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Measuring the Indicators of Cereal Production in Agricultural Land Use Effectiveness Growth in SAARC Countries: Evidence from Panel Data Modelling

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Abstract

Cereal production, cooperation and economic growth need to be distinct to generate policies that keep the environment make sure sustainable agricultural development around the world. Panel data comprise of the observations of manifold phenomena obtained over lots of time periods for either the same firms or individuals. The current study was conducted with an aim to find the efficiency growth in agricultural land and also find cereal production best model for South Asian Association for Regional Cooperation countries. The study used the secondary panel data of cereal production obtained from the World Bank. Moreover, for the selection of variables, pool-ability, Fixed Effect Model (FEM) and Random Effect Model (REM) were applied by F-test, Chow Test, Hausamn specification test and model selection criteria. Through analysis of present data, we proposed a FEM that can assume both the cross section and period effects to be fixed. It can forecast the cereal production for any given country contained by a specific forthcoming year. Governments in these countries must take the necessary steps to maintain agricultural land and encourage farmers to increase arable land in order to satisfy the food demands of SAARC's rising population.

Keywords

Variables selection test, Fixed effect model, Random effect model, Panel data analysis and SAARC countries.

1. Introduction

crop growing is the art of science of cultivating the different seeds, growing crops and raising livestock. Cereals have delivered limitless health assistances to people as a staple food in our nourishment. Cereals are absorbed in complex carbohydrates that provide you with plenty vitality, and help to preclude cancer, high blood sugar levels, constipation, and also benefit your overall health with plentiful proteins, fats, lipids, minerals, vitamins, and enzymes.

Most cereals have high fibre levels, notably oat, barley, and wheat, and they are fortified with niacin, iron, riboflavin, and thiamine. Moreover, soluble bran included in cereals helps decrease blood cholesterol levels and prevent heart disease. Consuming cereal also means consuming large amounts of protein because morning cereals are frequently consumed with milk, which results in a meal heavy in protein. Cereals with added iron are

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thought to be the best solid meals for babies. The best source of energy for humans is cereal.

According to economic survey of Pakistan (2016-2017), 19.50% gross domestic product (GDP) and 42.30% labor force depend on agriculture (World Bank 2022), So it is considered as an important factor in national development, food security and reduction of poverty. Regression analysis not only attempt to quantify the relationship strength of variables by modeling as well as to provide a powerful tool for predictions. The panel data consist of the explanation of manifold phenomena obtained over manifold time periods for either the same firms or individuals. Analysis of panel data deals with such complex phenomenon. In this study, we have analyzed the panel data of the cereal production (CP) of the SAARC countries for the selection of best model.

Many researchers used different panel data in their studies for estimation and prediction, which provides the basis for the development in the respective fields. Mayda (2010) investigates the determinants of economic, geographic, cultural, and demographic determinants of two-sided flows of immigration. By focusing on a simple theoretic context of both the factors, supply and demands, prediction-based analysis was presented. For Co-operation and Development countries (OECD), immigrants' inflows present in 14 organizations the author used fixed effect model (FEM) on the data with two dummy variables. Between exports and stock of outward foreign direct investment, the link was investigated by Falk and Hake (2008), by using the panel data of industries and European communities. They selected FEM and used generalized method of moments (GMM) for estimation.

Bangake and Eggoh (2011) and Gu *et al*. (2021) studied the cointegration and causality of relationship between economic growth and financial development and used the panel unit root and cointegration tests for stationary and then panel cointegration estimation.

Ghosal (2012), studied the growth of temporal and cross state behaviour present in India and tried to identify the relationship between poverty and inequality. With the prevalence of income poverty, he quantifies the nearby factors for the cross state and cross time variations by using FEM and the random effect model (REM). In growing countries like low income, upper middle income and lower middle-income territories, effects on poverty caused by inflation were examined by Talukdar (2012) by using FEM, pooled panel ordinary least square model (OLS) and dynamic panel least squared model.

