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VALIDATION OF SOLOW SWAN MODEL IN PAKISTAN: AN EMPIRICAL EVIDENCE BY USING ARDL APPROACH

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Abstract

The validation of Solow Swan (Macroeconomics model) in Pakistan is the main aim of this study. The purpose of this study is to figure out the association among labor force, human capital, natural resources rent institution, and formation of gross capital f with the gross domestic product (GDP) of Pakistan under the Solow Swan Model over adopting time series data from 1980-2017. This study employed ARDL techniques (autoregressive distributed lag) and found the long-run positive association of natural resources rent, labor force, human capital, and gross capital formation with the gross domestic product of Pakistan. Based on the empirical result of this investigation, it is recommended that Pakistan's government should try to increase economic growth by investing more in these factors and improve the performance of these variables.

Keywords

GDP, natural resource rents, labor, gross capital formation, ARDL

1. Introduction

The concept of the modern state came into existence after the treaty of Westphalia in 1648. Thus, the Industrial Revolution started from England in 1650 (Hartwell, 1965). Thus, modern growth and development concepts also existed (Levy-Leboyerd, 1965; Feinstein, 1998; De, 2001). Every state tries to achieve appropriate economic growth since the Industrial revolution (Jensen, 1993; Blinder, 2006; Shiue and Keller, 2007). First of all, the Mercantilist school of thought developed the concept of growth in the sense of export and import. According to Mercantilists, "Trade exists when the state produced more and more." Additional production

is possible through economic efficiency growth (Habyarimana and Opoku, 2018; Wenster, 1980). Because of this study, different economists of different schools of thought introduced different economic growth models. The 20th century was the time of economic war. The West achieved suitable economic growth through different economic growth models. Economic growth is the engine of the state. An economist defines economic growth as, "the production growth of goods and services (production) produced per head of population of one country over some time (one year)." In 1965, American economist Robert Solow and Australian economist Trevor Swan introduced a model the namely Solow and Swan growth macroeconomics model (economic growth model). Economic growth is considered a masterpiece of an economy. Numerous pieces of literature investigated economic growth under the Solow Swan Model by using different variables, proxies, econometrics approachers, annual period, panel dataset and their result cannot justify to each other (Perez-Trujillo and Lacalle-Calderon, 2020; Durusu-Ciftci *et al*., 2017; Accinelli and Brida, 2007; Guerrini, 2006; Li *et al*., 1998). Thus, one study cannot generalized to other study of country/ group of studies. If we talk about economic development growth theories, classical and Neo classical economicsts documented that land, labor and capital are main components of economic growth respectively and ignored other effected factors. The performance of land (natural resource rent) accessibility in urbanization economic growth has gotten less attention from scholars than the performance of natural resource rent (land) in financial development. Since four decates, the natural resource rents contributed significantly in economic growth because all industrial production depends on land resources. Poverty mitigation in the case of a rural region, where it has been literature contributes extremely with an accentuation on the role of property rights or, all the more explicitly, security of residency, in actuating interest in land and improving natural resources sector improvement efficiency all the more extensively (for example, Deninger, 2003).

The endowment of this study is to investigate the association of natural resource rent, labor force, gross capital formation, and human capital institution on gross domestic product. On behalf of the empirical analysis result, this study argues that the Pakistan government should try to increase economic growth by investing more in these factors and improve the quality. The remaining series of this study is organized in the following way, the second part will be presented to the literature review, the third part will be presented to data and methodology, the second last part represented to analysis and discussion, and the last one presented to a conclusion.

2. Literature Review under Solow Swan Model

The Neo-classical model Solow Swan represents in 1956 that the phenomena of economic growth (GDP growth) from the approach of capital (K), technology (T), and Labor (N) (Solow, Swan. 1956). This phenomenon represents that the economy of a country will be significant changes

