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Rural Infrastructural Investment and Rice Production in Pakistan

An Econometric Analysis

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Abstract- This study estimated the impact of rural infrastructure investment on rice production in Pakistan by using Cobb Douglas production function for 1972-2014 in Pakistan. Different tests are used to check the stationarity of time series data. Autoregressive distributive lag (ARDL) technique is employed to estimate long run and short run relationship. It is observed that good infrastructure is encouraging the rice production in Pakistan. The study found that fertilizer usage, water availability for rice, area under rice production and health expenditure has positive whereas electricity consumption has negative effect on the rice production in the long run. However, impact of electricity on rice production is found positive in the short run but this impact is minute due to the unavailability of electricity, load shedding and some other reasons. All variables are affecting positively in the short run except fertilizer consumption.

Index Terms- Economics; Investment; Rural Infrastructural; Pakistan; Rice; Water, Electricity; Mary

I. INTRODUCTION

Agriculture sector is one of the important sectors of the economies around the world. According to FAO (2014) 2.57 billion people depends on agriculture which comprises of 42% of total population in the world. This dependence is direct as well as indirect because people use agriculture for food as well as it provides livelihood to a significant number of population around the globe.

Agriculture is highly significant in both developed and developing countries. Even agriculture is equally important in industrialized countries. As indicated by FAO (2014) agricultural export of industrial countries alone were worth about US$290 billion in 2001. However, a clear decline in agriculture production has been seen in the past few decades. This decline is quite dominant in developing countries despite of having good climatic conditions for agriculture. According to World Bank (2013) the agriculture in developing countries like Pakistan, India and Bangladesh has drastically declined in the last two decades.

As far as Pakistan is concerned, its agriculture is an important component of GDP. It serves to fulfill the food needs and it is the main source of living for 66% of country's total population. Since Pakistan is an agricultural country thus most of its population is rural and affiliated to the farming and farm related activities. In relation to 1998 census of Pakistan, the total population was one hundred and thirty million. Approximately 3.4 million people are adding to the population every year. This rise in population drives a concern that agriculture should also rise with the same rate.

Pakistan is majorly producing wheat, sugarcane and rice to serve the food needs of its rising population. As stated by Pakistan Federal Bureau of Statistics (2014) during the last two decades some vital infrastructural changes have been made in agriculture sector as well as crop sector of Pakistan. To increase the production of food crops like wheat, rice, livestock, sugarcane and fisheries, infrastructural changes have taken place and brought significant increase in production of some crops like wheat and cotton. Cotton is equally significant as wheat in terms of value added with 1/5 share of entire income. Rice and wheat are major crops used as food consumption. Both of the crops are equally important but still not much of the research has been done to find the ways for increasing the production of both crops. Therefore present study is focused on rice crop to fill in the existing gap in research to find out ways to increase this important crop.

Rice occupies about 11% of total cultivated area in the country and is planted on about 6.4 million acres with a production of about 6 million metric tons of milled rice. Approximately 2/3 of the production is consumed domestically and 1/3 of surplus is exported. Pakistan is the 4^{th} largest rice exporting country in the world after Thailand, Vietnam and United States (AARI Annual Report, 2014). Annual exports of rice around 1 million ton/annum make rice yet another important crop to be highly progressive in production terms. However, about 5.541 million tons of rice was produced in 2010. This indicates that total rice produced to the set goal of 6.9 million tons.

Pakistan has experienced a decline of 19.7 percent during 2011-2012.[1] Due to this decline Pakistan's exports of rice have declined from US $2.18 billion in 2009-10 to US $1.92 billion in 2011-12. The target for producing rice in 2014 was set up to 6,200 (000) tons where as the total production was only 5,541 (000) tons. Therefore it is required to investigate the causes of reduction in the production and exports of rice.

Pakistan Economic Survey (2012) suggest that economic development strategies cannot be successful without giving due importance to infrastructure of agriculture sector. Moreover, agriculture has strong forward and backward linkages

1 Trade Development Authority of Pakistan

particularly with the industrial sector. According to Pakistan Economic Survey (2014), Public investment has recorded an impressive growth rate at 17.12 % as compared to negative growth of - 0.35 % during 2013. This indicates that there is a major shift in government expenditure priorities. But still there is a huge room for improvement because this amount still could not reach to the targeted number of 21.2%. This highlights that public investment is not up to the mark than required.

This is quite understandable that in developing countries like Pakistan public investment is one of the strongest instruments through which the government can achieve its development objectives in regard to production of important food crops but unfortunately reduced government development expenditure indicates that all these truths of the need of increased investment in rural infrastructure are being neglected in Pakistan from several past years (Federal Bureau of Statistics. Statistics Division, 2014). The decline in rice production point out that government attention has remained low for the provision of sufficient rural infrastructure.

