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Long Run Relationship between Use of Electricity in Agriculture and Agriculture Development in India: A Co-Integration Analysis

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I. Introduction

Agriculture has been accepted as backbone of Indian economy and played predominant role in providing livelihood for more than fifty percentage of the population. Matter of fact, the development of agriculture sector has been determined by many factors and energy is one of important determinants of agriculture development. It has been widely accepted that energy is an important factor in economic development though the cost of it very less or negligible. Accordingly, economic development will not be realized without energy use (Serap Çoban, 2013). The use of energy in total cost of production though it is very less and negligible, it plays predominant role in determination of development (William J. Nuttall, 2008). Accordingly energy will also play significant role in determination of agriculture production and growth (Painuly J P, 1992).In this present paper an attempt has made to establish the long-run stable relationship between energy use in agriculture and agriculture development. Johansen Co-integration technique has employed to establish the long-run stable relationship. The paper has tried to estimates the relationship of electricity use in agricultural sector with agricultural development.

Time series data have used for analysis, use of long run time series data always has threat of non stationary. Address the issue of non stationarity is one of the objectives of the paper. After checked the data for stationarity, they have used to identify the co-integrating vectors for electricity use and Agriculture development. Based on the co-integration short-run disturbances in the long-run relationships have been analyzed.

II. Review of literature and Conceptual Framework

There is positive relationship between energy and economic development (Muhammad Shahbaz a, 2013) (Serap Çoban, 2013)(Legey., 2012). Energy plays significant role in determination of agriculture production (Uhlin, 1998)(Uhlin H.-E. , 1999). Electricity is one of the factors of production in Agricultural production process (Painuly J P, 1992)(Shah., 2007). There is long run relationship between energy and economic development also there is long run relationship between energy and agriculture development (Kokichi Ito, 2005)(Luis Lopez-Bellidoa, 2012). . However, long-run relationship between electricity use in agriculture and agriculture development has not examined by the previous studies. Given the background, the present study has tried to estimate the long-run relationship between electricity use in agriculture and agricultural development by using Johansen co-integration analysis.

III. Methodology

In present study long-run time series data from 1972 to 2015 have used for the analysis, the analysis used co-integration econometric and vector- error correction methods. Johansen model has used for co integration analysis. Stationarity of data have checked with Phillips-Perron test. CAGR and graph have also used for understanding trend and growth. Results have estimated with the help of E-views and Gretl. Parameters have classified for this analysis as below.

- ❖ Parameters represent agricultural development
- ▪ AI : Agriculture Income (Amount in ` Billion)
- ❖ Parameters represent energy use in agriculture sector
- ▪ EAI: Electricity Availability in India (GWh)
- ▪ EG: Electricity Generation (GWh)
- ▪ TECI: Total Electricity Consumption in India (GWh)
- ▪ AEC: Agriculture Electricity Consumption (GWh)

Income is one of the traditional indicators of measuring development. Though there are many modern indicators like, HDI, GDI, GEM and others, the time series data are not available for all the years. At the same time, total agriculture production is not available for all the agricultural produce. Hence, income has been considered as efficient parameter of measuring development and used in the present study. In order to support the major objective of the chapter i.e. longer relationship of energy use in agriculture with agricultural development the relationship of energy use in economy with economic development has estimated. All necessary preliminary analysis like stationarity, data trends and growths of parameters have conducted as per requisite for co-integration analysis. Once the co-integration analysis has completed the vector error correction method analysis has been conducted to find short run disturbances in the long run relationship.

Stationarity:

In this section an attempt has made to estimate stationarity of time series data used in the analysis. The Phillip - Perron (PP) test was conducted to estimate the stationarity of data for the level data.