in output and the components of production (Linna. 2019). In the production function, the land is the most important element of it. Land represents natural resources (Letourneau 2012). Many studies shed light on the association of natural resources and output (y) under the Solow Swan Model (Boianovsky and Hoover. 2009; Farmer and Lahiri. 2006; Zhou *et al*., 2007; Gardoňová. 2016). Most research used empirical strategy to figure out the linkage among output (GDP) and natural resources under the panel and time-series data (Rees. 2017; Gylfason. 2001; Leite and Weidmann. 1999). Several studies documented a statistically reported positive association between natural resources and GDP (y) (Brunnschweiler, 2008; Erum and Hussain. 2019). Other studies show negative cointegration between natural resources and economic growth (output) (Auty. 1993; Kurniawan and Managi 2018). Other studies show the bidirectional cointegration causality of natural resources with economic growth (Zeb *et al*., 2014). For fifty-three countries panel, Cavalcanti *et al*. (2011) tested the association of natural resources with GDP (y) using panel data from 1980-2005 using panel data. The result represents the positive cointegration causality of economic growth with natural resources. In the same way, many other scholars also found positive bidirectional cointegration casualty of natural resources with economic growth (Rees. 2017; Gylfason. 2001; Leite and Weidmann. 1999). On the other hand, Tiba and Frikha (2019) tested the effect of natural resource rent on economic growth using panel data from 1990 to 2016 from 26 countries. The results indicate that natural resources have an insignificant effect on economic growth. Similarly, another scholar also finds a negative affiliation between natural resources and output (Auty. 1993; Abou-Ali and Abdelfattah. 2013; Kurniawan and Managi 2018). For Bangladesh, Adhikary (2011) investigated the impact of foreign investment, trade openness, and gross capital formation on economic growth using time series data from 1986-2008 by employing JohannsenJuselius. The empirical results indicate the gross capital formation had a positive impact on gross domestic product. Narayan and Smyth (2008) tested the relationship between CO_2 emission and capital formation on GDP (y) using panel data from G7 countries employing panel cointegration and granger causality statistical approaches. The results indicate that have a positive association between gross capital formation on real GDP. Many other theoretical literature studies have shown an association between capital formation and GDP (Kormendi and Meguire1985; Barro. 1991; Ghali and Ahmad. 1999). Adewole (2012) examined the effect between population and economic development using annual data from 1981 to 2007 by employing a PP econometrics test. The result reported a positive impact of POP (population) on economic development. For Nigeria, Tartiyus *et al*. (2015) tested the association between population growth and economic growth using time series data from 1980-2010 by employing regression tools. The results indicate that the

population has a positive association with economic growth. Fay and Medoff (1985) reported the association of labor on economic growth to have a positive in the long run. In contrast, Akkemik (2007); Hosjabr (2005) reported a negative impact of labor on economic growth.

3. Sample and Methodology:

This study aims to explore the association of natural resource rent (NRR), labor (L), and gross capital formation (GCF) and human capital institution (HCI) with the gross domestic product (GDP) in the case of Pakistan under Solow Swan Model. This study used time series data from 1980 to 2017. This time-series data is taken for analysis from the World Bank (WDI).

Solow Swan model represents the market equilibrium condition that the supply side is equal to the market demand side (Y^d=Y^s). In simple words, Solow Swan Model is an economic growth strategy of neoclassical. Solow Swan Model sheds light on the two most important variables, labor, and capital. These inputs represent to maximum production of an economy.

Solow Swan model reported that saving is equal to the investment:

$$S = I \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ (1)}$$

$$C = cY \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ (2)}$$

Consumption function elaborate

$$C = cY \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ (3)}$$

C represented marginal propensity to consume.

According to the definition savings:

$$S = Y - C = Y - cY \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ (4)}$$

We can elaborate that saving is some proportion of total output.

$$S = sY \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ (5)}$$

The collaboration of macroeconomics sustain the situation:

$$I = sY \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ (6)}$$

Further, dividing with L the quantity of the labor force of one economy. I/L= s(Y/L). the letter i represent i=I/L and y represented y=Y/L then we can get macroeconomics sustainability becomes i=sy. In the general form:

$$Y = f\ (L, N, K) \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ (7)}$$

Here in this equation, Y represents GDP, L represents ~~to~~ land (Natural resources), N represented labor (labor force) and K represent capital (gross capital formation)

Econometrics equation:

$$LGDP = \beta_0 + \beta_1 LNRR + \beta_2 LL + \beta_3 LGCF + \beta_4 LHCI + \epsilon \ldots\ldots\ldots \text{ (8)}$$

Equation 8 represents the dependent variables and the independent variable. GDP represents output, NRR represents Natural resource rent, L is highlighted to Labor, GCF is elaborate to gross capital formation, and HCI represents the human capital institution.

The above equation formulates in ARDL modeling formation as follows:

$$\Delta LGDP_t = \alpha_0 + \sum_{i=1}^{l} a_{1i} \Delta LGDP_{t-1} + \sum_{i=0}^{p} \alpha_{2i} \Delta LNRR_{t-i} + \sum_{i=0}^{q} \alpha_{3i} \Delta LL_{t-i} + \sum_{i=0}^{r} \alpha_{4i} \Delta LGCF_{t-i} + \sum_{i=0}^{s} \alpha_{5i} \Delta LHCI_{t-i} + \\ + \beta_1 LGDP_{t-1} + \beta_2 LNRR_{t-1} + \beta_3 LL_{t-1} + \beta_4 LGCF_{t-1} + \beta_5 LHCI_{t-1} + \mu_t \quad (9)$$

In equation (9), Δ (change) reported that the first difference operator of the concerned factors the deterministic drift parameter is α_0.

