalanced panel data is the Fisher-type unit root test. The test uses p-values from unit root tests for each cross-section and the formula of the test is written as

$$P = -2\sum_{i=1}^{N} ln \ p_i \tag{2}$$

which combines the p-values from unit root tests of each cross section i (Baltagi, 2005). The χ^2 distribution with 2 degrees of freedom is used to test the hypothesis. The rejection of the null hypothesis of Fisher-type unit root test indicates that the tested variable is stationary. Another major concern about panel model variables is the presence serial correlation. To identify whether the variables are serially correlated, the study applied Wooldridge test (Wooldridge, 2002) for autocorrelation described by Drukker (2003). The

test uses the residuals of a first-difference regression model. The first-difference regression model can be written as

$$\Delta Y_{it} = \Delta X_{it}\beta_{it} + \Delta\epsilon_{it} \tag{3}$$

where Δ is the first-difference operator. The procedure first estimates the parameters β_1 by regressing ΔY_{it} on ΔX_{it} and obtains the residuals. If errors are not serially correlated, than correlation between $\Delta\epsilon_{it}$ and $\Delta\epsilon_{it-1}$ equals to -0.5 (Drukker, 2003). Rejection of the null hypothesis indicates that there is a presence of the first-order autocorrelation in the variables. Breusch-Pagan heteroscedasticity test (Breusch and Pagan, 1980) was conducted on the residuals of the pooled ordinary least squares model. The null hypothesis of the test mentions that the variance of the residuals is constant. Therefore, the rejection of the null hypothesis means that the errors are heteroscedastic. Multicollinearity test was conducted on the potential explanatory variables of the model using the correlation matrix. The multicollinearity problem in regression arises when at least one linear origins of the function of the independent variables are very nearly equal to zero (Rawlings, 1988). If the regressors are highly correlated, standard regression models do not provide meaningful results. Generally, when problems of autocorrelation and heteroscedasticity are detected, random effects (RE) and fixed effects(FE) generalized least squares (GLS) models are deemed as appropriate regression techniques. Baum (2006) explained the FE and RE models using the equation

$$y_{it} = \ x_{it}\beta_k \ + \ z_i\delta + u_i + \ \epsilon_{it} \tag{4}$$

where x_{it} is a $1 \times k$ vector of variables that vary over individual and time, β is the $k \times 1$ vector of coefficients on x, z_i is a $1 \times p$ vector of time-invariant variables that vary only over individuals, δ is the $p \times 1$ vector of coefficients on z, u_i is the individual-level effect, and ϵ_{it} is the disturbance term. If the u_i are uncorrelated with the regressors, they are known as RE, but if the u_i are correlated, they are known as the FE (Baum, 2006). The effectiveness of RE and FE models can be determined by the Hausman test (Hausman, 1978). The null hypothesis of the test is that both the RE and FE models are appropriate. The alternate hypothesis is that only the fixed effects method is appropriate. Therefore, the rejection of the null hypothesis of the test indicates that the FE model is competitive over the RE model.

4 Data and Summary

The estimations of the study were derived from an unbalanced panel dataset extracted from the Data Bank of the World Bank[1]. The data set includes macroeconomic variables of 100 countries over a time period of 40 years starting from 1977 to 2016. The dependent variable of the study is the annual

[1] The dataset of the study can be accessed from: https://databank.worldbank.org/data/studydata/id/25b68437

Table 1: Summary statistics

Variable	N	Mean	Std. Dev.	Min	Max
Dependent Variable					
Annual GDP Growth Rate	3610	3.732	5.811	-64.047	123.140
Fiscal Policy Variables					
Govt. Expenditure Growth	3049	3.657	12.951	-68.238	566
Govt. Expenditure % of GDP	3481	15.798	5.888	1.375	76.222
Tax to GDP Ratio	2481	16.211	7.125	0.043	45.253
GDP Deflator (Inflation)	3609	47.558	542.712	-27.523	26765.860
Monetary Policy Variables					
Real Interest Rate	2104	5.328	12.123	-93.513	93.915
Deposit Interest Rate	2169	34.769	465.657	-0.210	17235.810
Lending Interest Rate	2170	20.033	114.217	0.500	4774.525
Broad Money (% of GDP)	2798	56.75	44.95	0.00	376.52
Broad Money Growth	2775	579.58	28352.64	-99.98	1499712.0
Broad Money to Reserve	2635	10.42	77.39	0.00	3691.14
Other Macroeconomic Variables					
Gross Savings to GDP Ratio	2985	23.231	11.002	-236.227	85.097
Consumption % of GDP	3472	75.712	12.588	8.575	169.234
Consumption Growth	3094	3.619	4.931	-24.157	50.312
Unemployment Rate	2600	7.676	5.129	0.140	31.840
Population Growth	3981	1.581	1.608	-5.814	16.332