In the following section, PP test was conducted with level, first and second difference data. The test results for level, first and second difference data are presented below;

Table 1:Phillips-Perron test for Stationarity

Sl. No.	Variables	t-statistic	P-value	Level	Model
1	**AI**	-5.903	0.000	*I ~ (1),*	$\Delta y_t = y_{t-1} + e_t$
2	**EG**	-5.950	0.000	*I ~ (1),*	$\Delta y_t = \alpha + y_{t-1} + e_t$
3	**EA**	-4.913	0.001	*I ~ (1),*	$\Delta y_t = \alpha + y_{t-1} + T + e_t$
4	**TECI**	-3.767	0.029	*I ~ (1),*	$\Delta y_t = \alpha + y_{t-1} + T + e_t$
5	**AEC**	-7.296	0.000	*I ~ (2),*	$\Delta y_t = y_{t-1} + e_t$

Source: Economic Survey of India, Government of India. Energy Statistics, ministry of Energy. Data are culled from RBI Website during 2017. Values are computed by researcher.

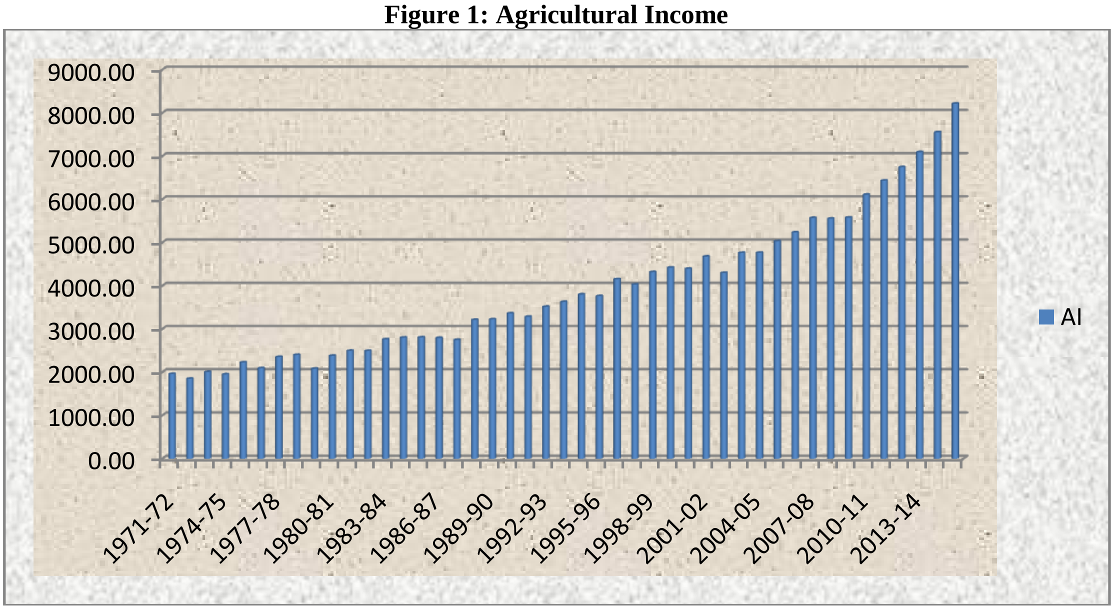
Note: *I ~ (1) means integrated order of one;* the variable stationary at first difference data

I ~ (2) means integrated order of two; the variable stationary at second difference data

Trend Analysis:

In this section an attempt has made to analyse the growth and trends of energy, economy and agriculture representing indicators. Time series data have presented in the graph form.