Equation 10.represented the estimation with econometrics techniques unrestricted error correction Model (approach ECM) gives below.

$$\Delta LGDP_t = \alpha_0 + \sum_{i=1}^{l} a_1 \Delta LGDP_{t-i} + \sum_{i=0}^{p} \alpha_2 \Delta LNRR_{t-i} + \sum_{i=0}^{q} \alpha_3 \Delta LL_{t-i} + \sum_{i=0}^{r} \alpha_4 \Delta LGCF_{t-i} + \sum_{i=0}^{s} \alpha_5 \Delta LHCI_{t-i} + \lambda ECT - 1 + vt_t \quad (10)$$

In the above equation, λ shows the speed of the adjustment parameter and ECT denotes the residuals from the estimated model.

4. Results and Discussion

Table 1: Descriptive Statistics

	LGDP	LNRR	LL	LGCF	LHCI
Mean	28.77740	0.265673	1.046116	23.74444	0.436030
Median	28.70888	0.118934	1.378766	23.73952	0.424949
Maximum	31.17535	1.044016	2.057963	24.46745	0.587633
Minimum	26.17935	-0.434664	-0.922057	22.93552	0.234769
Std. Dev.	1.552426	0.424801	0.868230	0.373516	0.131989
Skewness	-0.028848	0.304330	-0.956444	-0.237812	-0.090736
Kurtosis	1.726105	1.784496	2.768258	2.463946	1.354367
Jarque-Bera	2.642472	3.002868	6.033371	0.834556	4.454190
Probability	0.266805	0.222810	0.048963	0.658838	0.107841
Sum	1122.319	10.36125	40.79853	926.0330	17.00517
Sum Sq. Dev.	91.58106	6.857322	28.64528	5.301534	0.662004
Observations	39	39	39	39	39

Source: Author Own Estimation by Using Eviews 9.0

Table 4.1 presented a descriptive statistic of the data which variables mentioned with names such as Gross Domestic Product (LGDP), Natural Resource Rent (NNR), Labor (L), Gross Capital Formation (GCF), and Human Capital Institution in the case of Pakistan over using time series data from 1971 to 2017. In this table also mention above all descriptive feature such as Mean, Median, Max, Mini, Stander deviation, Skewness, Kurtosis, Jargue- Bera, Probability, Sum, Sum Sq. Deviation and Observation.

This table shows to result of descriptive statistics empirically indicates that the mean of LGDP is higher (M=28.77) from LNNR (M=0.26), LL (M=1.046), LGCF (M=23.74), and LHCI (M=0.43). The stander deviation of LGDP (S.D= 1.55) has higher than other variables such as LNRR (S.D= 0.42), LL (S.D=0.86), LGCF

(S.D=0.37) and LHCI (0.13). From the descriptive statistic table, the study argues that gross domestic product and gross capital formation and labor are more significant variation data.

Table 2: Correlation Matrix

	LGDP	**LNRR**	**LL**	**LGCF**	**LHCI**
LGDP	1				
LNRR	0.64	1			
LL	-0.38	-0.48	1		
LGCF	0.95	0.55	-0.40	1	
LHCI	0.96	0.75	-0.42	0.91	1

Source*:* Author Own Estimation by Using Eviews 9.0

Table 4.2 elaborates on the association between the variables. In the table, the results indicate the correlation matrix outcome that all variables have a positive association with GDP except labor (-0.3873). The statistic correlation metrics tools result indicates that the correlation matrix represents the positive and negative association and magnitude of all variables of data. This correlation Matrix table's result shows a significant and positive association between LGDP, LGCF, and LHCI and a negative association of LL (-0.38) with GDP. Moreover, the result argues that in this table, there is no multicollinearity issue.

Table 3: Unit Root Test Results (Stationary and Non-Stationary)

	ADF Test		**PP Test**	
	At Level	1st difference	At Level	1st difference
GDP	10.94	-4.26***	7.89	-4.46***
NRR	-1.55	-5.51***	-1.64	-5.50***
L	-2.17	-6.29***	-2.24	-6.29***
GCF	0.56	-3.56**	0.53	-3.35*
HCI	-1.44	-3.23**	-1.02	-3.04**

Note: Significant sign *, **, *** represent to 10%, 5%, 1% level.

Source: Author Own Estimation by Using Eviews 9.0

Table 4.3 result of the unit root test indicates that all variables are non-stationary at the level and become stationary at the first difference.

Table 4: Bound Test Results

	5%	**10%**	**1%**
Lower Bound	2.86	2.45	3.74
Upper Bound	4.01	3.52	5.06
F-Stat		4.082	

Source: Author Own Estimation by Using Eviews 9.0

Table 5 elaborates on the result of the bound test of cointegration. The computed F-value is greater than the upper bound, and the result of this test indicates that the outcome finds out the long-run association between GDP with other explanatory variables in the case of Pakistan.