Rural infrastructure can be improved through investment in two components of infrastructure i.e. social and physical infrastructure. Social infrastructure investment indicates investment in education and government health expenditures. On the contrary, physical infrastructure investment indicates investment to improve roads, electrification to villages, research and development in agriculture, provision of land, technology, irrigation facilities and market development. All these factors can play an imperative role in enhancing agricultural production in the country. There may be some drawbacks in the structural transformation of the rice production sector for the case of Pakistan. Nadeem, Mushtaq and Javed (2011) addressed these drawbacks by using social and physical rural infrastructure as an important determinant to increase the production but these studies were limited to Punjab only.

It is observed that social and physical infrastructure can increase the agriculture production. Educated and healthy farmers can produce more of the crop's output. Improved roads can help farmers to reach markets in time. Electrification to villages and subsidies on electricity can facilitate farmers for using tube wells for the production purpose. Provision of land at cheap rates can help framers to cultivate more land. The current study is important because no significant work has been done in Pakistan to find out the relationship among rice production and rural infrastructure investment in Pakistan. The present study has tried to remove the existing slit by identifying the affect of rural infrastructure investment variables on rice production in Pakistan.

II. Review of Empirical Literature

Many studies on rural infrastructure empirically investigated the relationship between rural infrastructure and agriculture growth. According to these studies crop wise usage of fertilizers (Ali, 1995; Akino, 1979; Abbas, Din, Ghani & Qureshi, 1996), Water availability for rice (Binswanger & Pingli, 1988; Fan, Hazell & Thorat, 1998), area under rice crop (Akino, 1979; Froster, 1947; Hamley, 1993; Oshiro, 1985), agricultural electricity consumption (Binswanger & Pingli, 1988; Li & Liu, 2009), and rural health expenditures (Datta, 2007; Froster, 1947; Hamley, 1993; Raymond, 2008) are important variables that effect the agriculture growth as well as rice production. ‘

Rural infrastructure increases the agriculture productivity on the whole. Dorosh (1996) found positive correlation of rural infrastructure development and agriculture as well as economic growth. Nagarbhavi (2003) studied different types of rural infrastructures and found that all types of infrastructure are important for each other and have positive effect upon agriculture and economic development. Javier (2005), Yuko and Kajisa (2012) also supported this relationship later on.

Fertilizer usage increases the rice production. Akino (1979) while doing case study of Japan found positive correlation between the fertilizer usage and agriculture production. Abbas et al. (1996) also supported these results. Ali (1995) found a negative relationship in contrast to the relationship between the fertilizer usage and rice production. The negative relationship was assumed to be due to excessive usage of fertilizer. Kouser and Mushtaq (2007) also determined a negative relationship between the two due to usage of fertilizer in off time.

Water availability is essential for rice production. Kessler and Hill (1979) during the study of Malaya found a significant importance of irrigation facilities for rice production. Kikuchi and Hayami (1983) while studying the shortage of water for crop production also found the positive impact of water supply upon production. Boyce (1988) while studying institutional alternatives in Asian rice found positive effect of water for rice production.. Fan et al. (1998) used water as a dummy variable for infrastructure and found positive impact of variable. Dutta and Bezbaruah (2006), Kouser and Mushtaq (2007) found positive correlation among water facilities and agriculture production. Faltermeier and Abdulai (2008) used the example of Ghana to state the positive relationship among agriculture production and water availability. Li and Liu (2009) in the study obtained highly significant coefficients for water supply which also showed the positive correlation. Nadeem et al. (2011) estimated the results on rural tube wells and agriculture production but data was only available for 1985-2005. To derive expenditure on water facilities, the study used percentage share of the water investment in rural areas with the total funds available for water facilities and found the positive results too.

Land is one of the important physical infrastructure variables for rice production. Forster (1947) estimated positive correlation among land and production. Scobie and Posada (1978) investigated the same relationship for the land availability and agriculture production. He also found positive results. Oshiro (1985) studying the case of Japan observed low interest loans to the farmers for buying more land increases the output. Looney (1994) found that agriculture growth and infrastructure are interlinked and rural infrastructure investment increases growth and vice versa. Wanmali and Islam (1997) and Bhatia (1999) used time series analysis to check the effect of rural infrastructure investment and total agriculture production and found that more land increases production and the areas where more subsidized land was provided had shown rapid improvement in growth.