The relationship between growth and power consumption of the economy was discussed by Nayan *et al.* (2013) that because of different sample periods had been inconclusive and conflicting. They examined by using the GMM method to estimate GDP and energy consumption model, and established long run relationship between energy usage, economic growth and energy pollutants. To investigate long run cointegration they used to test the approach famously known as Auto-regressive Distributed Lag (ARDL). Moreover to insure the validity and reliability of instruments they perform the serial correlation test AR (1) and AR (2) and Hansen test. Turmunkh (2021) used panel data to examine the causal economic implications on grain output and agricultural land use using estimation methods of differences and generalized moments. In the best of our knowledge no research has focused on the panel data modelling for cereal production of SAARC countries. Consequently, the literature motivates us to carry out the current study.

2. Material and Methods

Pakistan is an energetic participant of SAARC which can be responsible for appropriate agendas to its member states to jointly rouse collaboration and progress and to endorse concord and stability in South Asia. Now the tenancy of Pakistan to play the vigorous role to its best ability to promote peace, economic activities and prosperity. We have used the secondary data have been obtained from the World Bank for the study of CP or log of cereal production (LGCP). This study utilized annual balanced panel data for the following countries: Pakistan, Nepal, Bhutan, Maldives, Sri Lanka, India, Afghanistan, and Bangladesh, over the period of 51 years (1971-2022). So, we have 51 units and 8 cross sections and eventually 408 data points. We used ten potential explanatory variables, i.e. agricultural land (AGL) in square kilometres (kms), arable land (ARL) in hectares, land under cereal production (LUC) in hectares, agricultural land in percentage of total land area (AGLP), arable land hectares (ALHP), arable land percentage of land area (ALP), permanent crop land percentage of land area (PCP), land area (LA) in square kms, crop production index (CPI) for 2004-2006=100 and food production index (FPI) for 2004-2006=100. By the following formal procedure of panel data analysis, we have several statistical tools available for this analysis, such as variable selection tests, pool-ability tests and specification test as well as models for panel data.

2.1 Variable selection

There are several tests exist for selection the variables. These tests consist of Correlation; Mallow's C_p Criterion, Adjusted R-Squared (Adj-R^2), mean square error (MSE) and redundant variables test and are described briefly in the following.

Correlation matrix helps to analyse the strength of relationships between response and predictor(s). We may select the variables on the basis of higher values of r statistic and small p- values (Weisberg, 2005). Variables selection test based on the MSE gives us an asymptotic estimate of dispersion with which we select a model attaining least value of MSE. Adj-R^2 is an absolute measure of goodness of fit for a model. Larger value of Adj-R^2 leads to selection of the best model. Furthermore, a model with *p* parameters is an "adequate" model for which Mallow's C_P value becomes close to p (i.e., $C_P \approx p$). (Draper and Smith, 1998; Montgomery *et al.*, 2012).

For the significance of agricultural indicators to include in the model, redundant variable test is used. Whether some of the variables have zero co-efficient the same test is used so those variables might be remove for the formation of the model. To reach out the decision, F statistic and log-likelihood ratio statistic will be used. F statistic test is given below.

$$F = \frac{\left(RSS_1 - RSS_2\right)/(p_2 - p_1)}{RSS_2/(n - p_2)} \quad , \tag{1}$$

where, RSS_1 is simply the residual sum of square based on a model with restrictions and has p_1 number of parameters and for an unrestricted model RSS_2 is used, residual sum of square with number of parameters p_2. The decision, our null hypothesis (H_0: No redundant) is rejected will be made if the estimated value of F is larger than the critical value of F distribution with (p_2-p_1, n-p_2) degrees of freedom (d.f.). To compare the two models, log-likelihood ratio test is given as.

$$L = -2\ln\left(\frac{f(x|\beta_0)}{f(x|\beta_1)}\right) \quad (2)$$

$f(x|\beta_0)$ is likelihood for null model and $f(x|\beta_1)$ is the likelihood for alternative model. Conclusion of the model significance of best fit will be determined by the calculation of p-value of L - statistic.

