# A LAGRANGE MULTIPLIER APPROACH TOAGRICULTURAL PRODUCTIVITY AND NUCLEAR ENERGY CONSUMPTION IN PAKISTAN

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***ABSTRACT:****This study endeavors to observe the association between nuclear energy consumption and agricultural productivity inPakistan for theeraof1971 to 2015. The time series data is used for analysis to get results regarding relationship between nuclear consumption and agricultural productivity. The Ng-Perron Test is used to check order of integration between dependent and explanatory variables. The long-term and short term association between variables is found by using the ARDL, Granger-causality tests. The coefficient value of error correction terms shows speed of adjustment at which system get adjustment towards long-term equilibrium. The value of speed of adjustment is 149.4 %. The magnitude of nuclear energy consumption shows positive effect on agricultural productivity inPakistan over the period of research.*

Key words: Nuclear energy consumption, Agricultural productivity, Pakistan, ARDL

## INTRODUCTION

[1, 2, 3] used radiation in the agriculture, medicine, and industry in the Japan and United States. They investigated enhancement of gross domestic product at large scale in both countries. A detail study has been done in others countriesregarding theconsumption of nuclear energy and application of radiation. It was found that use of nuclear energy and radiations have a huge effect on agricultural productivity, medicine, and industry. In [4]authors performedsame work during 1991 and 1994 in the U.S and they investigated a large difference between this and the aforesaid study, the both studies have direct and indirect effects on agricultural productivity and industry of medicine that was 2–3 times larger.

It is alarming situation for us to realize that more than one billion people from total populationin the world go to bed hungry every night and several peoplepasses away from hunger related disease or hunger every day. So it is foremost need to find out new ways and direction to boost food production and agricultural products to meet the need of hunger population[5].

In 1953 President Eisenhower emphasizing in a conference" Atoms for Peace" and asked to scientists and engineers for increase use of the atom and radiations to boost welfare of humanity in medicine, agriculture, and field of industry. It is known that the proper amounts ofnutrients and water is used to produce maximum crop yields. In modern agriculture practices the use of fertilization is more necessaryfor maximization of crops' yields.The researchers used radioisotopes to increase crop yields instead of fertilizers by reducing cost of input factors and reducing environment damage. Similarly, neutron moisture gadgets assist cultivators to make the best use of restricted water supplies. The developments of new species-varieties with help of radioisotopes and bombarding radiation on seeds to alter DNA structures, which face highly temperature and storm damage easily, and give better growth and yields of various crops IAEA, [6]. These superior species play important for production of agricultural products in the world. With the tool of radiation, more than 30 nationsof the worldproduced 2250 new varietiesof crops, like wheat, rice, barley, beans, apples, cherries, oranges, bananas, peas, grapes, apricots, soybeans, sunflowers, grapefruit, and produced flowers such as roses, streptocarpus, chrysanthemums, alstroemerias, bougainvillea, begonias, dahlias, carnations, achieves, and azaleas Nicholas, [7].

To date, in world China has achieved benefit(27%); Netherlands (7.8%); USA (5.7 %,) USSR/Russia (9.3%); India (11.5%), and Japan (5.3%) from the use of nuclear energy. In the world, Thailand has become thelargest exporter of aromatic riceby using of radiation and nuclear energy consumption [8].

In the world cotton is most important crop for the textile industry for decades. In 1983, the researchers used gamma rays on cotton mutant NIAB-78 and produced a large amount of cotton for textile sector; really, this crop has brought a revolution in agricultural sector and earned a heavy amount of revenue for farmers. The large impact of this product has been seen in Pakistan. The productions of NIAB-78 have become double to radiation-induced variety within 5 years in Pakistan Walter, [9].

Increases in use of nuclear energy and control on climate change can cause boost in production crops and yields IAEA[10, 11, 12, and 14]

The foremost aim of this research is to fill the gap about the impacts nuclear energy consumption on the Agricultural Productivity in Pakistan and to find whether impact of nuclear energy consumption on agricultural productivity is positive or negative.

