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Climatic Effects on Cotton and Tea Productions in Bangladesh and Measuring Efficiency using Multiple Regression and Stochastic Frontier Model Respectively

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Abstract

The main objective of this study is to develop Multiple Regression model to measure the Climatic effects on cash crop (Cotton and Tea) productions and to measure productions efficiency due to Climates using Stochastic Frontier model. From the analysis of the Multiple Regression model which gives the high R-square value implies to accept a good model. At the same time, all other assumptions and model validation checking test are very well satisfied which implies these fitted model are good model to measure the climatic effects in Bangladesh. Again, From the Stochastic Frontier model, there is a huge opportunity to increase Cotton production by increasing Technology to get maximum productions and Tea achieves maximum productions.

Key words: Cash crop, Climate, Multiple Regression model and Stochastic Frontier model

Introductions

Considering the climates condition Jute, Tabaco, Sugercane, Cotton, Tea, etc. are the major cash crop productions in Bangladesh. Tea is grown in the northeast and Cotton in all over the country, specilly in Chittagong. Climate change and agriculture are interrelated processes, both of which take place on a global scale. Global warming is projected to have significant impacts on conditions affecting agriculture, including temperature, carbon dioxide, glacial run-off, precipitation and the interaction of these elements. These conditions determine the carrying capacity of the biosphere to produce enough food for the human population and domesticated animals. The overall effect of climate change on agriculture will depend on the balance of these effects. Climate is the primary determinant of agricultural productivity. Concern over the potential effects of long-term climate change on agriculture has motivated a substantial body of a research over the past decade. This body of research addresses possible physical effects of climate changes on agriculture such as changes in crop and livestock yields, as well as the economic consequences of these potential yield changes.

Review of Literature

A lots of work has done about the effects of climatic variable on agricultural production such as Richard M. Adams, Brian H. Hurd, Stephanie Lenhart and Leary (Inter-Research, 1998) had made a paper with headings " Effects of global changes on Agriculture : An interpretative review". This paper reviews the extant literature on these physical and economic effects and interprets this in terms of common themes or findings. Shafiqur Rahman (September, 2008) conduct an analysis with the title "Effect of Global Warming on Rainfall and Agriculture Production" by which he has shown the significant effects of temperature on agricultural production by using regression and correlation analysis. Hag Hamad Abdelaziz, Adam Abdelrahman, Abdalla and Mohmmed Alameen Abdellatif (2010) have published a paper with the title "Economic Analysis of Factors Affecting Crop Production in North Darfur State : Study of Umkdada District". This study shed light on the main constraints of crop production in the traditional rainfed sector in Umkdada district, North Darfur State (Sudan). The study used descriptive statistics and regression for data analysis. The results of regression analysis revealed that the crops produced in season 2006 were significantly affected by some factors. Rahman, Mia and Bhuiyan (2012) has conducted in the year 2008-2009 to estimate the farm-size-specific productivity and technical efficiency fall rice crops. Farm-size-specific technical efficiency scores were estimated using stochastic production frontiers. There were wide of variations of productivity among farms, where large farms exhibited the highest productivity. The lowest net return or the highest cost of production was accrued from both the highest wage rate and highest amount of labour used in medium farms. Muhammad Fauzi Makki, Yudi Ferrianta, Rifiana and Suslinawati (2012) has conducted a study in Indonesia to evaluate the impact of climate change on productivity and technical efficiency paddy farms in tidal swamp land The analysis showed Impact on productivity have not good because negative. Paulo Dutra Constantin and Diogenes Leiva Martin (2009) was conducted a study to apply a Cobb-Douglas Translog Stochastic Production Function and Data Envelopment Analysis in order to estimate inefficiencies over time as well as respective TFP (Total Factor Productivity) sources for main Brazilian grain crops - namely, rice, beans, maize, soybeans and wheat - throughout the most recent data available comprising the period 2001-2006.