2.2 Testing of pool-ability

To test the pool-ability of the panel data, we applied Chow test (Chow, 1960) for pool-ability of panel data relationship between the cereal production and related explanatory variables. The restricted model in the pooled model given as

$$Y_{it}= \alpha+\beta X_{it}+ u_{it}, i = 1, 2, ... , n; \; t = 1, 2, \dots , T \quad (3)$$

Y_{it} is the response variable with ith country and the time period, X_{it} is a (k×1) vector of explanatory variables changing over time and cross-sections, α is the unknown intercept absorbing the impacts of the time and country-invariant variables in the equation as well as any heterogeneity in the data and similarly β is (1×k) vector of constants (k = Number of regressors). Since we have a large number of observations over time periods (i.e.T=51) and only a few countries (i.e. N=8), we must interested in testing the pool-ability of data for the case of pooling across time (see Baltagi, 2005). In case of unrestricted model the values of parameters vary over time. In this situation, The F statistic, in this regard, is defined as.

$$F = \frac{(RSS_1 - RSS_2)/k}{(RSS_2)/(n_1 + n_2 - 2k)} \quad (4)$$

Where, RSS_1 and RSS_2 are restricted and unrestricted residual sum of squares respectively and k is number of regressors. Here the restricted model means the pooled model and the unrestricted model indicates a model based on distinct parameter values for each period of time. This test propagates that under the under the null hypothesis (H_0: No pool-ability), the calculated F statistic follows the F distribution with k and (n_1 + n_2 – 2k) d. f. We do not reject the null hypothesis (Hsiao, 2003) if the estimated F value do not exceed the critical value of F statistics.

2.3 Fixed effect model

A FEM technique is used if analysis is performed for the variables that their impact seems not to change over time. In this specific case, if the method would be found suitable, maintaining all other effects constant, FEM would restrict the analysis of cereal production in SAARC countries. The general form of the FEM is.

$$Y_{it}= \alpha_i+\beta X_{it}+ u_{it} i = 1, 2, ..., n; t = 1, 2, \dots, T \quad (5)$$

Y_{it} is the response variable with the country and the time period, X_{it} is a (k×1) vector of explanatory variables varying over time and cross-sections, α_i is the unknown intercept for each country absorbing the effects of the time-invariant variables in the equation as well as any heterogeneity in the data and β is (1×k) vector of constants. Here u_{it} only represents the errors associated with variables that occur between the countries and will change with time and do not depend on the individual's characteristics (Baltagi, 2005 and Hsiao, 2003).

2.4 Random effect model

Contrary to FEM in the sagacity that RFM allows if any of the differences present between countries to be random and un-correlated rather that fixed. This versatility make account in the analysis of these two variables time-invariant demographic and agricultural variables too. Where in the FEM they are absorbed by the intercept alone. The REM is given by.

$$Y_{it} = \alpha + \beta X_{it} + \varepsilon_i + u_{it} i = 1, 2, ..., n; t = 1, 2, ..., T \tag{6}$$

The main difference between the two models is the addition of ε_i in REM which is the error term connected with the agricultural indicators contained by everyone such as demographic and agricultural time-invariant variables. α is a frequent mean value for the intercept and the individual differences in the intercept values α_i of each cross-section are reflected in the ε_i error term (Baltagi, 2005 and Gujarati, 2003)

2.5 The Hausman's specification test for model selection

In panel data modelling, to make a distinction between FEM and REM, Hausman's specification test (Hausman, 1978) is used. This test is based on testing for orthogonality of the RE and regressors. The test statistic is defined as

$$H = (\hat{\beta}_1 - \hat{\beta}_0)' \left(\text{var}(\hat{\beta}_0) - \text{var}(\hat{\beta}_1) \right)^{-1} (\hat{\beta}_1 - \hat{\beta}_0) \tag{7}$$

Where, $\hat{\beta}_1$ is RE estimator and $\hat{\beta}_0$ is FE estimator. The Hausman's test is a kind of Wald Chi-square test with (k-1) degrees of freedom (d.f.). on the difference matrix between the variance-covariance of FEM with that of REM. Under the null hypothesis of no difference between FEM and REM, the test statistic H is assumed to follow Chi-square distribution with (k-1) d.f. Rejection of null hypothesis leads to the inconsistency of RE (Greene, 2002 and Hsiao, 2003).