## MATERIALS AND METHODS

In optimization, the method of Lagrange multipliers is used to find optimization of a given function subject to equal constraints.

For consideration the optimization problem, we select two variables and one constraint

maximize $f(\eta, \psi)$

subject to $g(\eta, \psi) = 0$.

Here we take first partial derivative of both continues function $f(\eta, \psi)$and $g(\eta, \psi)$ for critical values. The optimization of objective function can be searched out with help of critical values. The $\lambda$ is a Lagrange multiplier, which introduced as a new variable for optimization. The $\lambda$ term may be either added or subtracted in an equation.

The Lagrangian function can be expressed as

$F(\eta,\psi, \lambda) = f(\eta, \psi)+ \lambda [k-g(\eta, \psi)]$ (1)

The Lagrangian takes the form for the general case of an arbitrary number *M* of constraints and n choice variables and may be written as

$F(\eta_1, \ldots \eta_n, \lambda_1 \ldots \lambda_m) = f(\eta_1, \eta_n) + \sum_{k=1}^{m} \lambda k \, gk(\alpha 1, \ldots \alpha n)$ (2)

Now both control and controlled variables are expressed in version of a model:

F (AGP, NEC, λ) = F(AGP, NEC) + λ [k-g(AGP, NEC)]

In the above equation F (AGP, NEC, λ) is called Lagrangian function and F (AGP, NEC) is called objective function. The objective function is f (AGP, NEC) and the constraint of the function is g (AGP, NEC). In factg (AGP, NEC) = 0, therefore, the product λ [k-g(AGP, NEC) = 0. The critical values of AGP, NEC and λ can be calculated by taking 1st partial derivate. Thus critical values of AGP and NEC are given as

$F_{AGP}$ (AGP, NEC λ) = 0, $F_{NEC}$ (AGP, NEC, λ) = 0 and F λ (AGP, NEC, λ) = 0

**Data Collection**

Data of NEC have been taken from ycharts.com/indicators/ Pakistan/ Nuclear energy commission. The unit of nuclear consumption is Terawatt-hours, while data of AGP (Agricultural productivity) has been taken from ycharts.com/indicators/ Pakistan/ Ministry of Agricultural. The value of Agricultural productivity has been taken as U.S Dollar at current prices.

## RESULTS AND DISCUSSIONS

### Results of Ng-Perron test

Primarily, Ng-Perron Test [15] is used to check the unit roots of the variables and this test is also applied to find order of integration between agricultural productivity and nuclear energy consumption. The results of both series at level are reported in Table 1 and results at first difference are presented in Table 2. The findings explores that NEC is integrated at I (0), while AGP is integrated at I (1) but no one series is integrated at I (2).

**Table 1: Result of AGP and NEC of Ng-Perron Test at level**

| Vars | MZa | MZt | MSB | MPT |
|---|---|---|---|---|
| AGP | 1.92 | 2.01 | 1.049 | 89.76 |
| NEC | -10.51 | -2.16 | 0.20 | 2.80 |

Note: * shows significance at 1% significance level

**Table 2: Result of Ng-Perron at 1st Difference**

| Vars | MZa | MZt | MSB | MPT |
|---|---|---|---|---|
| AGP | -19.01* | -3.07 | 0.16 | 1.31 |
| NEC | -20.07* | -3.16 | 0.15 | 1.24 |

Note: * shows significance at 1% significance level

Consequently, the ARDL approach may be applied to find the m association between

AGP and NEC.Before using ARDL approach, it is necessary to check the optimum lag order.

The findings of VAR Lag order selection are reported in Table 3.