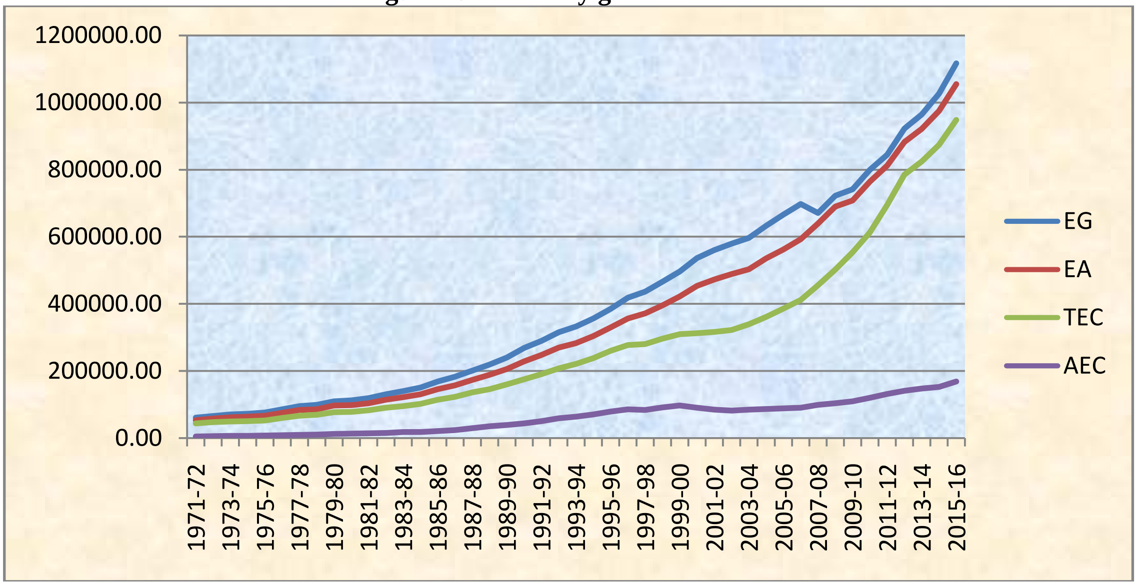
Figure 1: Agricultural Income



Source: Economic Survey of India, Government of India. Energy Statistics, ministry of Energy. Data are culled from RBI Website during 2017. Values are computed by researcher.

Agricultural Income in India for the period from 1972 to 2015 has presented in the above graph. It has been found from the graph that there has been increasing trend in agricultural income. The average growth of agricultural income will be analyzed with the help of CAGR

Figure 2: Electricity growth in India



Source: Economic Survey of India, Government of India. Energy Statistics, ministry of Energy. Data are culled from RBI Website during 2017. Values are computed by researcher.

Electricity generation, electricity availability in India, total electricity consumption in India and agriculture electricity consumption in India for the period from 1972 to 2015 has presented in the above graph. It has been found from the graph that there has been increasing trend in electricity generation electricity availability in India, total electricity consumption in India and agriculture electricity consumption in India The average growth of all the above mentioned variables have analyzed with the help of CAGR.

Growth Analysis:
In this bellow section an attempt has made to analyse the growth of agricultural income, energy, economy and agriculture representing indicators. Time series data have presented in the graph farm.

Table 2: CAGR of Agriculture Income and Electricity

Sl No	Variable	CAGR	Std Error	t-Value	P-Value
1	AI	3.10	0.0005	53.42	0.000
2	EG	6.71	0.0012	55.38	0.000
3	EA	6.88	0.0008	79.75	0.000
4	TECI	6.82	0.0009	71.98	0.000
5	AEC	8.00	0.0033	23.67	0.000

Source: Economic Survey of India, Government of India. Data are culled from RBI Website during 2017. Values are computed by researcher

Above table clearly explains the growth of agricultural income, domestic electricity generation, and electricity availability in India, total electricity consumption in India and agriculture electricity consumption in India. It found that, growth of agricultural income, electricity generation, electricity availability, total electricity consumption and agriculture electricity consumption in India have positive growth and significant at one percent level. Accordingly, agriculture electricity consumption increased at higher rate followed by electricity generation, electricity availability and total electricity consumption in India have the similar growth rate and finally growth of agricultural income in India has increased at very low growth rate with compare to electricity generation, availability and consumption in India.

Co-integration Analysis:
In the present section focused on identify the long-run stable relationship of Agricultural income with selected variables of electricity use in economy and agriculture. The co-integration Analysis has made for the non stationary time series data. The Johansen co-integration test has used for finding the non-stationarity. Vector Error Correction models have used to find short-run relationship. In this section tried to identify the long-run

stable relationship of agricultural income with electricity generation in India, electricity availability in India total electricity consumption in India and agricultural energy consumption in India.

Relationship of Agricultural Income with Electricity Generation:
The non-stationary time series data integrated of order one for both agricultural income with electricity generation has been used for the analysis. The Johansen co-integration test was used to find the long-run stable relationship.