Agriculture electricity consumption increases rice production. Rural electrification has direct effect on production. Binswanger and Pingli (1988) found the positive relationship of electricity and agriculture production in the short run but the relationship becomes negative over time because in the long run electricity becomes expensive due to which the farmers decline the production. Sbia and Shahbaz (2013) used Co-integration and Causality Analysis from the agriculture sector of Pakistan and found that electricity is an important component for improvement in production as well as the economic growth. This study illustrated that share of energy consumption in agriculture sector has constantly turned down from 19 percent to 14 percent in 1972 and 11 percent to 1 percent in 2005 in the case of petroleum and electricity correspondingly. This decline is the major fact of expensive electricity. In order to maintain the production up to a level the government is bound to pay attention upon the infrastructure like cheap electricity provision. Li and Liu (2009) observed that electricity prices negatively effects the production. They concluded that cheap electricity increases production. Llanto (2012) used Panel data analysis of different countries that invested in electricity and showed a significant progress in agriculture. It was found that with low cost electricity farmers experience feasible options of production.

Rural health expenditures by government increase the rice production. Gramlich (1994) during the review of infrastructure investment found that rural health expenditures of government positively affect the production. Yusuf (1996) examined the response of different countries to the infrastructure investment and returns to agriculture output and found investment in rural health directly effects agriculture production. Barrett, Moser, McHugh & Barison (2004) concluded that better health facilities increase the energy level and aptitude of farmers to work for more hours on the farm. Fan et al. (1998) used farmers' health as a determinant of good production and found similar results. Jahan and Selim (2005) took share of farmers and found with more of healthy farmer's production increases. Results of both studies showed that farmers with good health positively affect the production. Ali (2005) used panel data approach for the estimation purpose by collecting data from four different villages and found positive correlation among farmer's health and agriculture production. Haggblade (2007) found positive impact of rural health facilities upon agricultural production. Datta (2007) estimated that good social infrastructure positively increase the rice production. Raymond (2008) discussed the similar results. Hamid and Ahmad (2009) assessed that for many countries human is a major capital for production. If farmers health is considered it brings about many benefits to the country. Nadeem et al. (2011) concluded that injecting investments in farmer's health helped not only framers to be physically fit and increased their livelihood but also helped the whole economy. Llanto (2012) also found that one unit increase in health facilities increases the agriculture activity more than one.

One thing can be determined from the literature review that there was a interrelationship of rural infrastructural development and production. In past studies researchers sometimes used panel data approach and mostly use time series analysis to estimate the relationship of production and rural infrastructure investment. From the reviewed literature it can be easily observed that signs of some variables varies from study to study.

This study is different be because very few studies are available for Pakistan, more specifically upon the relationship of rural infrastructure investment and rice production. Mushtaq, Abbas and Ghafoor (2007) used co-integration and causality analysis of rice from Punjab, Pakistan and analyzed the importance of rural infrastructure for agriculture growth but the center of this study was to check the causality of infrastructure and rice production only for Punjab. Nadeem et al. (2011) checked the impact of rural infrastructure upon rice production and applied time series analysis but his study was still restricted to Punjab only therefore no study was found upon the interrelationship among rural infrastructure and rice production in Pakistan. This present study has put up the case of Pakistan to empirically examine the impact of rural infrastructure investment on rice production in Pakistan by using time series data.

III. Methodology and Data Sources

Time series data is taken from the past 42 years i.e. from 1972 to 2014 because the population increase and food decline has been seen during the past four decades (World Bank, 2014). This decline has led to the need of producing more food for the country. Rice is chosen to study the impact of infrastructure investment on its production and the results of this research are estimated partially by E. Views version 6.0 and partially by Microfit 4.0.

Estimating Model

The model of the study is stated in Cobb Douglas form as given below

The model is presented in to linear form by taking natural log of all variables[2].

$LNRP = \beta_0 + \beta^1 LNF + \beta^2 LNW + \beta^3 LNL + \beta^4 LNE + \beta^5 LNHE + \beta_6 FL + \hat{u}_t$ …. Eq 1

Where as

LNRP = Natural log of rice production

LNF = Natural log of crop wise usage of fertilizer

LNW= Natural log of water availability for rice

LNL = Natural log of area under rice crop

LNE= Natural log of agricultural electricity consumption

LNHE= Natural log of health expenditures by government

FL = Flood as dummy variable[3]

(i) According to null hypothesis all rural infrastructural variables of equation 1 are assumed to be increasing function of rice production i.e. β1, β2, β3, β4, β5, are expected to be positive The study is focused on detecting the long run and short run relationship among total rice production and independent variables. To address their relationship Pesaran and Pesaran (1995), Pesaran and Shin (1995, 2002) introduced a relatively feasible cointegration test known as Autoregressive Distributed Lag (ARDL) approach because it is used to test long and short run relationship between

2 Natural Log form of variables is taken to eliminate the non linear into linear form

3 Natural log of flood (FL) as dummy variable is not taken because its values can either be 0 or 1 and LN(0) = - infinity and LN(1) = 0 , in this case its impact cannot be determined with taking LN. Fundamentals of Linear Algebra by James B, Carrell (july,2005)

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the variables. [4] ARDL technique is more convenient to apply upon this study because it can be applied upon variables regardless of their cointegration level.