**Table 3. VAR Lag Order Selection**

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | -879.53 | NA | 6.38 | 48.97 | 49.06 | 49.00 |
| 1 | -799.87 | 146.08* | 9.536* | 44.26* | 45.08* | 44.88* |
| 2 | -797.52 | 4.06 | 1.05 | 44.86 | 45.30 | 45.01 |
| 3 | -794.92 | 4.18 | 1.14 | 44.94 | 45.55 | 45.15 |
| 4 | -792.87 | 3.08 | 1.28 | 45.04 | 45.84 | 45.32 |
| 5 | -791.71 | 1.60 | 1.53 | 45.20 | 46.17 | 45.54 |
| 6 | -789.09 | 3.34 | 1.70 | 45.28 | 46.42 | 45.68 |
| 7 | -781.42 | 8.95 | 1.44 | 45.07 | 46.39 | 45.53 |
| 8 | -780.59 | 0.87 | 1.82 | 45.25 | 46.75 | 45.77 |

* indicates lag order selection criterion

Thus in this situation ARDL bound testing technique is applied to find co integration between

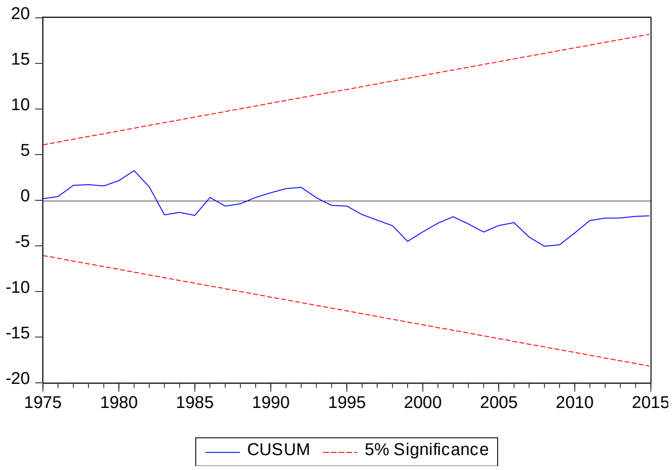
agricultural productivity and nuclear energy consumption. The results show that optimum lag is 2 for cointegration between two these variables.

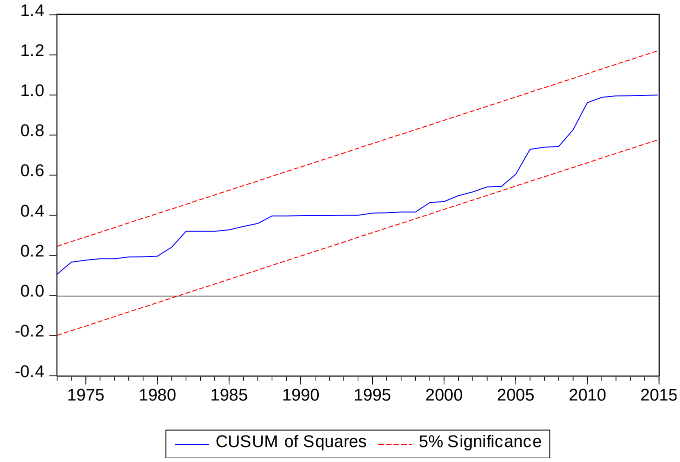
**Diagnostics test**

The diagnostics test shows that there is no problems of autoregressive white heteroscedisticity, Heteroskedasticity : ARCH and conditional heteroscedisticity in both models. Similarly, the problem of serial correlation is not found in short term and long term model. Thus it may be concluded that model is fit for analysis.

| **Sensitivity Diagnostics test** | |
|---|---|
| Heteroskedasticity Test: ARCH | 0.219 (0.146) |
| W. Heteroskedasticity | 0.286 (0.304) |
| L.M Test | 0.416 (0.49) |
| Ramsey test | 0.471 (0.479) |
| Cond. Hetroheteroscedisticity | 0.587 (0.645) |

### 3.3 The graph of CUSM and CUSM of square tests




The graph of CUSM and CUSM of square tests indicate that both lines lie between boundary of red lines, which indicate that model is fit for analysis in short term and long-term.