Table 3:Co-integration Test for Agricultural Income and Electricity generation

Trend assumption: Quadratic deterministic trend
Series: AI EG
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.354065	24.68438	18.39771	0.0058
At most 1 *	0.128029	5.890968	3.841466	0.0152

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Values computed by using base data with the help of E-views.

The Johansen test has used to estimate the long-run relationship between agricultural income and electricity generation in India. It has been found from the co-integration test that the trace has identified two co-integrating equations. Means, both the parameters used in this analysis have been co-integrating with each other. Accordingly, there has been long-run stable relationship between agricultural income and electricity generation in India. Therefore, agriculture income and electricity generation go hand in hand. Hence, Agricultural income and electricity generation are inter-dependent. Matter of fact, electricity generation without agricultural income and agricultural income without electricity generation cannot be imagined and realized in India.

Table 4: VECTest for Agricultural Income and Electricity generation in India

Error Correction:	D(AI)	D(EG)
CointEq1	0.122296	57.53746
	(0.19827)	(13.2810)
	[0.61682]	[4.33233]
D(AI(-1))	-0.576969	-29.05410
	(0.25644)	(17.1775)
	[-2.24992]	[-1.69140]

Source: Values computed by using base data with the help of E-views.

The Vector Error Correction (VEC) model has been used to find the short term disturbance in the long-run relationship and to identify the variable which responsible to restore the relationship between agriculture income and electricity generation. It has found from the VEC that both the parameters correct the short-term disturbances in the long-run relationship. However, both the parameters have takes one time period to restore the relationship.

Relationship of Industrial Income with Electricity Availability:
The non-stationary time series data integrated of order one for both agricultural income and electricity availability in India have been used for the analysis. The Johansen co-integration test was used to find the long-run relationship.

Table 5: Co-integration Test for Agricultural Income and Electricity Availability

Trend assumption: Linear deterministic trend
Series: AI EA
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.537986	40.41593	15.49471	0.0000
At most 1 *	0.154431	7.213082	3.841466	0.0072

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Values have computed by using base data with the help of E-views

The Johansen test has used to estimate the long-run relationship between agricultural income and electricity availability in India. It has been found from the co-integration test that the trace has identified two co-integrating equations. Means, both the parameters used in this analysis have been co-integrating with each other. Accordingly, there has been long-run stable relationship between agricultural income and electricity availability in India. Therefore, agriculture income and electricity availability go hand in hand. Hence, agricultural income and electricity availability are inter-dependent. Matter of fact, electricity availability without agricultural income and agricultural income without electricity availability cannot be imagined and realized in India.

Table 6: VEC Test for Agricultural Income and Electricity Availability in India

Error Correction:	D(AI)	D(EA)
CointEq1	0.131486	12.91024
	(0.06100)	(2.57888)
	[2.15566]	[5.00614]
D(AI(-1))	-0.594812	14.58349
	(0.19296)	(8.15844)
	[-3.08252]	[1.78753]
D(AI(-2))	-0.093052	17.98925
	(0.18927)	(8.00247)
	[-0.49163]	[2.24796]
D(EA(-1))	-0.000788	-0.335479
	(0.00408)	(0.17265)
	[-0.19292]	[-1.94316]

Source: Values have computed by using base data with the help of E-views

The Vector Error Correction (VEC) model has been used to find the short term disturbance in the long-run relationship and to identify the variable which responsible to restore the relationship between agricultural income and electricity availability. It has found from the VEC that both the parameters correct the short-term disturbances in the long-run relationship. Matter of fact both electricity availability and industrial income takes oneperiod to restore the relationship.

Relationship of Agriculture Income with Total Electricity Consumption:

The non-stationary time series data integrated of order one for both income and total electricity consumption in India have been used for the analysis. The Johansen co-integration test was used to find the long-run relationship.

Table 7: Co-integration Test for Agricultural Income and Total Electricity Consumption

Trend assumption: Linear deterministic trend
Series: AI TEC
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.328597	21.85952	15.49471	0.0048
At most 1 *	0.104144	4.728950	3.841466	0.0297

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Values computed by using base data with the help of E-views.