Objective of the study:

The main objective of this study is to develop Multiple Regression model to measure the climatic effects on cash crop productions in Bangladesh and Stochastic Frontier model for measuring the agricultural productions efficiency due to climates. The specific objective of this study is to develop an individual Multiple Regression model to measure the climatic effects on specific cash crops named as Cotton and Tea productions and Stochastic Frontier model of Cobb-Douglas type for measuring the productions efficiency due to climates covering the area Bangladesh.

Data source and Data manipulations

The climatic data sets are available from the websites http://www.barc.gov.bd. The crop data sets are also available from Bangladesh Agricultural Ministry's websites named as http://www.moa.gov.bd. These data set are available from the year1972 to 2006. Climatic information was in the original form such that it was arranged in the monthly average information corresponding to the years from 1972 to 2006 according to the 30 climatic stations. The name of these stations are Dinajpur, Rangpur, Rajshahi, Bogra, Mymensingh, Sylhet, Srimangal, Ishurdi, Dhaka, Comilla, Chandpur, Josser, Faridpur, Madaripur, Khulna, Satkhira, Barisal, Bhola, Feni, MaijdeeCourt, Hatiya, Sitakunda, Sandwip, Chittagong, Kutubdia, Cox's Bazar, Teknaf, Rangamati, Patuakhali, Khepupara, Tangail, and Mongla. We take the month October, November, December, January and February as a "dry season" and March, April, May, June, July, August, September as a "summer season" considering the weather and climatic conditions of Bangladesh. Then, finally we take average seasonal climatic information of 30 climatic station corresponding to the year from 1972 to 2006. We take the average of 30 climatic area because of focusing the overall country's situation and overall model fitting for whole Bangladesh.

Used Software:

This analysis has completely done by open source Software for statistical data analysis named as **R** with the version **R - 2.15.1.** The additional library packages used for analysis is **lmtest, gvlma, car, frontier, etc.**

Classical Linear Multiple Regression (CLMR) model

The multiple classical linear regression model is given by

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} \dots\dots\dots. \beta_q X_{qi} + \varepsilon_i \, , i = 1,2,3, \dots N \quad \dots\dots\dots (1)$$

Here , Y = Dependent variable, X_i 's are independent variables, ε = Stochastic error term

And β_0, β_1, β_2, … … …. B_q are the model parameters which are to be estimated

There are five critical assumptions relating to CLRM. These assumptions required to show that the estimation technique, Ordinary Least Squares (OLS), has a number of desirable properties, and also so that the hypothesis tests regarding the coefficient estimates could validly be conducted. These assumptions are (1) E (ε i) = 0 , The errors have zero mean, (2) Var (εi) = $\sigma^2 < \infty$, The values variance of the error is constant and have finite over all values of x_i, (3) Cov (ε i , ε j) = 0, The errors are statistically independent of one another, (4) Cov (ε ,i xi) = 0, There is no relationship between the error and the corresponding x, (5) $\varepsilon_i \sim N(0, \sigma^2)$, ε_i is normally distributed.

The Production Frontier: Theoretical Framework

The standard definition of a production function is that it gives the maximum possible output for a given set of inputs, the production function therefore defines a boundary or a frontier. All the production units on the frontier will be fully efficient. Efficiency can be of two kinds: technical and allocative. Technical efficiency is defined either as producing the maximum level of output given inputs or as using the minimum level of inputs given output Allocative efficiency occurs when the marginal rate of substitution between any of the inputs equals the corresponding input price ratio. If this equality is not satisfied, it means that the country is not using its inputs in the optimal productions. A production frontier model can be written as:

$$y_i = f(x_i;\ \beta)\, TE_i \ \ldots\ldots\ldots (2)$$

Where, y_i is the output of producer i (i = 1, 2,…, N); x_i is a vector of M inputs used by producer i; $f(x_i;\ \beta)$ is the production frontier and β is a vector of technology parameters to be estimated. Let TE_i be the technical efficiency of producer i,

$$TE_i = \frac{y_i}{f(x_i;\ \beta)} \ldots\ldots\ldots (3)$$

In the case, $TE_i = 1$, y_i achieves its maximum feasible output of $f(x_i;\ \beta)$. If $TE_i < 1$, it measures technical inefficiency in the sense that observed output is below the maximum feasible output. The production frontier $f(x_i;\ \beta)$ is deterministic.We have to specify the stochastic production frontier

