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Structural break analysis of rapeseed and mustard production in Jorhat District of Assam

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Abstract
The present paper is aimed to determine the exact time of the structural break in the rapeseed and mustard production, and followed by the examination of the presence of cointegration between the crop productivity and the various variables under investigation. The data collected for the study pertained to the annual time series of area, production, productivity, maximum temperature, minimum temperature, total rainfall, bright sunshine hours, and wind speed for the period 1988-89 to 2014-2015. The production of rapeseed and mustard is found to have breaks in the years 1995-96 and 1996-97. Johansen's cointegration test was used to check for the presence of the cointegration between the variables under the crop. It is concluded that the variables in the model are cointegrated. This is followed by the employment of the Vector Equilibrium Correction Model, finally proving the presence of a long-run relationship between the variables. It is found that minimum temperature has a negative relationship with the productivity of the crop whereas area and total rainfall have positive and significant short-run effects on the productivity of rapeseed and mustard crop in the study location.

Keywords: Structural break, cointegration technique, error correction model, Assam, Jorhat, rapeseed and mustard

1. Introduction
Jorhat, a district of Assam, has an area of 2,852 sq. km. (2011 census). It is in the central part of Brahmaputra valley. The river Brahmaputra forms the largest riverine island of the world, Majuli in the north of the district Jorhat. Majuli expands over 924.6 square kilometers. The mean average rainfall of the district is 2029 mm. The climate of Jorhat is temperate. Rapeseed and mustard is a principal oilseed crop in Assam. This crop makes up an area of 91.57 percent of total oilseed area (3,06,890 Ha) contributing 91.20 percent of total oilseed production in Assam in 2014-15. Rapeseed and mustard in Jorhat cover an area of 3.69 percent of total area, sharing production of 4.33 percent in Assam in 2014-15. This crop's production in Jorhat have increased from 7817 tonnes in 2012-13 to 9118 tonnes in 2013-14 and then decreased to 8129 tonnes in 2014-15. It reflects the structural change in the financial system of the district.
Considering the rapeseed and mustard production in the national, state and district levels, the oil requirement is not self-sufficient for the country's growing population according to the ICAR-ATARI, Umiam, Meghalaya. Majuli is a place where rapeseed and mustard is an important crop for the livelihood of the people. As per the report of KVK, Jorhat, Majuli covers an area of 8,500 hectares (Ha) of rapeseed and mustard cultivation with abundant use of the variety M-27 with a productivity of 900 Kg per Ha. Hence, decrease in the production in the grassroot level can affect the national production as well. Productivity of a crop is influenced by the availability of rainfall, favorable temperature, well conserved soil, area, production, and optimum sunshine hours. Moreover, the dissemination of technology is not uniform over crops or regions. Due to these factors the aggregate time series data on agricultural production may not be trend stationary. Therefore, it is essential to test for stationarity of rapeseed and mustard production and thus to check the presence of structural break.
The aims of this paper are engaged in determining the exact time of the structural break in rapeseed and mustard production, followed by the examination of the cointegration between production and the other important factors.

2. Methodology
The present work is typically based on the analyses of secondary data collected from various sources. The data on area, production, and productivity of rapeseed and mustard in Jorhat

district of Assam over the period 1988-1989 to 2014-2015 were collected from the Directorate of Economics and Statistics, Assam. The meteorological data were collected from the Department of Agrometeorology, Assam Agricultural University, Jorhat.

To test for the structural break in the production of rapeseed and mustard, it is necessary to check for the stationarity of the time series prior to testing for the structural break of the series. The first step to proceed with the work is to check for the stationarity of the variables. A series is said to be stationary if the means and variances remain constant over time (John *et al.*, 2014) [18]. It is referred to as I(0), denoting integrated of order zero (John *et al.*, 2014) [18]. When the time series is not stationary, i.e., having a mean and/or variance changing over time, it is said to have a unit root.