3. Results

We analysed the numerical data of cereal production in SAARC countries following the methods mentioned above and found the following results. Table 1 shows the values of correlation coefficients of SAARC countries p-values under-neath all indicators. All the explanatory variables except ALHP are significantly correlated with response variable CP. It indicates that ALHP is not likely to contribute in forecasting the CP. Further it indicates the potential inclusion of all of them in the model except ALHP.

3.1 Correlation matrix

Table 1: Association between agricultural indicators.

Indicators	CP	ARL	LUC	AGL	AGLP	ALHP	ALP	PCP	LA	FPI
ARL	0.9241 (0.001)									
LUC	0.933 (0.000)	0.997 (0.006)								
AGL	0.9061 (0.003)	0.987 (0.000)	0.979 (0.000)							
AGLP	0.4331 (0.002)	0.406 (0.000)	0.434 (0.000)	0.459 (0.000)						
ALHP	-0.045 (0.363)	0.060 (0.227)	0.026 (0.598)	0.186 (0.000)	0.147 (0.008)					
ALP	0.587 (0.000)	0.550 (0.000)	0.593 (0.000)	0.514 (0.000)	0.815 (0.000)	-0.179 (0.003)				
PCP	-0.143 (0.004)	-0.178 (0.000)	-0.175 (0.000)	-0.226 (0.000)	-0.105 (0.034)	-0.552 (0.000)	-0.178 (0.000)			
LA	0.013 (0.000)	0.980 (0.000)	0.968 (0.000)	0.993 (0.000)	0.426 (0.000)	0.2010 (0.000)	0.498 (0.000)	-0.262 (0.000)		
FPI	0.011 (0.025)	-0.070 (0.158)	-0.062 (0.209)	-0.045 (0.366)	0.069 (0.165)	-0.275 (0.000)	-0.107 (0.031)	0.332 (0.000)	-0.072 (0.146)	
CPI	0.006 (0.011)	-0.046 (0.355)	-0.040 (0.422)	-0.009 (0.857)	-0.143 (0.004)	-0.207 (0.000)	-0.078 (0.014)	0.343 (0.000)	-0.035 (0.002)	0.981 (0.001)

Note: p-values are shown in parenthesis. p-value < 0.05 indicates significance.

3.2 Model selection test

For the convenience of description, here we use the symbols A, B, C, D, E, F, G, H, I and J for all explanatory indicators ARL, LUC, AGL, AGLP, ALHP, ALP, PCP, LA, CPI and FPI respectively. In Table 2, 47 different models have been compared on the basis of S^2, Adj-R^2 and C_p for selection of the best model. The Model No.9 (i.e. ABCDEFGI) corresponds the largest value of Adj-R^2 (i.e. 92.3795) and the smallest value of MSE (i.e. 2.6548×10^{14}). Similarly the same model has an expected value of Cp (i.e. 7.0696) approximately equals to number of coefficients in the fitted model (including the constant). Consequently, this model recommends these 8 variables ARL, LUC, AGL, AGLP, ALHP, CPI, ALP, and PCP to be selected as explanatory variables in further discussion.

3.3 Redundant variable test

On the basis of redundancy test, the variables CPI (p-value = 0.8488), LA (p-value = 0.8219) and FPI (p-value =0.2415) are found redundant, and all others (having p-values less than 0.05) are likely to be included in the model. We may exclude these three variables but based on information of selection criteria (Table 2), we exclude the two variables LA and FPI and the resultant model with related statistics may be found as in Table 3.

3.4 Chow test for Pool-ability

The computed value ($F = 1.37\times10^3$) is significant at 5% level of significance and we can conclude that all the cross-sections and sub populations i.e. Pakistan, India, Sri Lanka, Maldives, Bhutan, Bangladesh, Afghanistan and Nepal have dissimilar regression and structural breaks in data over the period 1970-2021.