$$y_i = f(x_i;\ \beta)\exp(v_i)\, TE_i \ \ldots\ldots\ldots (4)$$

Where, $f(x_i;\ \beta)\exp(v_i)$ is the stochastic frontier, which consists of a deterministic part $f(x_i;\ \beta)$ common to all producers and a producer-specific part which $\exp(v_i)$ captures the effect of the random shocks to each producer. TE_i can be computed for Stocahastic Fromntier productions of i^{th} producer

$$TE_i = \frac{y_i}{f(x_i;\ \beta)\exp(v_i)} \ldots\ldots\ldots (5)$$

Stochastic Frontier Productions Function

The econometric approach to estimate frontier models uses a parametric representation of technology along with a two-part composed error term. Under the assumption that is of $f(x_i;\ \beta)$ is of Cobb-Douglas type, the stochastic frontier model in equation (5) can be written as

$$Y_i = \alpha + \beta X_i + \varepsilon_i \ldots\ldots\ldots (6)$$

Where, ε_i is an error term with $\varepsilon_i = v_i - u_i$

The economic logic behind this specification is that the production process is subject to two economically distinguishable random disturbances: statistical noise represented by v_i and technical inefficiency represented by u_i

The productions function of Cobb-Douglas type used in this analysis is

$$\begin{aligned}\log(Yi) = {} & \beta_0 + \beta_1\log(\text{sun.sum}) + \log(\beta_2\text{sun.dry}) + \beta_3\log(\text{clo.sum}) + \beta_4\log(\text{clo.dry}) \\ & + \beta_5\log(\text{max.tem.dry}) + \beta_6\log(\text{max.tem.sum}) + \beta_7\log(\text{min.tem.dry}) \\ & + \beta_8\log(\text{min.tem.sum}) + \beta_9\log(\text{rain.dry}) + \beta_{10}\log(\text{rain.sum}) + \beta_{11}\log(\text{rh.dry}) \\ & + \beta_{12}\log(\text{rh.sum}) + \beta_{13}\log(\text{wind.dry}) + \beta_{14}\log(\text{wind.sum}) + \varepsilon \ldots\ldots\ldots\ (7)\end{aligned}$$

Where, Y_i is the specific cash crop productions named as Cotton and Tea, Where, β_0 is the intercept, β_j's are coefficients of the regressors, sun.sum = sunshine of the summer season, sun.dry = sunshine of dry the season , clo.sum = cloud coverage of the summer season, clo.dry = cloud coverage of the dry season, max.tem.dry =

maximum temperature of dry the season, max.tem.sum = maximum temperature of summer the season, min.tem.dry = minimum temperature of dry the season, min.tem.sum = minimum temperature of summer the season, rain.dry= ammounts of rainfall of dry the season, rain.sum= amounts rainfall of summer the season, rh.dry= relative humidity of dry the season, rh.sum= relative humidity of summer the season, wind.dry= wind speed of the dry season and wind.sum = wind speed of the summer season.

Climatic effects on Cotton Productions

Summary statistics of the Multiple Regression model for measuring climatic effects on Cotton productions in Bangladesh is given as in the Table-1

Table-1: Summary statistics of Cotton productions

Coefficients	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	-390.96884	1380.57083	-0.283	0.7799
sun.sum	-37.68389	33.98654	-1.109	0.2807
sun.dry	-26.34711	19.0066	-1.386	0.1809
clo.sum	-97.18847	45.54695	-2.134	0.0454
clo.dry	20.96727	45.94745	0.456	0.6531
max.tem.dry	-18.12747	28.61635	-0.633	0.5336
max.tem.sum	35.47078	49.62556	0.715	0.483
min.tem.dry	20.09509	31.31716	0.642	0.5284
min.tem.sum	-49.07211	39.08301	-1.256	0.2237
rain.dry	-0.02228	0.34472	-0.065	0.9491
rain.sum	-0.14236	0.16343	-0.871	0.394
rh.dry	-6.20863	6.43499	-0.965	0.3462
rh.sum	24.73761	12.63581	1.958	0.0644
wind.dry	-46.00362	90.00774	-0.511	0.6149
wind.sum	28.00028	41.43196	0.676	0.5069