Table 1 presents the detailed variables description, their theoretical perception and data sources.

4 Pesaran *et al.*, (1996, 2001)

Table 1 Variables Description, Definitions of variables, Units and Data Sources

Variable Name	Variable Description	Definition of Variables and their Units	Expected Signs	Data Source
LNRP	Rice Production	Production of rice is the yield or ending result crop cultivation. It is measured in yield per hectares	N/A	Ministry of Food and Agriculture (1972), (2014)
LNF	Crop wise usage of fertilizer	Fertilizer is a mixture of organic compounds spread into soil to increase its capacity to support crop growth. Its use is measured in nutrient tones (000N/T)	Positive	National Fertilizer Development Centre (NFDC), Planning & Development Division(2014)
LNW	Water availability for rice	Improved water source is construction of more tube wells. It is calculated in terms of number of tube wells million acre feet (MAF)	Positive	Planning & Development Division (Water) (1972), (2014)
LNL	Area under rice crop	Area under rice crop represents the land utilized to cultivate rice. It is measured in million hectares	Positive	Ministry of Food and Agriculture (1972), (2014)
LNE	Agriculture Electricity Consumption	Agriculture electricity Consumption represents the farmers consuming electricity. More consumption reflects that electricity is easily available at cheap rates. It is measured in Gigawatt Hour (Gwh)	Positive	Various Issues of Pakistan Economic Survey (PES)
LNHE	Development and non development health expenditures by government	Health expenditures reflect the expense by government for the provision of quality of medical facilities for villagers. It indicates the social rural infrastructure development for farmers. It is measured in million rupees	Positive	Various Issues of Pakistan Economic Survey (PES)
FL	Flood	Flood is an overflow of a large amount of water beyond its normal limits.	Any	National Monsoon Contingency Plan 2013, 2014(NMCP)

Flood is introduced in the model as dummy variable to undertake the sudden shocks like flood during rice production. The year 1973, 1975, 1976, 1977, 1978, 1981, 1983, 1984, 1988, 1994, 1995, 2010, 2011 and 2012, 2013, 2014 reflects the years in which flood came. The values of dummy variable FL in the given years of flood is taken as 1 and 0 otherwise. FL is taken to check whether or not floods had any effect on the total rice production in Pakistan during the years.

IV. Empirical Results

The model applied in this study has empirically found the effect of rural infrastructure investment upon rice production in Pakistan. The results of Graphical plots, Correlograms, Augmented Dickey-Fuller and Phillips Perron tests results are summarized in Table 2. After determining the stationary level ARDL is applied to estimate the long and short run relationship among the variables irrespective of the level whether I(0) or I(1). However, ARDL can collapse if variables are I(2) or higher. So it cannot be applied on the variables whose order of integration is 2. In this study all of the variables are integrated at I(1) so ARDL can be applied. ARDL use Error Correction Model (ECM) to determine short run relationship between variables. Lastly, CUSUM and QCUSUM graphs are plotted to check the structural stability of the model. The estimation of the model is started with the graphical analysis discussed in the next section.

A summary of unit root test results related to order of integration is given in the following table. The final conclusion about the level of stationarity is drawn on the bases of majority test results.

Table 2 Decision about order of integration from all tests of Stationarity

Variables	Results of graph test	Results of Correlogram	Results of ADF	Results of PP	Final Conclusion
LNRP	**I(1)**	**I(1)**	**I(1)**	**I(1)**	**I(1)**
LNF	**I(1)**	**I(1)**	**I(I)**	**I(I)**	**I(I)**
LNW	**I(1)**	**I(1)**	**I(1)**	**I(1)**	**I(1)**
LNL	**I(1)**	**I(1)**	**I(1)**	**I(1)**	**I(1)**
LNE	**I(1)**	**I(1)**	**I(1)**	**I(1)**	**I(1)**
LNHE	**I(1)**	**I(1)**	**I(1)**	**I(1)**	**I(1)**

The results of Table 2 showed that all variables are integrated at 1st difference i.e. I(1). As none of the variables is integrated of higher order, so the study with no doubt has applied ARDL technique for examining rural infrastructural investment impact on rice production in Pakistan.