GDP growth rate. Independent variables are government expenditure growth, government expenditure as percentage of GDP, tax revenue as percentage of GDP, GDP deflator or inflation rate, interest rates, broad money as percentage of GDP, broad money growth, broad money to reserve ratio, gross savings as percentage of GDP, net investment as percentage of GDP, unemployment rate, consumption growth, and population growth. Table 1 provides summary statistics of the dependent and independent variables. Countries selected for the study are relatively well functioning and had a minimum of $25 billion GDP in 2016. The countries were ranked based on the per capita GDP in 2016. The top 20 countries were categorized as the high-income. Countries ranked from 21 to 50 were categorized as the middle income and rest of the countries were categorized as low-income[2]. Table 2 shows the means of annual and per capita GDP growth for the period 1977-2016. Mean of annual GDP growth rate was 3.732% and mean of per capita GDP growth rate was 2.072% during this period. The highest average aggregate growth rate, which is 4.519%, was observed during the period 1997-2006 and lowest was 3.231% observed during the period 1987-1996. The per capita GDP growth rate has been relatively lower than aggregate growth during the period. The highest

[2]The list of countries and their income ranks are provided in Appendix-2

Table 2: Aggregate and per capita GDP growth

	High Income	Low Income	Middle Income	Overall
Aggregate Annual GDP Growth				
1977-1986	3.029	3.552	3.417	3.391
1987-1996	3.251	2.936	3.817	3.231
1997-2006	3.666	4.969	4.330	4.519
2007-2016	2.297	4.866	2.505	3.644
Income Group Average	**3.056**	**4.140**	**3.507**	**3.732**
Per Capita GDP Growth				
1977-1986	2.397	0.873	0.907	1.253
1987-1996	2.346	0.715	2.076	1.416
1997-2006	2.588	3.287	3.261	3.141
2007-2016	0.876	3.211	1.364	2.190
Income Group Average	**2.036**	**2.126**	**2.001**	**2.072**

level of per capita GDP growth was observed during the period 1997-2006.

5 Tests and Results

Table 3 shows the results of the unit-root test conducted on all the dependent and independent variables. The test was conducted using the lag of one period including time trend and drift term. All the variables were found stationary except the broad money to GDP ratio. Figure 1 shows the trend of broad money to GDP ratio across time and Figure 2 shows the distribution of broad money to GDP ratio for different continents. Multiple variables were affected by outliers too. Causes of such outliers in annual GDP growth rate were wars and political instability. Iraq, Iran, Libya, and some other middle eastern countries experienced a massive drop in GDP during the wars in the 1980s, 1990s, and early 2000. Other critical variables affected by outliers are gross savings ratio, broad money to total reserve, broad money growth, inflation rate, government expenditure ratio, and government expenditure growth.