2.1 Unit Root Test

The Augmented Dickey-Fuller (ADF) statistic, used in the unit root test, is a negative number. The more negative it is, the stronger the rejection of the hypothesis that there is a unit root at some level of confidence. The Augmented Dickey-Fuller test is carried out in the context of the model

$$\Delta Y_t = \beta_1 + \beta_2 t + \partial Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-i} + \varepsilon_t \quad (1)$$

(Gujarati, 2005) [11]

In equation (1) 'Y_t' is the dependent variable (area or production or productivity), 'Δ' is the first difference of the series, 't' is the year, 'β_1' is the intercept, 'β_2' is the coefficient, 'ΔY_{t-i}' is the lagged difference term of the dependent variable, 'ε_t' is the error term. The null hypothesis is $\partial = 0$ (has a unit root) and the alternative hypothesis is $\partial \neq 0$ (stationary).

The F test and Chow test are used to check the existence of endogenously determined structural breakpoints in the production of rapeseed and mustard (Allaro, 2018) [2]. The test statistic of Chow-test is given as:

$$F = \frac{\frac{RSS^{**}}{k}}{\frac{RSS^{*}}{(N-2k)}} \sim F\,(k, N-2k) \quad (2)$$

In equation (2), k is the number of parameters in the model, including the intercept term; RSSR, RSS_1 & RSS_2 is the residual sum of square with $(N\text{-}k)$, (N_1-k) & (N_2-k) degrees of freedom, respectively;

where $RSS^* = RSS_1 + RSS_2$ and $RSS^{**} = RSSR - RSS^*$

Hence, RSS* has $(N_1\text{-}\ k + N_2\text{-}k) = (N\ \text{-}2k)$ degrees of freedom and RSS** has $(N\ \text{-}\ k)\ \text{-}\ (N\text{-}2k) = k$ degrees of freedom. For the null hypothesis, when there is no structural change (the same relationship holds for the entire period), the above F-test can be written as:

$$F = \frac{RSS^{**}}{RSS^{*}} \times \frac{N-2k}{k}$$

Or

$$F = \frac{\{RSSR - (RSS_1 + RSS_2)\}/k}{(RSS_1 + RSS_2)/(N_1 + N_2 - 2k)} \quad (3)$$

2.2 Cointegration Test

Two or more variables are said to be co-integrated if each is individually non-stationary but there is a linear combination of the variables (Akintunde *et al.*, 2013) [1]. It implies that the variables under examination are integrated of order 1 (Dritsakis, 2004) [6], and so are stationary. And thus, there is a possibility for the existence of a long-run equilibrium relationship. If the cointegration analysis shows that there is a cointegrating vector, it is implied that the tested series will not drift apart in the long-run, and will return to equilibrium levels following any short-term drift that may take place (Maggiora and Skerman, 2009) [23]. The Johansen Full Information Maximum Likelihood test is used for the present work. This technique is chosen because, unlike other methods that assume a single cointegrating vector, the Johansen method allows for all possible co-integrating relationships and permits empirical determination of the number of cointegrating vectors (Kuwornu *et al.*, 2011) [20]. Moreover, short-run coefficients are estimated in such a way that they are guided by and consistent with long-run relationships (Boansi, 2014) [3]. The model for the Johansen approach can be defined as

$$Y_t = A_1 Y_{t-1} + A_2 Y_{t-2} + \ldots + A_p Y_{t-p} + \mu_t \quad (4)$$

In equation (4), Y_t is an (n×1) vector of I(1) variables, A_1 through A_p represent (m×m) matrix of coefficients, and μ_t is (n×1) vector of the error term (Boansi, 2014) [3].

There is two likelihood ratio (LR) tests that are used in identifying the number of the co-integrating vectors (Boansi, 2014) [3] that exists between two or more time series that are econometrically integrated (Akintunde *et al.*, 2013) [1], namely the trace test and maximum eigenvalue test. According to Harris, the trace test shows more robustness to both skewness and excess kurtosis in the innovations than the maximum eigenvalue test. Thus, the trace test is preferred for the present study.

2.3 Error Correction Model

Error Correction Model (ECM) is an attempt to integrate economic theory useful in characterizing a long-term equilibrium with an observed disequilibrium by building a model that explicitly incorporates behavior that would restore the equilibrium (Akintunde *et al.*, 2013) [1]. The use of ECM is facilitated when variables are first-differenced stationary and co-integrated (Akintunde *et al.*, 2013) [1]. To ensure correct VAR (Vector Autoregression) or VECM (Vector Error Correction Model), there is a need to set appropriate lag length(s) (Boansi, 2014) [3]. In determining the lag length for the Johansen approach, any of the two processes, namely Akaike Information Criterion (AIC) and Schwarz Bayesian Information Criterion (SBIC) is chosen (Maggiora and Skerman, 2009) [23]. The SBIC is usually more consistent but inefficient, while AIC is not as consistent but is usually more efficient (Brooks, 2008) [4].