From the summary statistics in the Table-1, it is clear that regressors variable sun.sum, sun.dry, clo.sum, max.tem.dry, min.tem.sum, rain.dry, rain.sum, rh.dry and wind.dry have negative effects and clo.dry, max.tem.sum, min.tem.dry, rh.sum and wind.sum have negative effects on Cotton productions in Bangladesh. At the same time, clo.sum and rh.sum have statistically significance effects on Cotton productions at 6% level of significance.

Again from the fitted model, Multiple R-squared is 0.7709 implies approximately 77% variation of cotton productions can be explained by climatic variable and Adjusted R-squared is 0.6106 implies approximately 61% variation of cotton productions can be explained by climatic variable after adjustemts. Again, from the overall significance test the p-value= Pr(|F| > 4.808) = 0.000792 which implies that all of the regressors are not eqully effects on cotton productions at 5% level of significance. That is why, we can primarily say that our fitted model is very good fitted model

From the Figure-1, it displays the partial relationship between the response's residuals and each of the predictor's residuals. All of the plots shows that they follow a staright line with non-zero slopes and there is no curvature relationship ammong the predictor's residuals and respon's residuals. That is why, it can be said that all of the variabls added to the model with maintaing a lineae relation , not maintaing a acurvature relations. That is, this model is going to make a linear relationship between the response variable and predictor variables to measure the climatic effects on cotton productions in Bangladesh.