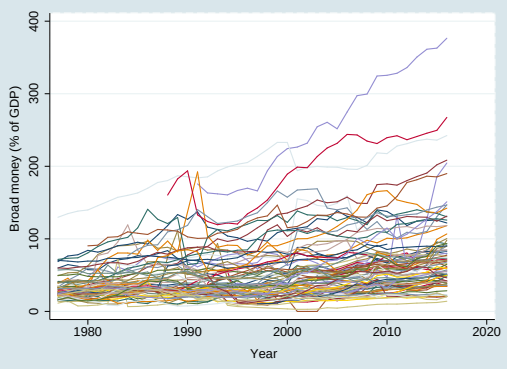

Figure 1: Evidence of nonstationary trend in Broad Money to GDP Ratio

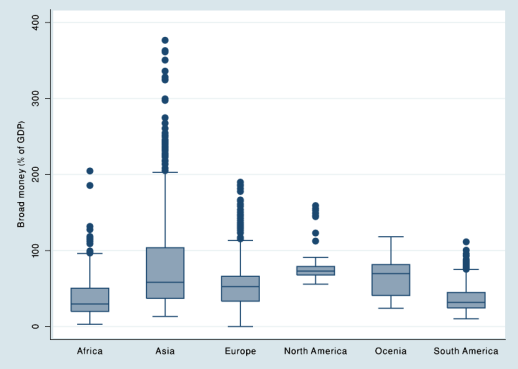

Figure 2: Distribution of Broad Money to GDP Ratio across continents

Table 3: Fisher-type unit root test

	Unit toot test (Time Trend)				Unit root test (Drift Trend)			
Variables	**P**	**Z**	**L***	**Pm**	**P**	**Z**	**L***	**Pm**
Aggregate GDP Growth	927.50	-20.85	-24.84	36.37	1479.19	-31.54	-40.77	63.95
Per Capita GDP Growth	941.13	-21.07	-25.28	37.06	1450.54	-31.16	-39.98	62.52
Govt. Expenditure Growth	798.63	-18.11	-22.09	31.49	1292.73	-29.08	-37.14	57.79
Govt. Expenditure % of GDP	319.93	-4.46	-5.00	6.00	803.70	-19.67	-21.79	30.19
Tax to GDP Ratio	296.38	-3.60	-4.72	6.56	597.43	-15.82	-17.07	22.70
GDP Deflator (Inflation)	590.24	-14.02	-15.05	19.51	1072.68	-25.115	-29.47	43.63
Real Interest Rate	437.78	-9.57	-10.91	15.12	800.68	-20.68	-24.17	35.15
Deposit Interest Rate	664.24	-11.49	-17.58	27.34	642.17	-16.06	-18.87	26.13
Lending Interest Rate	701.36	-11.43	-18.30	29.67	639.26	-16.13	-18.91	26.24
Money Supply (% of GDP)*	175.31	0.20	0.091	0.739	363.84	-8.63	-9.01	11.21
Broad Money Growth	691.32	-15.90	-20.11	29.40	1043.77	-24.83	-31.78	48.99
Broad Money to Reserve	434.83	-7.66	-10.67	15.79	774.62	-19.26	-23.85	35.02
Gross Savings to GDP Ratio	478.03	-6.97	-9.43	14.42	811.14	-19.85	-22.24	31.33
Consumption % of GDP	413.33	-5.743	-7.28	10.66	792.67	-19.00	-21.25	29.63
Consumption Growth	822.91	-18.11	-22.53	32.468	1272.65	-28.52	-36.14	55.94
Unemployment Rate	285.64	-3.420	-3.785	4.282	730.07	-18.45	-19.73	26.50
Population Growth	1734.44	-28.17	-46.25	76.72	1295.51	-26.29	-35.310	54.77

Note: P= Inverse chi-squared, Z=Inverse normal, L*=Inverse logit t, and Pm=Modified inverse chi-squared
*Broad-money to GDP ratio is the only nonstationary variable found in the dataset.

Table 4 shows the results of autocorrelation and heteroscedasticity tests. The test results indicate that there is evidence of first-order autocorrelation in the dependent and independent variables. The test of heteroscedasticity on the residuals of the pooled ordinary least squares model provides the evidence that the errors are heteroscedastic. Multicollinearity among independent variables

Table 4: Results of autocorrelation and heteroscedasticity tests

Test Name	**Null Hypothesis**	**Test Statistic**	**P-Value**
Wooldridge test for autocorrelation	No first-order autocorrelation	F=20.782	0.0000
Breusch-Pagan test for heteroskedasticity	Constant variance	χ^2= 19.54	0.0000

was tested too. It was found that the real interest rate is highly positively correlated with the inflation rate. Other moderately high correlations are found among unemployment, government expenditure, and tax revenue. Tax revenue and government expenditure were found positively correlated. Table 5 shows the comparison of correlations of aggregate economic growth and per capita growth with macroeconomic variables. Per capita GDP growth is found less sensitive to all the independent variables of the study. Population growth was positively correlated with aggregate growth but negatively with per capita growth during the period. On the other hand, money supply growth and tax to GDP ratio are positively correlated with per capita growth but negatively correlated with aggregate growth. Based on the overall comparison of correlation coefficients, aggregate GDP growth is found to be more sensitive to the independent variables of the study. Table 6 presents the results of primary fixed effects and random effects models needed for the Hausman test.