Table 2: Model selection criterion.

Model No.	Included variables	MSE	Adj R^2	C_p
1	ABCDEFGHIJ	2.6823×10^{14}	92.3004	10.1934
2	ABCDEFGHI	2.6654×10^{14}	92.3491	8.6532
3	ABCDEFGHJ	2.6702×10^{14}	92.3352	10.3759
4	ABCDEFGIJ	2.6613×10^{14}	92.3610	9.0364
5	ABCDFGHIJ	2.6950×10^{14}	92.2642	14.0667
6	ABCDEFHIJ	3.0100×10^{14}	91.3599	59.3250
7	ABCDFGHJ	2.7180×10^{14}	92.1982	16.5156
8	ABCDFGHI	2.6891×10^{14}	92.2812	12.1931
9	ABCDEFGI	2.1548×10^{14}	92.3795	7.0116
10	ABCDEFGJ	2.6614×10^{14}	92.8607	9.0507
11	ABCDFGIJ	2.6883×10^{14}	92.2834	12.0765
12	ABCDFGI	2.6677×10^{14}	92.3424	11.0000
13	ABCDFGJ	2.7120×10^{14}	92.2154	14.6362
14	ABCDEFG	2.8831×10^{14}	91.7241	40.3008
15	ABCDEFJ	2.9868×10^{14}	91.4264	55.8478
16	ABCDEFI	3.0018×10^{14}	91.3835	59.8420
17	ABCDFJ	3.0483×10^{14}	91.2501	64.2026
18	ABCDFI	3.0517×10^{14}	91.2402	64.7220
19	ABDFHI	3.1237×10^{14}	91.0335	75.5446
20	ABDFHJ	3.1532×10^{14}	90.9488	79.1635
21	ABDEHI	3.1542×10^{14}	90.9460	80.1277
22	ABDHI	3.1486×10^{14}	90.9622	79.2773
23	ABDHJ	3.1852×10^{14}	90.8570	83.9834
24	ABCHI	3.2291×10^{14}	90.7310	90.5953
25	ABHIJ	3.2544×10^{14}	90.6585	94.4025
26	ABEHI	3.2558×10^{14}	90.6545	94.6129
27	ABHI	3.2625×10^{14}	90.6352	94.8489
28	ABGI	3.2767×10^{14}	90.5944	96.9961
29	ABDI	3.3135×10^{14}	90.4888	102.5540
30	ABGJ	3.3195×10^{14}	90.4715	102.7060
31	ABEI	3.3223×10^{14}	90.4635	103.8830
32	ABI	3.3179×10^{14}	90.4761	103.2230
33	ABJ	3.3646×10^{14}	90.3422	109.5320
34	BFI	3.4134×10^{14}	90.2021	116.9190
35	BCI	3.4435×10^{14}	90.1157	121.4780
36	BCJ	3.4714×10^{14}	90.0355	125.7080
37	BI	3.5163×10^{14}	89.9066	131.8300
38	BJ	3.5860×10^{14}	89.7067	142.4000
39	AI	4.0389×10^{14}	88.4067	211.1560
40	AJ	4.1280×10^{14}	88.1508	224.6900
41	AB	4.2076×10^{14}	87.9223	236.7760
42	B	4.5093×10^{14}	87.0562	282.2740
43	A	5.1107×10^{14}	85.3302	373.7880
44	C	6.2390×10^{14}	82.0914	545.5050
45	H	7.0429×10^{14}	79.7839	667.8490
46	F	2.2901×10^{15}	34.2633	3081.3300
47	Constant	3.4838×10^{15}	0.0000	4909.0100

Table 3: Redundant test for agricultural indicators.

Included as Independent Variables (Indicators)	MSE	Adj-R^2	C_p
ARL, LUC, AGL, AGLP, ALHP, ALP, PCP, CPI	2.1548×10^{14}	92.3795	7.0116

3.5 Hausman's specification test

To select the FEM or REM, Hausman-specification test has been used. Table 4 presents the Correlated Random Effects - Hausman Test for Panel data.