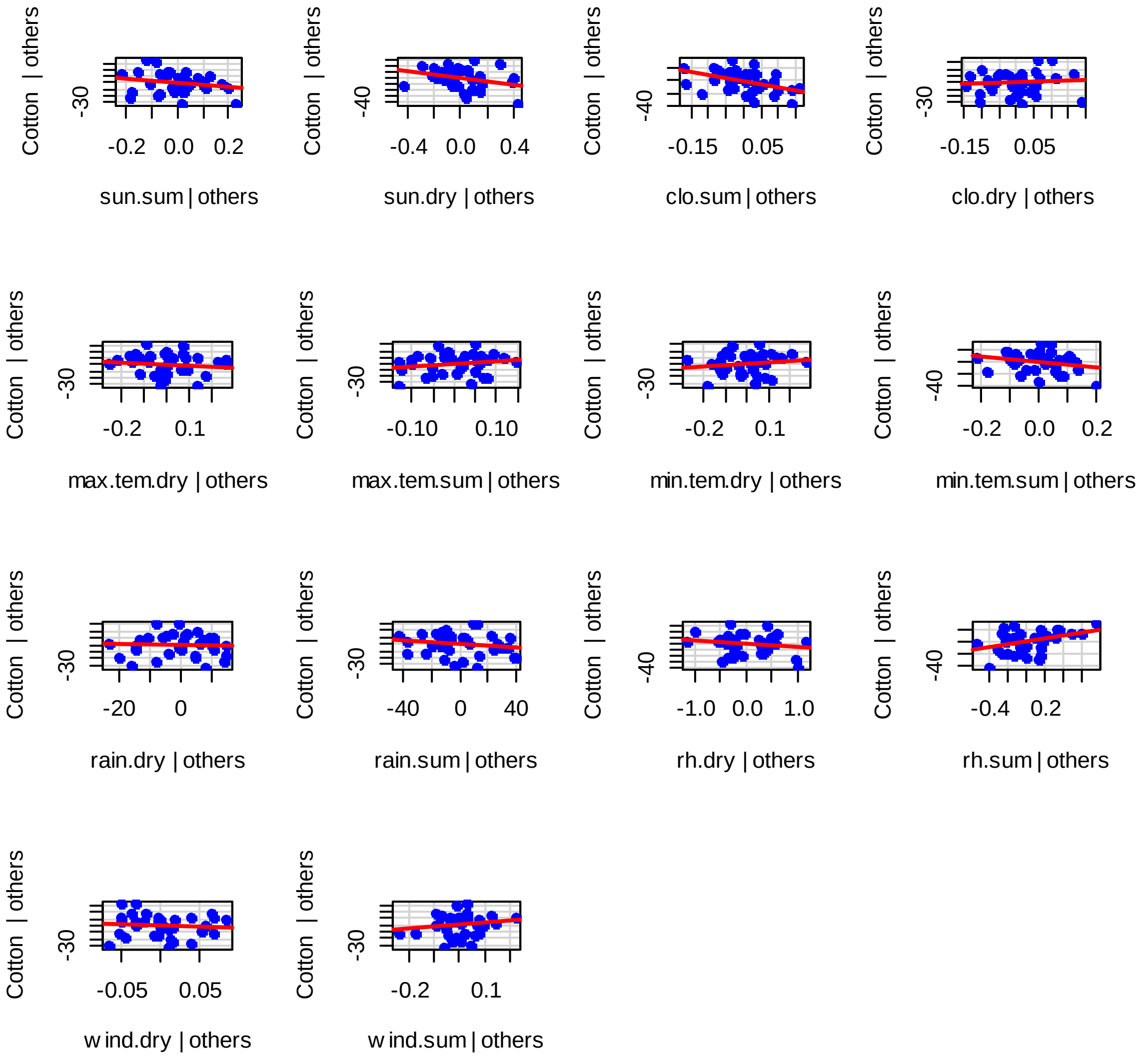

Figure-1: Added Variable plots for cotton productions model

Residuals Diaagonstics Plots for measuring the climatic effects on cotton productions model are shown in the figure-2

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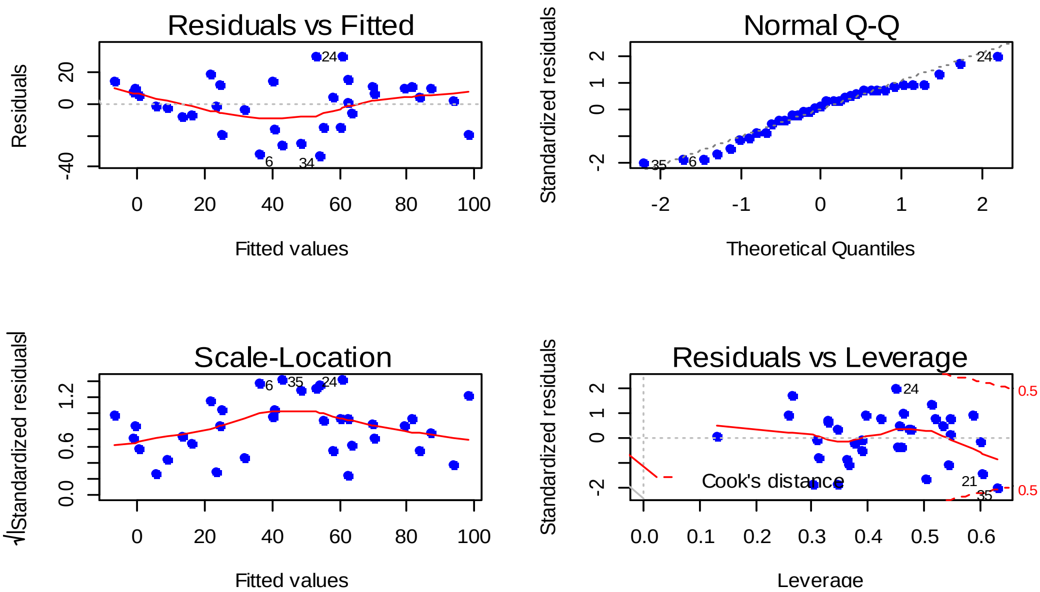

Figure-2: Residual diagnostic for the fitted model's residuals of Cotton Productions

From the Figue-2, following decission can be made

1) From the "Residuals vs Fitted", we see that all of the points lie around the horizontal line and they create horizontal band and implies constant variance among the residuals.
2) From "Scale-Location" graph, that is, "fitted value" versus "squre root of the absolute value of the standard residuals" create a horizontal band implies equal variance
3) Fom the "Residuals vs leverage" plots it is clear that there is no highly infuential observations and according to the cookies distance they lie inside the approximalely 50% of the leverage points Cook's interval and very well accepted leverage points and which has small amounts of influence on model's properties.
4) In the "Normal Q-Q" plots we see that all of the points follow the Q-Q line that's why it can be said that residuals of the fitted model are normally distributed.