3. Results and Discussion

3.1 Test for structural break

To determine the exact time of the structural break in the production of the selected crop namely, Rapeseed and mustard in the Jorhat district of Assam for the study period, the graphical analysis and the Augmented Dickey Fuller test were adopted to check the stationarity of the time series data prior to the identification of the structural break by Chow test.

3.1.1 Graphical analysis

A graphical plot of the data can give the first impression of the stationarity of the time series. The value of the real Area and Production of Rapeseed and mustard in Jorhat district of Assam for the period 1988-89 to 2014-15 is presented in Figure 1.

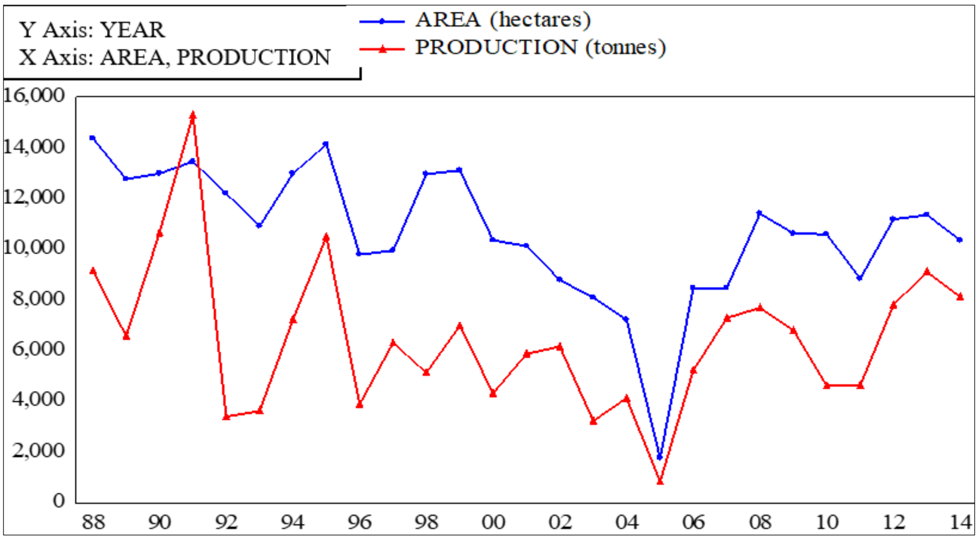

Fig 1: Structural break time for area and production of Rapeseed and mustard in Jorhat district (Source: Compiled from the results obtained in Eviews)

From the graph in Figure 1, it is possible that the data are not stationary. Conversely, graphical analysis is not conclusive and much credence is given to the econometric analysis which is described in later sub section.

3.1.2 Unit root test

Table 1: Test of stationarity before differencing of the variables for rapeseed and mustard crop

Variables	ADF test statistic	Critical value at 1%	Critical value at 5%	Decision
Area	-0.922121	-2.656925	-1.954414	Non-stationary
Production	-1.440601	-2.669359	-1.956406	Non-stationary
Productivity	-0.445109	-2.660720	-1.955020	Non-stationary
Maximum temperature	-0.741343	-2.664853	-1.55681	Non-stationary
Minimum temperature	0.083914	-2.664593	-1.955681	Non-stationary
Total rainfall	-0.408398	-2.664853	-1.955681	Non-stationary
Bright sunshine hours	-0.449471	-2.660720	-1.955020	Non-stationary
Wind speed	-1.234566	-2.656900	-1.954400	Non-stationary

(***Source:*** Compiled from the results obtained in Eviews)

The test showed that the variables are non-stationary at levels (in table 1). But the variables for rapeseed and mustard crop had become stationary after the first difference. Moreover, it can be concluded that structural break(s) is(are) present in the time series data for the crop.