Table 5: Aggregate vs. Per Capita GDP: Comparison of correlation coefficients with macroeconomic variables

	Aggregate Growth			Per Capita Growth		
Independent Variables	**Corr(AG)**	**P-Value**	**N**	**Corr(PCG)**	**P-Value**	**N**
Govt. Expenditure Growth	0.282	0.000	3038	0.243	0.000	3038
Govt. Expenditure % of GDP	-0.179	0.000	3436	-0.133	0.000	3436
Tax to GDP Ratio	-0.078	0.000	2461	0.016	0.439	2461
GDP Deflator (Inflation)	-0.096	0.000	3609	-0.104	0.000	3609
Real Interest Rate	0.019	0.396	2104	0.021	0.342	2104
Deposit Interest Rate	-0.067	0.002	2095	-0.067	0.002	2095
Lending Interest Rate	-0.069	0.002	2104	-0.071	0.001	2104
Money Supply (% of GDP)	-0.026	0.171	2718	0.014	0.470	2718
Broad Money Growth	0.024	0.210	2693	0.034	0.079	2693
Broad Money to Reserve	-0.124	0.000	2547	-0.119	0.000	2547
Gross Savings to GDP Ratio	0.174	0.000	2973	0.150	0.000	2973
Consumption % of GDP	-0.159	0.000	3431	-0.124	0.000	3431
Consumption Growth	0.669	0.000	3083	0.603	0.000	3083
Unemployment Rate	-0.096	0.000	2546	-0.031	0.121	2546
Population Growth	0.127	0.000	3605	-0.155	0.000	3605

Note: Per capita GDP growth rate is found less associated with the macroeconomic variables. However, signs of correlation coefficients of both aggregate growth and per capita growth are same except for the annual population growth, money supply growth, and tax to GDP ratio.

Variables found significant through fixed effects model were government expenditure growth, tax to GDP ratio, broad money growth, gross savings to GDP ratio, consumption growth, consumption to GDP ratio, and population growth. Variables found significant through random effects model were government expenditure to GDP ratio, government expenditure growth, tax to GDP ratio, broad money growth, gross savings to GDP ratio, and consumption growth. The constant was found significant for the fixed effects model but not for the random effects model. Overall-r^2 of fixed effects model was 0.345, and random effects model was 0.517. However, a comparison of the random effects and fixed effects model through the Hausman test suggested that the fixed effects model is appropriate for this particular unbalanced panel dataset. Considering the fixed effects GLS method as the regression technique for this study, multiple test models were run. Table 7 shows the results of all the FE models that were developed through different combinations of independent variables. In the first model, government expenditure growth, broad money growth, gross savings to GDP ratio, and consumption growth were found significant. The total number of observations was 1445, and the overall-r^2 was 0.435. The correlation between unobserved heterogeneity term and the linear combination of the regressors was -0.0438. Statistically insignificant variables such as tax to GDP ratio, consumption to GDP ratio, and population growth were dropped in the second model. The number of observations increased to 2058 and all the regressors included in the second model were found signifi-

Table 6: Test Models: Coefficients of fixed effects and random effects models

Independent Variables	**FE Model**	**P-Value (FE)**	**RE Model**	**P-Value (RE)**
Govt. Expenditure % of GD	-0.0421	0.495	-0.140	0.000
Govt. Expenditure Growth	0.0391	0.000	0.0419	0.000
Tax to GDP Ratio	0.146	0.005	0.0633	0.009
GDP Deflator (Inflation)	-0.00164	0.704	-0.00414	0.318
Real Interest Rate	0.0112	0.301	0.00211	0.819
Broad Money Growth	0.00000424	0.011	0.00000446	0.008
Broad Money to Reserve	-0.0150	0.402	-0.00959	0.430
Gross Savings to GDP Ratio	0.0676	0.021	0.0663	0.001
Consumption % of GDP	0.446	0.000	0.439	0.000
Consumption Growth	-0.136	0.000	0.00769	0.671
Unemployment Rate	0.0639	0.163	0.0343	0.253
Population Growth	-0.339	0.037	-0.0208	0.825
Constant	9.178	0.008	0.688	0.731
N	893		893	
R^2 (Within)	0.496		0.465	
R^2 (Between)	0.345		0.517	
R^2 (Overall)	0.118		0.587	

Note: Chi-squared value found through Hausman test is 77.43 and p-value was found 0.000. The test rejects the null hypothesis that both the random effects and fixed effects model are efficient. Therefore, in this particular unbalanced panel dataset, Hausman test indicates that fixed effects generalized least squares model is appropriate.