Results of Auto Regressive Distributive Lag Model (ARDL)

ARDL bond testing approach is performed to determine the long run relationship among the variables. The econometric ARDL model for the given study is as followed

$$\Delta LNRP = \beta_0 + a_1 \sum_{i=1}^{p} \Delta LNRP_{t-i} + \beta_1 \sum_{i=0}^{p} \Delta LNF_{t-i} + \beta_2 \sum_{i=0}^{p} \Delta LNW_{t-i} + \beta_3 \sum_{i=0}^{p} \Delta LNL_{t-i} + \beta_4 \sum_{i=0}^{p} \Delta LNE_{t-i} + \beta_5 \sum_{i=0}^{p} \Delta LNHE_{t-i} + \beta_6 FL + \gamma LNRP_{t-1} + \gamma_1 LNF_{t-1} + \gamma_2 LNW_{t-1} + \gamma_3 LNL_{t-1} + \gamma_3 LHE_{t-1} + u_t$$

The optimum lag length is selected through "Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC) and Hannan-Quinn information Criterion" (HQIC). The results for the selection of optimal lag length for each model are given in Table 3. The study takes the optimum lag length of 2 as suggested by Hannan-Quinn Information Criterion and Schwarz Information Criterion (SC) for carrying on further estimation.

Table 3 VAR Lag Order Selection Criteria

Endogenous variables LNRP
Exogenous variables C LNF LNW LNL LNE LNHE FL
Date 05/22/15 Time 16 33
Sample 1972 2014
Included observations 39

Lag	LogL	LR	FPE	AIC	SC	HQ
0	60.51915	NA	0.004317	-2.610690	-2.318129	-2.504156
1	67.11135	10.61184*	0.003292	-2.883481	-2.535456	-2.761727
2	68.68792	2.460988	0.003208*	-2.911606*	-2.549125*	-2.774633*

* indicates lag order selected by the criterion
LR sequential modified LR test statistic (each test at 5% level)
FPE Final prediction error
AIC Akaike information criterion
SC Schwarz information criterion
HQ Hannan-Quinn information criterion

F statistic is obtained to test the joint hypotheses that all slope coefficients of lagged variables are equal to zero. Pesaran provide critical values based on their stochastic simulation. For this study Table 4 show that Pesaran critical values for this model are (90%, 95%).

Table 4 Bound Testing for ARDL Co-integration

<table>
<tr><th colspan="3">Wald Test</th><th colspan="2">Critical Bounds for 95% Significance</th><th colspan="2">Critical Bounds for 90% Significance</th><th>Status</th></tr>
<tr><td>Null Hypothesis</td><td colspan="2">There exist no cointegration among the variables</td><td>Lower</td><td>Upper</td><td>Lower</td><td>Upper</td><td rowspan="4">Reject H_0</td></tr>
<tr><td rowspan="2">F-statistic (6, 27)</td><td>Calculated F-Stat</td><td>Probability Value</td><td rowspan="3">2.73</td><td rowspan="3">3.90</td><td rowspan="3">2.43</td><td rowspan="3">3.51</td></tr>
<tr><td>12.88357</td><td>0.0000</td></tr>
<tr><td>Chi-square</td><td>90.17799</td><td>0.0000</td></tr>
</table>

The Pesaran critical values in brackets (90%, 95%) show the lower and upper bound respectively.
The significance level was examined through F-stat table given by Pessran (1995).

Calculated F-Stat		Tabulated F-stat (Pessran Upper Critical Value at 95%)
12.88357	>	3.90

The F- value of calculated F-Stat > Tabulated F-stat. This result indicates that the estimation can proceed because there is a long run relationship between the variables of the model. After having the Wald test the study preceded to ARDL estimation.

Table 5 Autoregressive Distributed Lag Estimates

ARDL (1,1,1,1,0,1,0) selected based on Schwarz Bayesian Criterion
41 observations used for estimation from 1974 to 2014
Dependent variable is LNRP

Regressor	**Coefficient**	**Standard Error**	**T-Ratio[Prob]**
LNRP(-1)	0.54933	0.10252	5.3581[.000]
LNF	-0.16925	0.070838	-2.3893[.024]
LNF(-1)	0.17420	0.067468	2.5820[.015]
LNW	0.13621	0.10774	1.2643[.216]
LNW(-1)	0.36789	0.12551	2.9312[.007]
LNL	0.70638	0.099127	7.1260[.000]
LNL(-1)	-0.48453	0.11401	-4.2500[.000]
LNHE	0.26018	0.10178	2.5563[.016]
LNE	0.038646	0.054988	.70280[.488]
LNE(-1)	-0.20561	0.053254	-3.8610[.001]
FL	0.0073740	0.012947	.56957[.573]
C	-0.40486	0.76259	-.53091[.600]

R-Squared	.96464	R-Bar-Squared	.95122
S.E. of Regression	.033409	F-stat. F(11, 29)	1.9160[.000]
Mean of Dependent Variable	7.5044	S.D. of Dependent Variable	.15127
Residual Sum of Squares	.032368	Equation Log-likelihood	88.2789
Akaike Info. Criterion	76.2789	Schwarz Bayesian Criterion	65.9974
DW-statistic	2.3078	Durbin's h-statistic	-1.3062[.191]