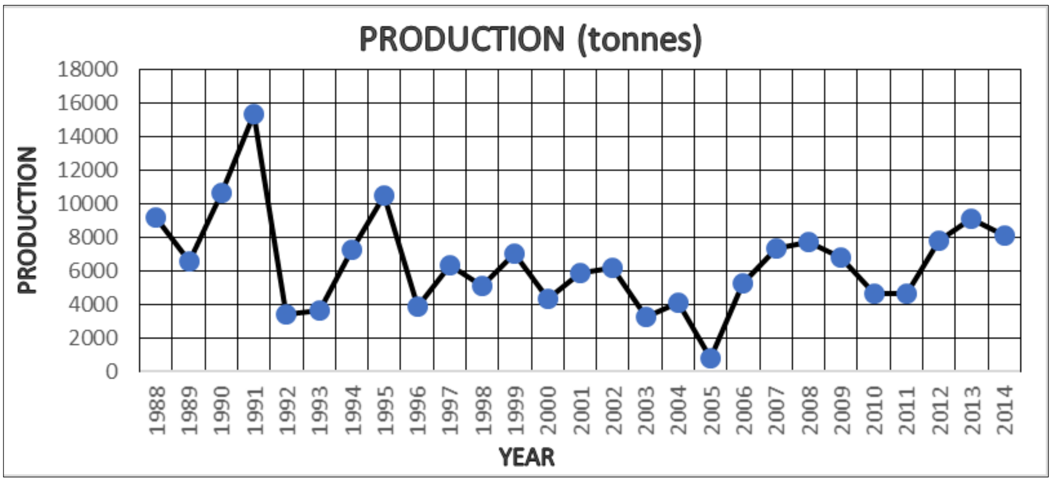

Fig 2: Structural break time for the production of rapeseed and mustard in Jorhat district (Source: Compiled from the results obtained in MS Excel)

Table 2: Test of stationarity after differencing of the variables for rapeseed and mustard crop

Variables	Order of integration	ADF test statistic	Critical value at 1%	Critical value at 5%	Decision
Area	I(1)	-6.575944	-2.660720	-1.955020	Stationary
Production	I(1)	-6.612838	-2.661000	-1.955020	Stationary
Productivity	I(1)	-6.959916	-2.660720	-1.955020	Stationary
Maximum temperature	I(1)	-5.936770	-2.664853	-1.955681	Stationary
Minimum temperature	I(1)	-5.897501	-2.664853	-1.955681	Stationary
Total rainfall	I(1)	-6.148476	-2.664853	-1.955681	Stationary
Bright sunshine hours	I(1)	-8.496307	-2.660720	-1.955020	Stationary
Wind speed	I(1)	-4.995952	-2.660720	-1.955020	Stationary

(***Source:*** Compiled from the results obtained in Eviews)

From figure 2, it is indicated that the structural breaks have probably occurred in the years 1995-1996, 1996-1997, and 2005-2006. Thus, it can be analyzed that a single regression line is not a suitable fit for the data because of the structural break in the aforementioned years. The Chow test which is a variation of F test is performed for the affirmation of the presence of breakpoints. This needs the residual sum of squares.

Table 3: RSS (residual sum of squares) for all data

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	105798372.904	6	17633062.151	3.060	.027
Residual	115241999.170	20	5762099.958		
Total	221040372.074	26			

(***Source:*** Compiled from the results obtained in SPSS), RSSR= 115241999.170

Table 4: RSS (residual sum of squares) before the structural break with breakpoint 1995-1996

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	109868389.763	6	18311398.294	46.470	.112[b]
Residual	394043.737	1	394043.737		
Total	110262433.500	7			

(***Source:*** Compiled from the results obtained in SPSS), RSS_1= 394043.737

Table 5: RSS (residual sum of squares) after the structural break with breakpoint 1995-1996

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	47796701.188	6	7966116.865	3.880	.022[b]
Residual	24635890.601	12	2052990.883		
Total	72432591.789	18			

(***Source:*** Compiled from the results obtained in SPSS), RSS_2= 24635890.601

Based on the output from table 3, 4, and 5, the test statistic is calculated using the equation (3):

$$F = \frac{\{RSSR - (RSS_1 + RSS_2)\}/k}{(RSS_1 + RSS_2)/(N_1 + N_2 - 2k)}$$

$$F = \frac{\{115241999.17-(394043.737+24635890.601)\}/7}{(394043.737+24635890.601)/(8+19-14)} = 6.693$$

The critical value for F (7,13) is 2.8321 at a 5% significance level. It is seen that the F test statistic (6.693) in 1995-1996 exceeds the 95% critical value of the F test. It can be concluded that there is a structural break in the rapeseed and mustard crop in the year 1995-1996. Further, analysis with the Chow breakpoint test (using the log likelihood ratio) has been performed in the software EViews 10.