To check different assumptions for a multiple regression model is shown in the following table-2

Table-2: Residuals Diagnostic test for Assumptions Checking

Residuals Diagnostic	Test Name	test statistics	P-value
Constant Variance test	Breusch-Pagan	14.0994	0.4423
Auto-correlation test	Box-Ljung test	3.1764	0.07471
Normality Test	Shapiro-Wilk	0.9702	0.4487

From table-2, it is clear that residuals of the fitted Regression model for cotton productions have constant variance, have no auto-correlation and they are follow normal distributions at 5% level of significance which implies the fitted model's assumptions are very well satisfied. These all test are made based on Chi-square test.

For model validation checking of the fitted regression model, Globa test is used with 4 degrees of freedom at 5% level of significance. The results obtained from the "Golbal test" is shown in the Table-3

Table-3: Global model validation Checking for Cotton productions model

Parameters	Value	p-value	Decision
Global Stat	8.344	0.07976	Assumptions acceptable.
Skewness	0.4122	0.52083	Assumptions acceptable.
Kurtosis	0.3385	0.56068	Assumptions acceptable.
Heteroscedasticity	2.3383	0.12622	Assumptions acceptable.

From Table-3, it is observed that the p- value of Global Stat is 0.07976 which implies that the assuptions of linearity of the parameters, Homoscedasticity, Autocorrelation and Normality test are very well satisfied at 5% level of significance, That is , the fitted model is valid a model. Again, Skewness and Kurtosis of the fitted model's residuals are 0.4122 and 0.3385 respectively and their corresponding p-values are 0.52083 and 0.3385 which suggest that the assumptions of the skewness and kurtosos are very well acceped to a linear model. At the same time, the heterocedasticity assumptions is also accepted with the p-value =0.12622 suggests to fit a good model. That's why we can easily say that the fitted model is the best fitted linear regression model for measuring the climatic effects on Cotton productions in Bangladesh.

Finally, from all of the test, assumptions of residuals like Homoscedasticity, Autocorrelation Normality are very well satisfied and model validation test "Global Tesst" also satisfied all of the assuptions of a linear model and the fitted model is a valid model. Without any kind of loss of generality, it can be said that this fitted model is the best fitted model for measuring the climatic effects on Cotton productions based on the sample data.

Stochastic frontier modeling for measuring efficiency of Cotton productions

Summary statistics of the fitted stochastic frontier model of Trans-log Cobb-Douglas type for the cotton productions is given in the Table-4 such as

Table-4: Summary statistics of the frontier model for Cotton productions model

Coefficients	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	-98.60129	0.99394	-99.2022	<0.0001
sun.sum	-6.80543	0.88689	-7.6733	<0.0001
sun.dry	-7.23121	0.7825	-9.2411	<0.0001
clo.sum	-12.22631	1.00005	-12.2257	<0.0001
clo.dry	-0.43697	0.65812	-0.664	0.50671
max.tem.dry	8.77509	0.94866	9.25	<0.0001
max.tem.sum	23.05247	0.9078	25.3938	<0.0001
min.tem.dry	-5.11648	0.95946	-5.3327	<0.0001
min.tem.sum	-23.68737	0.9374	-25.2693	<0.0001
rain.dry	0.5231	0.26793	1.9524	0.05089
rain.sum	0.84242	0.71228	1.1827	0.23693
rh.dry	-9.62073	0.97645	-9.8527	<0.0001
rh.sum	37.31186	1.00364	37.1764	<0.0001
wind.dry	-0.67145	0.66023	-1.017	0.30916
wind.sum	-0.16627	0.72356	-0.2298	0.81825
sigmaSq	0.62864	0.11813	5.3217	<0.0001
gamma	1	0.00002	61710.7484	<0.0001

From the Table-4 of the summary statistics, it is clear that sun.sum, sun.dry, clo.sum, max.tem.dry, max.tem.sum, min.tem.dry, min.tem.sum, rain.dry, rh.dry and rh.dry have statistically significance effects on frontier Cotton productions due to Climates covering the whole county Bangladesh at 1% level of significance.