Diagnostic Tests

Test Statistics	**LM Version**	**F Version**
A Breusch-Godfrey (LM) test (Serial Correlation)	CHSQ (1) = 1.7374[.187]	F(1, 28) = 1.2390[.275]
B Ramsey RESET (Functional Form)	CHSQ (1) = .046410[.829]	F(1, 28) = .031731[.860]
C Jarque-Bera (Normality)	CHSQ (2) = 3.453[.178]	Not applicable
D ARCH test (Hetroscedasticity)	CHSQ (1) = .0031523[.955]	F(1, 39) = .0029988[.957]

First of all stability of ARDL model was tested through sensitivity analysis. The results of ARDL of diagnostic test are provided in Table 5. The Diagnostic test results of Breusch-Godfrey test (LM) of serial correlation was also insignificant at 5% significance level which suggests that lagged values of residuals are not correlated. While the insignificant value of Ramsey RESET at 5% level of functional form shows that the model of the study was in right functional form. The results estimated by Jarque-Bera normality test for skewness and kurtosis of residuals are normally distributive, also was insignificant at 5% level. Since the hypothesis of normal distribution is accepted. The insignificance of ARCH test for hetroscedasticity indicates the residuals are homoscedastic.

The results of diagnostic tests indicated that there is no autocorrelation and hetroscedasticity. After having the good diagnostic testing for the ARDL model the next step is to estimate long-run coefficients of model. Table 6 presents the long-run results of the ARDL model.

Table 6 Estimated Long Run Coefficients using the ARDL Approach

ARDL(1,1,1,1,0,1,0) selected based on Schwarz Bayesian Criterion
Dependent variable is LNRP
41 observations used for estimation from 1974 to 2014

Regressor	**Coefficient**	**Standard Error**	**T-Ratio[Prob]**
LNF	0.010982	0.11510	0.95410[.925]
LNW	1.1186	0.35902	3.1156[.004]*
LNL	0.49228	0.25969	1.8956[.068]***
LNHE	0.57731	0.18278	3.1585[.004]*
LNE	-0.37049	0.11518	-3.2165[.003]*
FL	0.016362	0.028962	.56497[.576]
C	-0.89837	1.7224	-.52158[.606]

Note *,**, and *** show the 1%, 5% and 10% significance level respectively

The coefficient of intercept in the ARDL long run coefficients was negative. It suggests that if all other variables were equal to zero the total rice production would not be highly effected and would be reduced up to 0.898%.

The estimated coefficient of LNF which is proxy for technology showed that it had positive and insignificant effect on the LNRP in the long run. The study found that the coefficient of LNF showed that 1% change in the fertilizer usage brings about 0.010% changes in the total rice production.

There is a positive correlation between water availability for rice and total rice production. The coefficient of LNW showed that 1 percent increase in LNW resulted in 1.111% change in the total rice production. P-value of LNW is .004 which is highly significant at 1% significance level suggesting that in Pakistan the water availability or access to water supply for the famers involved in producing rice rapidly increase the total rice production. The results of LNW are similar to the studies of Ali (1995), Binswanger, & Pingali (1988), Fan, Hazell, & Thorat (1998), Kouser, & Mushtaq (2007), Li,& Liu (2009), Nadeem, Mushtaq & Javed (2011), Siddiqi (1993) analyzed that water availability and irrigation had significant impact on rice production. Kouser, & Mushtaq (2007) argued that it would have large effect on the agriculture output. This fact can be justified because mostly farmers are encouraged to cultivate rice if water is easily available for production. These results suggests in case for Pakistan the water availability or access to water supply for the famers involved in producing rice would rapidly increase the total rice production in the long run.

The results showed positive relationship between area under rice crop and total rice production. The coefficient of LNL showed that if there is 1% change in the area under rice crop and there would be 0.492% changes in the total rice production. The P-value for LNL is .068 indicating 10% significance level. Boyce (1988), Looney (1994), Musisi, (2006), Nadeem (2011), Oshiro (1985), Singh & Kalra (2002), Welch, et.al. (2010) found that the results of area under cultivation corresponds to agriculture investment have positive effect on production. Their results indicated that land is essential factor for production.

Coefficient of LNHE was positive and it was found that 1% change in the health expenditures result 0.57731% change in the total rice production. The P-value for LNHE is .004 which indicated that it was significant at 1%. Hamid and Ahmad (2009), Nadeem, Mushtaq & Javed (2011), Gramlich (1994), Barrett, Moser, McHugh, & Barison (2004), Haggblade (2007), Jahan and Selmi (2005) found health as an important driver for the production.