The results of the Chow breakpoint test (using the log likelihood ratio) which has been performed in the software EViews 10, on the regression of area, production, maximum temperature, minimum temperature, total rainfall, bright sunshine hours and wind speed with breakpoint 1995-1996 are presented in table 6.

Table 6: Chow test on regression of area, production, maximum temperature, minimum temperature, total rainfall, bright sunshine hours and wind speed (1995-1996)

F-statistic	Log likelihood ratio	Probability
6.712442	41.28786	0.0000

(***Source:*** Compiled from the results obtained in Eviews)

It has been observed from table 6, that the probability value is 0.00001 which is less than 0.05, implying that the null hypothesis of no structural break can be rejected. Thus, there is a structural break in the year 1995-1996.

The results of the RSS before the structural break with breakpoint 1996-1997 which is required for the calculation of F statistic are presented in table 7.

Table 7: RSS (Residual sum of squares) before the structural break time with breakpoint 1996-1997

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	109868599.978	6	18311433.330	2.062	.362[b]
Residual	17757558.022	2	8878779.011		
Total	127626158.000	8			

(***Source:*** Compiled from the results obtained in SPSS), RSS_1= 17757558.022

Table 8: RSS (Residual sum of squares) after the structural break time with breakpoint 1996-1997

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	50171015.376	6	8361835.896	4.892	.011[b]
Residual	18803873.068	11	1709443.006		
Total	68974888.444	17			

(***Source***: Compiled from the results obtained in SPSS), RSS_2= 18803873.068

Based on the output from tables 3, 7, and 8, the test statistic is calculated using the equation (3):

$$F = \frac{\{RSSR - (RSS_1 + RSS_2)\}/k}{(RSS_1 + RSS_2)/(N_1 + N_2 - 2k)}$$

$$F = \frac{\{115241999.17-(17757558.022+18803873.068)\}/7}{(17757558.022+18803873.068)/(9+18-14)} = 3.996$$

The critical value for F (7,13) is 2.8321 at a 5% significance level. It is seen that the F test statistic (3.996) in 1996-1997 exceeds the 95% critical value of the F test. It can be concluded that there is a structural break in the rapeseed and mustard crop in the year 1996-1997. Further, the results of the Chow breakpoint test (using the log likelihood ratio) with breakpoint 1996-1997 are presented in table 9.

Table 9: Chow test on regression of area, production, maximum temperature, minimum temperature, total rainfall, bright sunshine hours and wind speed (1996-1997)

F-statistic	Log likelihood ratio	Probability
6.693453	41.22797	0.0017

(***Source:*** Compiled from the results obtained in Eviews)

From table 9, it has been observed that the probability value is 0.0017 which is less than 0.05, implying that the null hypothesis of no structural break can be rejected. Thus, there is a structural break in the year 1996-1997.

The results of the RSS before the structural break with breakpoint 2005-2006 which is required for the calculation of F statistic are presented in table 10.

Table 10: RSS (residual sum of squares) before the structural break time with breakpoint 2005-2006

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	111760485.882	6	18626747.647	2.369	$.102^b$
Residual	86496072.618	11	7863279.329		
Total	198256558.500	17			

(***Source:*** Compiled from the results obtained in SPSS), RSS_1= 86496072.618

Table 11: RSS (Residual sum of squares) after the structural break time with breakpoint 2005-2006

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	16953272.968	6	2825545.495	1.343	$.486^b$
Residual	4207793.921	2	2103896.961		
Total	21161066.889	8			

(***Source:*** Compiled from the results obtained in SPSS), RSS_2= 4207793.921

Based on the output from tables 3, 10, and 11, the test statistic is calculated using the equation (3):

$$F = \frac{\{RSSR - (RSS_1 + RSS_2)\}/k}{(RSS_1 + RSS_2)/(N_1 + N_2 - 2k)}$$

$$F = \frac{\{115241999.17-(86496072.618+4207793.921)\}/7}{(86496072.618+4207793.921)/(18+9-14)} = 0.502$$

The critical value for F (7, 13) is 2.8321 at a 5% significance level. It is seen that the F test statistic (0.502) in 2005-2006 smaller than the 95% critical value of the F test. It can be concluded that there is no structural break in the rapeseed and mustard crop in the year 2005-2006. Further, the results of the Chow breakpoint test (using the log likelihood ratio) entails that there is no structural break time for the variables under investigation in table 12.