Table 5: Short and Long-run result of econometrics ARDL approach

Short Run Results				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNRR)	0.025	0.038	0.677	0.503
D(LL)	0.036	0.022	1.645	0.111
D(LGCF)	0.075	0.162	0.464	0.646
D (LGCF (-1))	-0.501	0.155	-3.215	0.0033***
D(LHCI)	-2.972	1.612	-1.842	0.076*
CointEq(-1)	-0.104	0.037	-2.804	0.009
Long Run Results				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRR	0.247	0.388	0.636	0.529
LL	0.353	0.176	1.999	0.055*
LGCF	1.668	0.769	2.167	0.038**
LHCI	6.360	2.553	2.490	0.018**
C	-12.390	17.321	-0.715	0.480
Diagnostic Tests				
R^2	0.949	J.B Test	32.53(0.095)	
Hetero Test	1.293(0.286)	LM Test	0.972(0.391)	
RAMSEY Test	0.207(0.652)			

*Note: *, **, *** represent the level of significance at 10%, 5%, 1%.*

Source: Author Own Estimation by Using Eviews 9.0

Table 5 indicates the statistical result of the short and long-run effect of natural resources rent (LNRR), Labor (LL), gross capital formation (LDCF), and human capital institution (LHCI) on the gross domestic product (LGDP). The finding shows the positive association of natural resource rent, labor force, gross capital formation, and human capital in both the short-run and long run. Also, the result of the ECT term is negative and significant that shows the insanity of long-run adjustment of equilibrium.

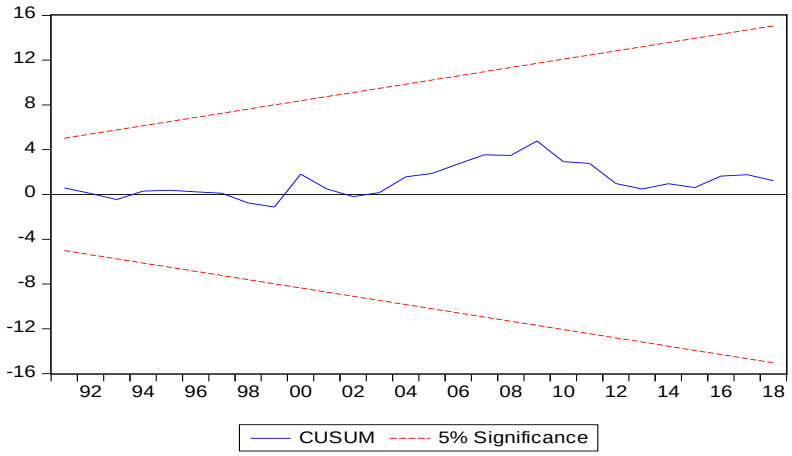

Figure 1: The results of CUSUM Test

Source: Author Own Estimation by Using Eviews 9.0

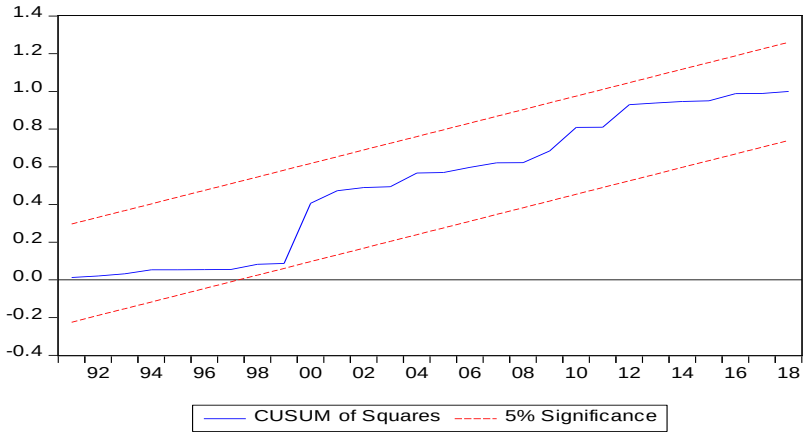

Figure 2: The results of CUSUMSQ Test

Source: Author Own Estimation by Using Eviews 9.0

Statistically, CUSUM and CUSUMSQ show the graphical stability of data estimated coefficients in the case of Pakistan that is shown in figure 1 figure 2.

4. Conclusion:

The purpose of this study was to investigate the link between natural resources rent, labor force, gross capital formation, and human capital with the gross domestic product of Pakistan under the Solow Swan Model using time series data from 1980 to 2017. The study employed the autoregressive distributed lag (ARDL) and found the long-run positive association of natural resources rent, labor force, gross capital formation, and human capital with the gross domestic product in Pakistan. This study verified with empirical evidence that the Solow Swan model is valid for Pakistan's economy in long run. This study recommends that the Pakistan government should attempt to increase economic growth by investing more in these factors and improve the performance of these variables.

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