The impact of agricultural electricity consumption on total rice production in Pakistan is negative. P-value of LNE is 0.003 showing that it is statistically significant at 1% level. This result did not support the hypothesis because according to the null hypothesis there should be a positive relationship between agricultural electricity consumption and total rice production. The coefficient of LNE suggested if there is 1% change in agricultural electricity consumption there would be 0.37049% reduction in the total rice production. Douglas (1928) empirically found the negative relationship between electricity and rice production in the long run. The reason this study gave for the negative relation between the two is that electricity would become more expensive in the long run and for farmers profit margins decline for producing the rice crop. In this regard the farmer declines the rice production and with using expensive electricity rice production is reduced and other alternatives fuel or petroleum may be considered.

Flood in the study was expected to have negative sign but have positive sign according to the model. The ARDL long run coefficient of FL indicated that if the flood comes the rice production will be affected by 0.01636. This positive relation was maybe due to after effects of flood on rice. Flood increases soil fertility and water table that have positive effect on crops especially rice. So whenever flood comes farmers become happy due to its positive effects in the long run.

From the above analysis of long run relationship of rice production in Pakistan with water availability of rice, area under rice crop, agricultural electricity consumption and health expenditures are significant. On the contrary crop wise fertilizer usage and floods are insignificant over the selected sample.

It is important to check the relationship between rice production and explanatory variables in short run. For this purpose study estimated Error Correction Mechanism. Results of ECM were as follow.

V. Results of Error Correction Model (ECM)

After having the long run parameters of rice production model the study proceeded to estimate the short run parameters for ECM equation. This is the third step for ARDL estimation. P is the suggested lag length of the model. The empirical results of short run estimates are given in table 7 The ECM equation for the rice production model is as follows

$$\Delta \text{ LNRP} = \beta_0 + a_{1i} \sum_{i=1}^{p} \Delta \text{LNRP}_{t-i} + \beta_{1i} \sum_{i=0}^{p} \Delta \text{ LNF}_{t-i} + \beta_{2i} \sum_{i=0}^{p} \Delta \text{ LNW}_{t-i} + \beta_{3i} \sum_{i=0}^{p} \Delta \text{LNL}_{t-i} + \beta_{4i} \sum_{i=0}^{p} \Delta \text{LNHE}_{t-I} + \beta_{5i} \sum_{i=0}^{p} \Delta \text{LNHE}_{t-i} + \alpha_3 \text{ FL} + \alpha_2 \text{ECM}_{t-1} + u_t$$

ARDL model for ECM is (1,1,1,1,0,1,0). The estimated coefficient results of dLNF in the short run showed that it has negative but significant effect on the dLNRP in the short run. The reasons for negative sign maybe because the farmers did not use fertilizer at right time or may have used wrong combination of fertilizer in the short run. This is happening due to the lack of information and knowledge for using the fertilizer. Another reason can also be the unavailability of sufficient funds to buy the crop booster on time. Coefficient of dLNF in short run showed that 1% change in the fertilizer usage result into 0.16925% change in the total rice production. These changes are negative. P-value of dLNF is 0.023 which showed it is significant at 5% significance level. The results of LNF are quite similar to findings of (Kouser, & Mushtaq, 2007) that there exists a negative relationship between the fertilizer usage and rice production.

In the short run there is a positive relation between water availability for rice and total rice production. The coefficient of dLNW showed that 1% change in water availability for rice would influence about 0.136% changes in the total rice production.

Table 7 Error Correction Representation for the Selected ARDL Model

ARDL(1,1,1,1,0,1,0) selected based on Schwarz Bayesian Criterion
Dependent variable is dLNRP
41 observations used for estimation from 1974 to 2014

Regressor	**Coefficient**	**Standard Error**	**T-Ratio[Prob]**
dLNF	-0.16925	0.070838	-2.3893[.023]**
dLNW	0.13621	0.10774	1.2643[.215]
dLNL	0.70638	0.99127	7.1260[.000]*
dLNHE	0.26018	010178	2.5563[.015]*
dLNE	0.038646	0.054988	0.70280[.487]
dFL	0.0073740	0.012947	0.56957[.573]
dC	-0.40486	0.76259	-0.53091[.599]
ecm(-1)	-0.45067	0.10252	-4.3957[.000]*

R-Squared	.81189	R-Bar-Squared	.74054
S.E. of Regression	.033409	F-stat. F(7, 33)	17.8808[.000]
Mean of Dependent Variable	.010662	S.D. of Dependent Variable	.065588
Residual Sum of Squares	.032368	Equation Log-likelihood	88.2789
Akaike Info. Criterion	76.2789	Schwarz Bayesian Criterion	65.9974
DW-statistic	2.3078		

R-Squared and R-Bar-Squared measures refer to the dependent variable dLNRP and in cases where the error correction model is highly restricted, these measures could become negative.

Note *,**, and *** show the 1%, 5% and 10% significance level respectively

Positive coefficient of dLNL suggested that if there is 1% change in the area under rice crop and there would be 0.706% increase in the total rice production in the short run. The P-value for dLNL is . 000 which indicated that it is highly significant at 1% significance level.