The Johansen test has used to estimate the long-run relationship between agricultural income and total electricity consumption in India. It has been found from the co-integration test that the trace has identified two co-integrating equations. Means, both the parameters used in this analysis have been co-integrating with each other. Accordingly, there has been long-run stable relationship between agricultural income and total electricity consumption in India. Therefore, agricultural income and total electricity consumption in India go hand in hand. Hence, agricultural income and total electricity consumption in India are inter-dependent. Matter of fact, total electricity consumption in India without agricultural income and agricultural income without total electricity consumption cannot be imagined and realized in India.

Table 8:VEC Test for Agricultural Income and Total Electricity Consumption in India

Error Correction:	D(AI)	D(TEC)
CointEq1	-0.276301	-10.22683
	(0.06803)	(4.70364)
	[-4.06123]	[-2.17423]
D(AI(-1))	-0.530105	16.41240
	(0.15137)	(10.4655)
	[-3.50197]	[1.56824]
D(AI(-2))	-0.165197	15.12454
	(0.15288)	(10.5698)
	[-1.08055]	[1.43093]
D(TEC(-1))	-0.000733	0.644089
	(0.00255)	(0.17642)
	[-0.28716]	[3.65079]

Source: Values computed by using base data with the help of E-views.

The Vector Error Correction (VEC) model has been used to find the short term disturbance in the long-run relationship and to identify the variable which responsible to restore the relationship between agricultural income and total electricity consumption. It has found from the VEC that one of the parameters correct the short-term disturbances in the long-run relationship. Matter of fact total electricity consumption is the correcting parameter and it takes one period to restore the relationship.

Relationship of Industrial Income with Agricultural Electricity Consumption:

The time series non stationary data integrated of orders one for agricultural income and integrated of order two for agriculture electricity consumption in India have been used for the analysis. The Johansen co-integration test was used to find the long-run relationship

Table 9: Co-integration of Agricultural Income & Agricultural Electricity Consumption

Trend assumption: Linear deterministic trend
Series: AI AEC
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.343564	22.07588	15.49471	0.0044
At most 1 *	0.088317	3.975910	3.841466	0.0461

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: Values computed by using base data with the help of E-views.

The Johansen test has used to estimate the long-run relationship between agricultural income and agricultural electricity consumption in India. It has been found from the co-integration test that the trace has identified two co-integrating equations. Means, both the parameters used in this analysis has been co-integrating with each other. Accordingly, there has been long-run stable relationship between agricultural income and agriculture electricity consumption in India. Therefore, agricultural income and agricultural electricity consumption has go hand in hand. Hence, agricultural income and agricultural electricity consumption in India are inter-dependent. Matter of fact, agricultural electricity consumption without agricultural income and agricultural income without agricultural electricity consumption cannot be imagined and realized in India.

Table 10: VEC Test for Agriculture Income and agriculture Energy Consumption

Error Correction:	D(AI)	D(AEC)
CointEq1	0.268070	3.786456
	(0.06931)	(1.30452)
	[3.86786]	[2.90257]
D(AI(-1))	-0.816297	-6.820513
	(0.20987)	(3.95019)
	[-3.88957]	[-1.72663]

The Vector Error Correction (VEC) model has been used to find the short term disturbance in the long-run relationship and to identify the variable which responsible to restore the relationship between agricultural income and agricultural electricity consumption. It has found from the VEC that both the parameters correct the short-term disturbances in the long-run relationship. Matter of fact both agricultural income and agricultural electricity consumption has takes one period to restore the relationship.

IV. Conclusion

In the present paper an attempt has made to estimate the long-run stable relationship between agricultural income and electricity. It has been found from the analysis that agricultural income has long-run stable relationship with electricity generation, availability and total consumption in India. Specifically, agriculture electricity consumption has long-run stable relationship with agricultural income. The short-term disturbances in long-run relationships have been corrected in one time period. Specifically, agriculture electricity consumption has acted as a correcting parameter of long-run relationship with agricultural income. Therefore, electricity plays predominant role in determinant of agriculture income in India. Hence, there is need to integrate the electricity policy with agriculture policy for better outcomes of both agriculture sector as well as energy sector.

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