Table 4: Correlated Random Effects-Hausman test (Period random).

χ^2- Statistic	d.f.	p-value
36.860720	8	0.0001

Agricultural Indicators	FEM	REM	Var (Diff.)	p-value
AGL	0.001029	0.000027	0.0000	0.1174
AGLP	-0.014192	0.014364	0.0001	0.0015
ALHP	1.281428	-0.102805	0.0997	0.0000
ALP	-0.033849	-0.059380	0.0007	0.0019
ARL	-0.000020	-0.000220	0.0000	0.0359
CPI	-0.001148	0.007323	0.0000	0.0000
LUC	0.000002	0.000071	0.0000	0.9048
PCP	-0.091237	-0.093212	0.0000	0.7148

Since the p-value (i.e., 0.0001) is smaller than the level of significance, the Hausman test significant result shows in favor of FEM. So, the final FEM of panel data in SAARC countries is given by

$$LGCP_{it} = \alpha_i + \beta_1 AGL_{it} + \beta_2 AGLP_{it} + \beta_3 ALHP_{it} + \beta_4 ALP_{it} + \beta_5 ARL_{it} + \beta_6 CPI_{it} + \beta_7 LUC_{it} + \beta_8 PCP_{it} + \mu_{it}. \quad (8)$$

3.6 Models for the panel data

We are using LGCP as the response variable. We have used different panel model on the basis of different assumption about cross-section and time period.

3.6.1 Simple (Pooled) Least Square Model

Table 5: Simple (Pooled) least square regression model.

Agricultural Indicators	Coefficient	SE	t-Statistic	p-value
C	6.449400	1.076320	5.9921	0.0000
AGL	-6.05×10^{-5}	1.09×10^{-5}	-5.5494	0.0000
AGLP	0.437842	0.070375	6.2216	0.0000
ALHP	4.924541	1.804278	2.7294	0.0066
ALP	-0.283316	0.063855	-4.4369	0.0000
ARL	9.34×10^{-7}	1.73×10^{-7}	5.3844	0.0000
CPI	0.015122	0.008067	1.8745	0.0016
LUC	-4.07×10^{-7}	1.23×10^{-7}	-3.3011	0.0010
PCP	-0.531451	0.066409	-8.0027	0.0000

R^2	Adj- R^2	p-value(F-statistic)
0.568775	0.560129	0.00000

The fitted model is as under.

$$LGCP_{it} = 6.449400 - 6.05\times10^{-5} AGL_{it} + 0.437842 AGLP_{it} + 4.924541 ALHP_{it} - 0.283316 ALP_{it} + 9.34\times10^{-7} ARL_{it} + 0.015122 CPI_{it} - 4.07\times10^{-7} LUC_{it} - 0.531451 PCP_{it} \quad (9)$$

3.6.2 Panel EGLS (Period random effects)

Following table shows the estimated generalized least square (EGLS) panel data model. In this case, we assumed the Cross-sections effect to be fixed (dummy variables) and period's effect to be random as specification effects.

Table 6: Panel estimated generalized least square (random effects periods).

Agricultural Indicators	Coefficient	SE	t-Statistic	p-value
C	9.336463	1.756452	5.3155	0.0000
AGL	2.59×10^{-5}	8.68×10^{-6}	2.9853	0.0030
AGLP	0.014363	0.035841	0.4007	0.6888
ALHP	-0.103804	0.451022	-0.2279	0.8198
ALP	-0.079380	0.043776	-1.3565	0.1757
ARL	-1.41×10^{-7}	7.84×10^{-8}	-1.8581	0.0639
CPI	0.007323	0.002079	3.5231	0.0005
LUC	5.77×10^{-8}	3.54×10^{-8}	1.6309	0.1037
PCP	-0.093212	0.038153	-2.4431	0.0150
R^2	Adj-R^2	F-statistic		p-value
0.982364	0.981689	1455.666		0.0000

The fitted model is given below.

$$LGCP_{it} = 9.336463 + 2.59\times10^{-5}AGL_{it} + 0.014363AGLP_{it} - 0.103804ALHP_{it} - 0.079380ALP_{it} - 1.41\times10^{-7}ARL_{it} + 0.007323CPI_{it} + 5.77\times10^{-8}LUC_{it} - 0.093212PCP_{it} \quad (10)$$

3.6.3 Panel least squares

In this case, we assumed the both the Cross-sections and Periods to be fixed effect (dummy variables) as specification effects. The results have been compiled in Table 7.