Table 12: Chow test on regression of area, production, maximum temperature, minimum temperature, total rainfall, bright sunshine hours and wind speed (2005-2006)

F-statistic	Log likelihood ratio	Probability
1.812917	18.39156	0.1681

(***Source:*** Compiled from the results obtained in Eviews)

From table 12, it has been observed that the probability value is 0.1681 which is greater than 0.05, implying that the null hypothesis of no structural break can be accepted. Thus, there is no structural break in the year 2005-2006.

3.2 Cointegration test

Johansen's cointegration test was used for this purpose. To test for the cointegrating relationship between the variables-namely, productivity, area, maximum temperature, minimum temperature, total rainfall, bright sunshine hours (BSSH) and wind speed- at first, all the lag length selection criteria such as Akaike information criteria (AIC), Hannan-Quinn information criteria (HQIC), Schwarz information criteria (SIC) were checked and thus a lag order of one (1) is selected for the rapeseed and mustard production model.

The results of trace statistic and maximal Eigen statistic are depicted in tables 13 and 14, respectively. The null hypothesis is that the number of cointegrating vectors is less than or equal to r, where r is 0, 1, 2, 3, 4, 5, 6 or 7.

Table 13: Cointegration test results (based on the trace statistic)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.958166	186.6409	125.6154	0.0000
At most 1 *	0.859273	107.2897	95.75366	0.0064
At most 2	0.602548	58.26625	69.81889	0.2924
At most 3	0.559355	35.19925	47.85613	0.4375
At most 4	0.269366	14.71134	29.79707	0.7984
At most 5	0.191255	6.865264	15.49471	0.5934
At most 6	0.060435	1.558468	3.841466	0.2119

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:*** Compiled from the results obtained in Eviews)

Table 14: Cointegration test results (based on the maximal Eigen statistic)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.958166	79.35125	46.23142	0.0000
At most 1 *	0.859273	49.02342	40.07757	0.0038
At most 2	0.602548	23.06700	33.87687	0.5254
At most 3	0.559355	20.48791	27.58434	0.3083
At most 4	0.269366	7.846078	21.13162	0.9129
At most 5	0.191255	5.306796	14.26460	0.7027
At most 6	0.060435	1.558468	3.841466	0.2119

Max-eigenvalue 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:*** Compiled from the results obtained in Eviews)

From the results of table 13, it is indicated that there are "two" cointegrating equations at the 0.05 level. Thus, it can be concluded that the variables in the model are cointegrated. In such a case, a dynamic error correction model or vector equilibrium correction model (VECM) rather than a Vector Autoregression (VAR) is more appropriate. According to Johansen (1995), the variables that are cointegrated follow a long-run equilibrium relationship. The existence of cointegration between the variables results in spurious correlation and for that Error Correction Model was suggested by Akintunde *et al.*, 2013 [1]. Following the VECM, the long-run elasticities for the variables namely, area, maximum temperature, minimum temperature, total rainfall, bright sunshine hours and wind speed have been estimated with the help of statistical package EViews. The normalized equation for the productivity of rapeseed and mustard in Jorhat district of Assam is given as:

PRY = -0.003434AREA +35.02619MAXTEMP +37.10167MINTEMP+0.014906TOTRAIN

(0.00061) (3.14213) (2.09668) (0.00761) [-5.65819]** [11.1473] [17.6954] [1.95803]** +34.68488BSSH - 12.48393WIND -1854.352 (5)

(3.40759) (1.69376) [10.1787] [-7.37053]

In equation (5), PRY is Productivity (in tonnes per hectare), AREA is area of the crop (in Hectares), MAXTEMP is maximum temperature (in °C), MINTEMP is minimum temperature (in °C), TOTRAIN is total rainfall (in millimetres), BSSH is bright sunshine hours (in hours) and WIND is wind speed (in kilometre per hour) where ** indicates significance at 1% level, values in parentheses are standard error of the coefficients of the variables, values in square brackets are t-statistic of the coefficients of the variables

The significant results of the above model indicate that productivity of the rapeseed and mustard crop is dependent on area and total rainfall for the crop in the long run.