**Ordinary least square regression results**

Log (AGP) = δ +ß log (NEC)

= 23.55 +0.263log (NEC)

Prob = (0.055)

R-squared = 0.084

F-Stat = 3.897

D.W = 1.89

The OLS regression findings argued that there is positive association between agricultural productivity and nuclear energy consumption at 5% level of significance. These findings are reliable with the results of empirical study of various researchers.

Here D-W Stat is 0.89 that is greater than vale of $R^2$ (0.084). Thus, this demonstrates that model is non spurious and it is appropriate for analysis. The probability value of model is 0.05 and this shows that nuclear energy has positive impact on agricultural productivity at significant level at significant level.

**ARDL approach**

Nevertheless, the value of F-statistic is determined by using the VECM as follows:

$$\Delta \text{Ln AGP}t = \alpha + \sum_{i=1}^{m} \alpha 1 \Delta \text{Ln AGP}t - 1 + \sum_{i=0}^{m} \alpha 2 \Delta LnNECt - 1 + \alpha 3 \Delta \text{Ln AGP}t - 1 + \alpha 4 \Delta LnNECt - 1 + \eta i \quad (3)$$

$$\Delta \text{Ln NECT}t = \beta + \sum_{i=1}^{m} \beta 1 \Delta \text{Ln NEC}t - 1 + \sum_{i=0}^{m} \beta 2 \Delta LnAGPt - 1 + \beta 3 \Delta \text{Ln NEC}t - 1 + \beta 4 \Delta LnAGPt - 1 + \psi i \quad (4)$$

Where, Ln AGPtand LnNECare agricultural productivity and nuclear energy consumption are in natural logs and t is time trend variable. The error terms are η and ψ. The first part of equation with $\alpha_1$, $\alpha_2$ and $\beta_1$ and $\beta_2$ shows short term of dynamics whereas $\alpha_3$, $\alpha_4$ and $\beta_3$, $\beta_4$ depicts long-term picture of the model.

In equation (3), the null hypothesis is $\alpha_3 = \alpha_4$ which shows that there is no long-term associationbetween variablesand vice versa, while in equation (4) the null hypothesis is $\beta_3 = \beta_4$ which indicates there is no long- term association and vice versa.

In the subsequently step computed value of the F-statistics are compare with tabulated critical bounds values by [16, 17]. There is no long-term relationship if the critical value of F-statistic exceed critical bound values, thus null hypothesis of no long-term association is not accepted, regardless orders of integration of the variables are I(0) or I(1). In the same way, if the computed values of F-statistic remain below the critical bound value, the null hypothesis is not accepted.

According to the Granger causality theorem the cointegration exist among variables if the Granger casualty is occurred at least in one direction.[18]suggested that it will not show the presence of cointegration if the Granger causality test is employed at first difference through Vector Auto Regression. For that reason, the error-correction term in VAR give helps to detain the long-term association.

The VECM may be written as under:

$$\begin{bmatrix} \Delta LnAGPt \\ \Delta LnNECt \end{bmatrix} = \begin{bmatrix} C1 \\ C2 \end{bmatrix} + \sum_{J}^{P} \begin{bmatrix} d11(L) & d12(L) \\ d21(L) & d22(L) \end{bmatrix} x \begin{bmatrix} \Delta LnAGPt-j \\ \Delta LnNECt-j \end{bmatrix} + \begin{bmatrix} \beta1 \\ \beta2 \end{bmatrix} x \begin{bmatrix} ECT-1 \\ ECT-1 \end{bmatrix} + \begin{bmatrix} \eta1 \\ \eta2 \end{bmatrix}$$

Where difference operator is a Δ and the ECT is error correction term, which obtained from ARDL model. C is constant where $C_i$ = 1, 2. The uncorrelated random disturbance terms with zero mean are $\eta_i$ where i=1, 2. Nevertheless, the ECT and VECM give new direction for Granger causality. The significance level of lagged ECTs by T-test show long-term causality. The Wald test or F-Statistics find short-term causality through sum of lags of independent variables.