Table 7: Panel least squares regression.

Agricultural Indicators	Coefficient	S.E.	t-Statistic	p-value
C	8.616740	1.886332	4.5680	0.0000
AGL	2.85×10^{-5}	8.84×10^{-6}	3.2257	0.0014
AGLP	-0.014162	0.036955	-0.3832	0.7018
ALHP	1.281458	0.550578	2.3275	0.0205
ALP	-0.033839	0.044538;8	-0.7600	0.4479
ARL	-1.16×10^{-7}	7.96×10^{-8}	-1.4587	0.1456
CPI	-0.001147	0.002801	-0.4095	0.0824
LUC	5.61×10^{-8}	3.80×10^{-8}	1.4778	0.1404
PCP	-0.091238	0.038533	-2.3678	0.0185
R^2	Adj-R^2	F-test	p-value	
0.985119	0.982291	348.3244	0.0000	

Following is the fitted model for forecasting.

$$LGCP_{it} = 8.616747 + 2.85\times10^{-5}AGL_{it} - 0.014162AGLP_{it} + 1.281458ALHP_{it} - 1.281458ALP_{it} - 1.16\times10^{-7}ARL_{it} – 0.001147CPI_{it} + 5.61\times10^{-8}LUC_{it} - 0.091238PCP_{it} \quad (11)$$

3.6.4 Panel EGLS (Cross-section random effects)

Following table shows the EGLS Panel data model. Here, the Cross-section effect has been assumed to be random and Period effect to be fixed (dummy variables) as specification effects.

Table 8: Panel estimated generalized least square (Random Effects Cross-section).

Agricultural Indicators	Coefficient	SE	t-Statistic	p-value
C	10.88065	1.489301	7.3059	0.0000
AGL	2.03×10^{-5}	7.71×10^{-6}	2.6301	0.0089
AGLP	-0.024174	0.036186	-0.6681	0.0045
ALHP	1.145329	0.546314	2.0965	0.0368
ALP	-0.012144	0.042854	-0.2834	0.7770
ARL	-1.21×10^{-7}	7.85×10^{-8}	-1.5391	0.1247
CPI	-0.000416	0.002770	-0.1502	0.8807
LUC	7.68×10^{-8}	3.65×10^{-8}	2.1023	0.0362
PCP	-0.083263	0.037905	-2.1966	0.0287
R^2	Adj-R^2	F-statistic		p-value
0.326135	0.214145	2.912199		0.0000

Following is fitted model of Panel estimated generalized least square.

$$LGCP_{it} = 10.88065 + 2.03\times10^{-5}AGL_{it} - 0.024174AGLP_{it} + 1.145329ALHP_{it} - 0.012144ALP_{it} - 1.21\times10^{-7}ARL_{it} - 0.000416CPI_{it} + 7.68\times10^{-8}LUC_{it} - 0.083263PCP_{it} \quad (12)$$

3.6.5 Panel EGLS (Random Effects two way)

Following table shows also the EGLS Panel data model. In this method, both cross-section and period effects have been assumed as random for specification effects.

Table 9: Panel estimated generalized least square (Two-way random effects).