The coefficient of agricultural electricity consumption in the short run is positive but very small value of it; indicated that effect of agricultural electricity consumption on total rice production in Pakistan is very small in the short run. Result of this variable supported the hypothesis because according to the null hypothesis. There should be a positive relationship between of agricultural electricity consumption and total rice production. The coefficient of dLNE suggested that 1% change in agricultural electricity consumption resulted in 0.038% increase in the total rice production. Farmers avoid using large amount of electricity for producing rice due to which electricity does not heavily effect the rice production in the short run.

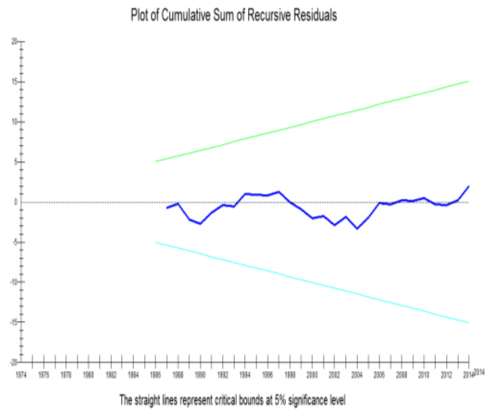
Coefficient of dLNHE is also positive showing that 1% change in the health expenditures resulted about 0.2601 % change in the total rice production. The P-value for dLNHE is 0.015 indicating significance at 1% level.

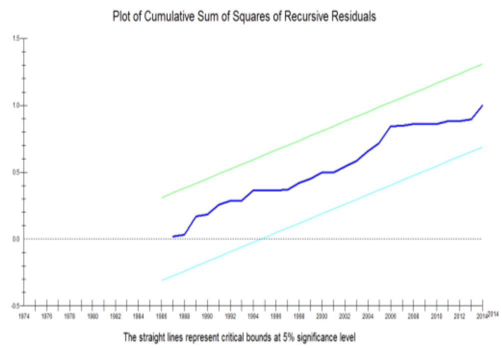
The ARDL short run coefficient of FL indicated that if the flood comes the rice production will be affected by 0.0073. Flood has a very minute affect upon the production of rice in the short run. The reason for the very small coefficient was may be due to the time of flood arrival. If it comes at early stages or harvesting time it will destroy the crop but if it comes in between these stages it is less harmful (Pakistan Economic Survey 2013-14)[5]. The coefficient of intercept in the ARDL short run coefficient is negative suggesting that if all other variables are equal to zero the total rice production would not be highly effected and would be reduced up to 0.40486% in the short run.

The process of short-run adjustment can be observed from the Error Correction term. In case of this model Error Correction term is -0.45067and was statistically significant. This indicated that 45% of the disequilibrium of the previous period would be adjusted in current year. This short run process is showing speed of adjustment towards the long run equilibrium.

Results of Cumulative (CUSUM) and Cumulative sum of square (CUSUMQ)

The plots of CUSUM and CUSUMQ test supported the residual stability of the specified model of study over the sample period of 1972-2014 in Pakistan because recursive residual line is within the bounds of 5% significance level. It refers the stability of variables in long run.





VI. Conclusion and Policy Recommendations

On the basis of estimation the study concluded that good infrastructure can help encouraging the rice production in Pakistan. Two physical variables like water availability for rice and electricity consumption were found to be highly significant. Electricity had negative effect in the long run. Health expenditure had positive and significant effect on rice production in the long run. Floods and fertilizer usage had the positive but insignificant effect on rice production in the long run. In the short run three variables like water availability for rice, electricity consumption and health expenditure were found to be highly significant. Fertilizer usage in the short run had negative effect on rice production. On the whole these results illustrate that more of the investment should be done in improving infrastructure for production which will help the progress of country. Several types of domestic policy changes can help to increase the rice production and improve rural infrastructure investment. Some suggestions are derived from the estimated results as follow:

Investment in public goods such as demand led extension along with the regulations to stimulate more efficient water usage can go a long way in helping farmers to take full advantage of higher rice production. Land is found to be significant for rice production. Millions acres of land still remain uncultivated due to lack of irrigation and non-availability of other inputs and cheap land. Therefore, farmers should be facilitated with cheaper resources. Government should subsidize the electricity for agriculture this will encourage farmers for the production also rice crop because empirical findings have also shown that it negatively effects the rice production in the long run due to expensive electricity. Results indicate that farmer's health positively improves the rice production. If government increases

[5] Highlights of Economic Survey of Pakistan 2013-14.

the health expenditures and health facilities for farmers health of farmers will be improved and they will be able to work for more hours. Flood used as a dummy variable also had minute but significant effect upon rice production. So the government should find some better ways to properly manage the flood water.

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