cant. However, the significance of broad money growth remained low and also the constant remained insignificant. Overall-r^2 of the model dropped slightly from 0.435 to 0.430. However, the insignificance of the constant is a critical flaw of the model. Therefore, in the third test model, broad money growth was dropped. Exclusion of the broad money growth increased the number of observations to 2703 and the overall-r^2 and within-r^2 improved. However, the between-r^2 dropped slightly, and the constant remained insignificant. In the fourth model, only gross savings to GDP ratio and consumption growth were considered as regressors. The model provided a significant constant. However overall-r^2 dropped to 0.101. The fifth model included only gross savings to GDP ratio and consumption growth as independent variables. In this case, the constant became insignificant but all the r^2 values improved significantly. In the final test model, the independent variables were government expenditure growth and consumption growth. The number of observations increased to 3024, and all the regression coefficients including the constant became highly significant and all other test statistics improved significantly. However, as all the coefficients of the third model were found significant, the study decides to select the model as the final proposed model. The model can be written as,

$$G_{gdp} = -0.411 + 0.502G_{cons} + 0.037G_{govx} + 0.091R_{gs} + u_i \tag{5}$$

where, G_{gdp} is the annual GDP growth, G_{cons} is the annual consumption growth, G_{govx} is the annual government expenditure growth, R_{gs} is the gross

Table 7: Fixed effects models

Independent Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Govt. Expenditure Growth	0.038***	0.040***	0.037***	0.075***		0.036***
	(0.005)	(0.005)	(0.005)	(0.006)		(0.005)
Tax to GDP Ratio	0.057					
	(0.037)					
Broad Money Growth	0.000*	0.000*				
	(0.000)	(0.000)				
Gross Savings to GDP Ratio	0.100**	0.077***	0.091***	0.119***	0.092***	
	(0.030)	(0.012)	(0.011)	(0.013)	(0.011)	
Consumption Growth	0.518***	0.476***	0.502***		0.532***	0.528***
	(0.020)	(0.015)	(0.014)		(0.013)	(0.013)
Consumption % of GDP	0.021					
	(0.031)					
Population Growth	0.024					
	(0.149)					
Constant	-3.243	0.130	-0.411	0.639*	-0.418	1.565***
	(3.160)	(0.287)	(0.252)	(0.308)	(0.254)	(0.072)
N	1445	2058	2703	2713	2741	3024
r^2 (Within)	0.396	0.397	0.404	0.096	0.396	0.412
r^2 (Between)	0.525	0.574	0.556	0.135	0.571	0.730
r^2 (Overall)	0.435	0.430	0.440	0.101	0.438	0.455
Corr(u_i, X_b)	-0.0438	0.0360	0.0386	-0.0889	0.0474	0.1869

Note: Model 3 was selected as the optimum model by analyzing results of all six models
Standard errors in parentheses
* p<0.05, ** p<0.01, and *** p<0.001

savings to GDP ratio. All the independent variables are positively correlated with the dependent variable.

6 Discussion on Results

The study applied GLS techniques for estimation of the regression coefficients. There are two main reasons behind using GLS model: The presence of serial correlation in the observations, and the problem of heteroscedasticity in residuals. Furthermore, among the GLS models, the fixed effects model was preferred to the random effects model. Under the random effects model, the assumption is that there is no correlation between unobserved heterogeneity across clusters and the explanatory variables. However, the final model derived

Table 8: Summary of dependent and independent variables of the proposed model

Model Variables	N	Mean	Std. Dev.	Min	Max
Aggregate GDP Growth	3610	3.732	5.811	-64.047	123.14
Govt. Expenditure Growth	3049	3.657	12.951	-68.238	565.54
Gross Savings to GDP Ratio	2985	23.230	11.002	-236.227	85.097
Consumption Growth	3094	3.619	4.931	-24.157	50.31

in the study shows that $Corr(u_i, X_b) \neq 0$. As a result, the fixed effects model is the appropriate model for explaining the relationship between GDP growth and macroeconomic variables in the cross-country unbalanced panel dataset. The within-r^2 of the proposed model is 0.404. The between-r^2 is 0.556 which is computed in two steps. In the first step, the fitted values are computed using the vector of fixed-effects parameters and within-individual means of the regressors. In the second step, r^2 is calculated as the squared correlation between the predicted values and the within-individual means of the dependent variable. The overall-r^2 of the model is 0.440 which is also calculated in two steps similar to the calculation of between-r^2. However, in the first step, to calculate the fitted values it uses the untransformed independent variables. The second step is the same as the calculation of between-r^2. The study also finds that consumption growth, government expenditure growth, and gross savings to GDP ratio are the most influential regressors on the GDP growth. The model can be tested using historical means of the dependent variables. Table 8 provides a summary of the dependent and independent variables of the proposed model. If the historical means of consumption growth, government expenditure growth, and gross savings to GDP ratio are placed on the regression equation, the predicted value of aggregate GDP growth can be calculated using the model as