Agricultural Indicators	Coefficient	S.E.	t-Statistic	p-value
C	10.53414	3.884481	2.7119	0.0070
AGL	1.99×10^{-5}	7.45×10^{-6}	2.6724	0.0078
AGLP	-0.002179	0.034434	-0.0633	0.9496
ALHP	0.182329	0.463065	0.3937	0.6940
ALP	-0.026369	0.041260	-0.6391	0.5231
ARL	-1.33×10^{-7}	7.56×10^{-8}	-1.7551	0.0800
CPI	0.005365	0.002223	2.4131	0.0163
LUC	7.81×10^{-08}	3.46×10^{-8}	2.2587	0.0244
PCP	-0.086172	0.036581	-2.3557	0.0190
R^2	Adj-R^2	F-statistic		p-value
0.150436	0.133402	8.831600		0.0000

The following is fitted model.

$$LGCP_{it} = 10.53414 + 1.99\times10^{-5}AGL_{it} - 0.002179AGLP_{it} + 0.182329ALHP_{it} - 0.026369ALP_{it} - 1.33\times10^{-07}ARL_{it} + 0.005365CPI_{it} + 7.81\times10^{-08}LUC_{it} - 0.086172PCP_{it} \quad (13)$$

3.6.6 Summary characteristics of different models

For the comparison purpose, the summary characteristics of different models discussed above have been compiled in Table 10.

Table 10: Summary characteristics of different models.

Model No.	Assumptions	Significant coefficients	Adj-R^2
5	Pooled	AGL, AGLP, ALHP, ALP, ARL, CPI, LUC, PCP	0.5600
6	Cross Fixed, Time Random	AGL, CPI, PCP	0.9817
7	Cross Fixed, Time Fixed	AGL, ALHP, PCP	0.9823
8	Cross Random, Time Fixed	AGL, AGLP, ALHP, LUC, PCP	0.2141
9	Cross Random,	AGL, CPI, LUC, PCP	0.1334

From Table 10, it is obvious that the Model 7 has the highest value of Adj-R^2 (i.e. 0.9823). It means that this model explains the maximum proportion of the variability of the dependent variable LGCP. For this model we have assumed both the cross section and period effects to be fixed. This assumption coincides with the declaration of Hausman Specification test. Another Interesting fact about this model becomes obvious that the dependent variable LGCP significantly depends only on three variables AGL, ALHP and PCP.

4. Discussion and conclusion

In South Asian Association for Regional Cooperation nations with a high level of agricultural output, 64% of the population lives in rural regions, while agriculture employs more than 45% of the total labour force and contributes for about 27% of GDP on average. Arable land in SAARC is mostly found in desert and mountain pastures.Arable land accounts for around 22% of total agricultural land area.In Central Asia, agricultural land is divided into three categories and is used by rural families in the form of mining, agricultural, and livestock holdings. This article was solely concerned with agricultural usage and grain output in the agricultural sector.

To estimate the CP of SAARC countries, the panel data analysis has been carried out. The variables LA and FPI were not found as important factors on the basis of model selection criteria and the redundancy test. Chow test rejected the pool-ability of the data for all sub populations (i.e. Pakistan, Sri Lanka, India, Maldives, Bhutan, Nepal, Bangladesh and Afghanistan) and subsequently suggested the consideration of FEM or REM. The Hausman specification test helped out in the selection of FEM or REM. This test presented the significant result in favour of FEM. Moreover, we used panel FEM and REM on the basis of a number of assumptions on cross-sections and periods. The significance of FEM is verified by the two models (Models 6 and 7) with the highest Adj- R^2 (i.e., 0.9817 and 0.9823 respectively, reported in Table 10).

The two models are characterized by cross sectional fixed effect. Further the Model 7 is characterized by time fixed effect as well. So we conclude our discussion with the selection of this Model 7 (i.e. Panel least squares model). In this model, interestingly the variables

AGLP, ALP, ARL and CPI have adverse effect on response variable LGCP are significant as well. On the other hand variable LUC is insignificant but had a positive effect. Whereas, the variable PCP responds in an opposite fashion (i.e. negative but significant).

Therefore, we concluded that the dependent variable LGCP significantly depends only on three variables AGL, ALHP and PCP. Using this model we can forecast the cereal production in any specific SAARC country in a specific forthcoming year. In conclusion, these countries search out the plan of productive financial improvement arrangements and centre on their achievement in line with approaches to move forward rural arrive utilize. monetary growth is not a make well for getting better the worth of the environment, and policies to carry economic growth are not an alternate for environmental policies.

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