Table 15: Results of Vector Error Correction Model for the productivity of rapeseed and mustard

Attributes	Coefficient	Standard Error	t-statistic
EC (-1)	-0.00504	0.00353	-1.42704**
Δ PRY (-1)	-0.28196	0.22142	-1.27346
Δ AREA	0.000018	0.000023	0.76416**
Δ MAXTEMP	0.10530	0.13654	0.77115
Δ MINTEMP	-0.04460	0.08919	-0.50011
Δ TOTRAIN	0.000022	0.00015	0.14414**
Δ BSSH	0.41321	0.18808	2.19701
Δ WIND	0.05602	0.09763	0.57385
Constant	0.01806	0.05081	0.35545
R^2 0.38968 Breusch-Godfrey 0.5027 Jarque-Bera 0.919801 Breusch-Pagan 0.0536			

(***Source:*** Compiled from the results obtained in Eviews)
** indicates significance at 1%

The results from table 15 show that the coefficient of error correction term (EC) is significant in the model for rapeseed and mustard. This validates the existence of a long-run relationship between the variables (Boansi, 2014) [3]. The coefficient of EC is -0.00504 which implies that when disturbances have occurred, their movements with time in the rapeseed and mustard model are checked and the speed of adjustment back to the equilibrium in the long-run is 0.00504. The coefficients of all variables except that of lagged productivity and minimum temperature have shown a positive relationship with the rapeseed and mustard productivity. The coefficient of minimum temperature is -0.04460 which indicates that a decrease in minimum temperature creates an increase in the rapeseed and mustard productivity in the short run.

From the significance results of table 15, the coefficient of the area is 0.0000179 ($p<0.01$) and that of total rainfall is 0.000022 ($p<0.01$) for rapeseed and mustard model which are significant in nature. This indicates that area and total rainfall have positive significant short-run effects on the productivity of rapeseed and mustard. By a 1% increase in the area and total rainfall in the study area, the rapeseed and mustard productivity can be significantly increased by 0.0000179% and 0.000022% respectively. This implies that annual total rainfall affects significantly and positively in the production of rapeseed and mustard in Jorhat district of Assam. The coefficient of multiple determination (R^2) is 0.38968. This entails that the variables such as area, maximum temperature, minimum temperature, total rainfall, bright sunshine hours, and wind speed explain a total of about 38.96% variation in the productivity of rapeseed and mustard for the study period. The probability value of Jarque-Bera test is 0.919801 which is greater than 0.05 indicating that the residuals are normally distributed. The probability of Chi square for the Breusch-Pagan test is 0.0536 which is greater than 0.05 implying that the model is homoscedastic. The probability of Chi square for the Breusch-Godfrey test is 0.5027 which is greater than 0.05. This implies that the residual series do not exhibit serial correlation. An approximate of 0.10% of total deviations in productivity from the long-run equilibrium is restored, which is significant at 1% level.

4. Conclusion

From the discussion, it can be concluded that the variables under observation for the rapeseed and mustard crop are non-stationary. This indicated the presence of a structural break in the crop's production, conclusively, in the years 1995-1996 and 1996-97. In the analysis of the checking of cointegration between the variables and the productivity of rapeseed and mustard crop, the variables become stationary after its first difference and there were two cointegrating equations at 0.05 level. The study employed the Vector Equilibrium Correction Model, and it was found that there is a long-run relationship between the variables. The coefficients of the variables, *viz.* area, maximum temperature, total rainfall, bright sunshine hours, and wind speed had shown a positive relationship with the rapeseed and mustard productivity. The coefficient of minimum temperature indicated that a decrease in minimum temperature created an increase in the rapeseed and mustard productivity in the short run. The results showed that area and total rainfall had a positive and significant effect on the productivity of rapeseed and mustard crop at a 1% level of probability which might be due to the availability of sufficient rainfall necessary for the crop's production. Moreover, the government might had launched schemes for oilseed crop leading to increase of the cultivation of the rapeseed and mustard by the farmers.

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