$$G_{gdp} = -0.411 + 0.502 \times 3.619 + 0.037 \times 3.656 + 0.091 \times 23.230 = 3.655 \quad (6)$$

which is very close to the historical mean of annual GDP growth (3.732 percent). Furthermore, the signs of the model coefficients do not contradict established macroeconomic theories. Thus it can be concluded that consumption growth, government expenditure growth, and gross savings to GDP ratio are the most significant in explaining annual GDP growth among all the variables explored in this study. However, before concluding on the effectiveness of the fixed effects model, it must have a final comparison with pooled OLS, feasible GLS, and random effects models. Table 9 shows the results of all four types of models. The coefficients of all the models are statistically significant, and the r-squared values are very close. Hence, it may be tempting to conclude that all the models are efficient under this scenario. However, the results of Breusch-Pagan heteroscedasticity test (Breusch and Pagan, 1980) shows that residuals of pooled OLS are still heteroscedastic. The result of Breusch-Pagan Lagrangian multiplier test (Breusch and Pagan, 1980) recom-

Table 9: Comparison of POLS, FGLS, REGLS, and FEGLS Models

Independent Variables	**POLS**	**FGLS**	**REGLS**	**FEGLS**
Govt. Expenditure Growth	0.040***	0.040***	0.038***	0.037***
	(0.005)	(0.006)	(0.005)	(0.005)
Gross Savings to GDP Ratio	0.049***	0.049***	0.063***	0.091***
	(0.007)	(0.010)	(0.009)	(0.011)
Consumption Growth	0.539***	0.539***	0.514***	0.502***
	(0.013)	(0.030)	(0.013)	(0.014)
Constant	0.400*	0.400	0.149	-0.411
	(0.168)	(0.224)	(0.225)	(0.252)
N	2703	2703	2703	2703
r^2	0.449	0.449		0.404
Adj-r^2	0.449	0.449		0.383
r^2 (Within)			0.403	0.404
r^2 (Between)			0.628	0.556
r^2 (Overall)			0.448	0.440

Standard errors in parentheses
* p<0.05, ** p<0.01, and *** p<0.001

mends the random effects model instead of the pooled OLS model. The results of the random effects and fixed effects model are strikingly similar. However, based on the result of the Hausman test (Hausman, 1978), the study prefers to apply fixed effects regression technique. Other than the econometric conclusion about the appropriate model, the macroeconomic conclusion from the model is simple. The consumption growth, government expenditure growth, and gross savings to GDP ratio are the most influential macroeconomic variable on economic growth. Thus, the regression coefficients of the independent variables of the suggested model carry significant economic meanings for the policymakers across the world.

7 Conclusion

The variables explored in this study are assumed to be relevant to the closed economy model. Initially, stationary proxies of all the relevant macroeconomic variables were considered as equally important to explain the dynamics of economic growth. Among the fiscal policy variables, government expenditure and taxation are theoretically proven to be capable of explaining economic growth. Among the monetary policy variables interest rate, money supply, and inflation rate are also theoretically proven to be correlated with economic growth. However, both categories of variables are of exogenous nature, and there are disputes among economists about the effectiveness of the policy variables. In addition to the fiscal and monetary variables, other macroeconomic variables that are theoretically significant and taken under the scope of the study were

gross savings, net investment, consumption, unemployment, and population growth. However, the study found only the consumption growth, government expenditure growth, and gross savings to GDP ratio as the most significant explanatory variables. However, it should be noted that the findings are limited by the unbalanced panels. It is expected that if number of countries and years are reduced to a balanced panel dataset and pooled OLS or random effects models are applied, more significant variables can be included in the model. The conclusion of the study is also limited to the closed-economy model. Among the closed-economy variables, the investment growth rate data could not be included in the model due to the unavailability of data. The inclusion of the investment growth and open-economy variables such as export, import, and exchange rate can add more explanatory power to the model proposed in this study. Moreover, the growth in government expenditure is positively correlated with consumption growth. Therefore, further study on consumption growth and its determinants can provide additional insights to policymakers about a well-balanced set of policy tools that can influence consumption and subsequently the aggregate economic growth.

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