**Table 5. Granger causality test**

| Null Hypo | F-Stat | Prob |
|---|---|---|
| Log (AGP) does not Granger Cause Log (NEC) | 2.35 | 0.126 |
| Log (NEC) does not Granger Cause Log (AGP) | 3.53 | 0.037 |

The experimental confirmation specifies that nuclear energy consumption granger causes agricultural productivity in the long-term and as well as in short term. The conclusion further expose that agricultural productivity does not cause energy consumption in the short term and the long-term. The findings of different approaches indicate that normal distribution of error terms take place in both models. The results of Granger Causality test[16] are reported in Table 5. The findings show that nuclear energy consumption does not Granger causes AGP in Pakistan and Null hypothesis is accepted. This shows that AGP does not Granger cause nuclear energy consumption because p-value is greater than 10 percent significance level. In second row NEC does not Granger causes AGP and this detect that nuclear energy consumption effect agricultural productivity at 5 percent significance level and null hypothesis is rejected. This shows unidirectional causality from NEC to AP in Pakistan.

**Table.4 ARDL approach for long term relationship**

| Estimated Model | F-Stat<br>F= 4.846 | Opt Lag<br>2<br>2 |
|---|---|---|
| LOGNEC/LOGAGP | 0.8875 | |
| LOGAGP/LOGNEC | 4.876 | |
| | Pesaran et al. (2001) | |
| Critical values<br>Signif level | Lower Critical Bound | Upper Critical Bound |
| 1% | 5.150 | 6.360 |
| 5% | 3.793 | 4.850 |
| 10% | 3.170 | 4.140 |

Note: Critical values of Pesaran et al. (2001) following unrestricted intercept and no trend. The lag selection is
based on AIC and SBC. ** denotes cointegration exists at 10% level of significance

The results of Pesran et al.[17,18] and ARDL are presented in Table-4. The computed value of F-statistic shows co-integration and long-termassociationbetween agricultural productivity and nuclear energy consumption. This is so because the computed F-Statistics is larger than upper critical bound at 10% significance level, because nuclear energy consumption is a forcing variable.

**Table 5. Short term Analysis**

| Variables | Short- term | | Long-term | |
|---|---|---|---|---|
| ΔNEC | ΔNEC | ΔAGP | ECT-1 | R-Squ |
| | | 3.713<br>(0.033) | -1.494<br>(0.0058) | 0.278 |
| ΔAGP | 1.941<br>(0.157) | | | |

The findings of long-term andshort-term, are reported in Table 6. The problem of spuriousness can be reduced by using the appropriate lag length.

The ARDL technique is employed to check the long termassociation between agricultural productivity and nuclear energy consumption. The findings of ARDL techniquespoint out that thelong-runassociation between agricultural productivity and consumption of nuclear energy.Furthermore, the coefficient value of ECT (-1) is -1.494,which shows the system will get adjustment towards long-term equilibrium at speed of adjustment 149.4 %. Nevertheless, in short term model, there is no problem of serial correlation and instability, thus the model is fit for analysis.

## CONCLUSIONS

This study discovers the causal coalition between agricultural productivity and nuclear energy consumption in case of Pakistan from 1971-2015. The integrating order of variables is detected by using Ng-Perron unit root test. From aforesaid series, one series is integrated at I(0) and other series is integrated at I(1), thus ARDL bounds test technique can apply to find the long-term relationship between variables. The Granger causality test expresses theunidirectional causality between nuclear energy utilization agricultural productivity. The findings show positive impact of nuclear consumption on agricultural productivity in Pakistan.These results are reliable with the findings[8, 1, 3] and many others.Finally, for continue of growth of agricultural productivity, Government of Pakistan requires to raise nuclear energy consumption inagricultural sector, which will pull up the growth in Pakistan.

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