From the calculated results, Average Technical Efficiency is 0.59749. The highest value of the efficiency is 0 .9997249 which occurs in the year 1989 and the lowest is 0.1511223 which occurs in the year 1979. These result indicate the majority of year are relatively not well in achieving maximum Cotton productions. Efficiency rate 56 percent gives sense that halve of the year can achieve maximum Cotton productions. At the same time, according to the Coelli's test $H_0: \gamma = 0$, gives the value of gamma is 1 and it's p-value for testing the hypothesis is < 0.0001 indicates highly significance and all of the deviations arises due to technical inefficiency. It also means that there is a huge opportunity to increase Cotton production in the Bangladesh by increasing technology. Again, from the likelihood ratio test, p-value = Pr($|\chi^2|$ > 10.748)= 0.0005 which implies to reject the null hypothesis there is no production inefficiency, that is, there exist production inefficiency of the Cotton productions due to climates.

Climatic effects on Tea Productions

Summary statistics of the fitted Multiple Regression model for measuring climatic effects on Tea productions in Bangladesh is given as in the Table-5

Table-5: Summary statistics of Tea productions

Coefficients	Estimate	Std. Error	t-value	Pr(>|t|)
(Intercept)	189.885322	234.122354	0.811	0.4274
sun.sum	-14.490683	5.852624	-2.476	0.0229
sun.dry	-1.017332	3.493489	-0.291	0.774
clo.sum	-7.542719	7.547643	-0.999	0.3302
clo.dry	6.06167	8.418987	0.72	0.4803
max.tem.dry	4.911693	5.244634	0.937	0.3608
max.tem.sum	0.920349	8.529631	0.108	0.9152
min.tem.dry	-6.545088	5.935539	-1.103	0.2839
min.tem.sum	2.538308	6.622315	0.383	0.7058
rain.dry	-0.023892	0.057567	-0.415	0.6828
rain.sum	-0.007719	0.026644	-0.29	0.7752
rh.dry	0.57166	1.173612	0.487	0.6318
rh.sum	-1.823508	2.265563	-0.805	0.4308
wind.dry	-15.862929	15.298608	-1.037	0.3128
wind.sum	-15.954489	6.692981	-2.384	0.0277

From the summary statistics in the Table-5, it is clear that regressors variable sun.sum, sun.dry, clo.sum, min.tem.dry, rain.dry, rain.sum, rh.sum, wind.sum and wind.dry have negative effects and clo.dry, max.tem.dry, min.tem.sum and rh.dry have negative effects on Tea productions in Bangladesh. At the same time, sun.sum and wind.sum have statistically significance effects on Tea productions at 2% level of significance.

Again from the fitted model, Multiple R-squared is 0.9228 implies approximately 92% variation of Tea productions can be explained by climatic variable and Adjusted R-squared is 0.8659 implies approximately 87% variation of tea productions can be explained by climatic variable. Again, from the overall significance test the p-value= Pr(|F| > 16.22) < 0.0001 which implies that all of the regressors are not equly effects on tea productions at 5% level of significance. That is why, we can primarily say that our fitted model is very good fitted model

From the Figure-3, it displays the partial relationship between the response's residuals and each of the predictor's residuals. All of the plots show that they follow a staright line with non-zero slopes and there is no curvature relationship ammong the predictor's residuals and respon's residuals. That is why, it can be said that all of the regressor variables added to the model with maintaing a lineae relation , not maintaing a acurvature relations. That is, this model is going to make a linear relationship between the response variable and predictor variables to measure the climatic effects on tea productions in Bangladesh.

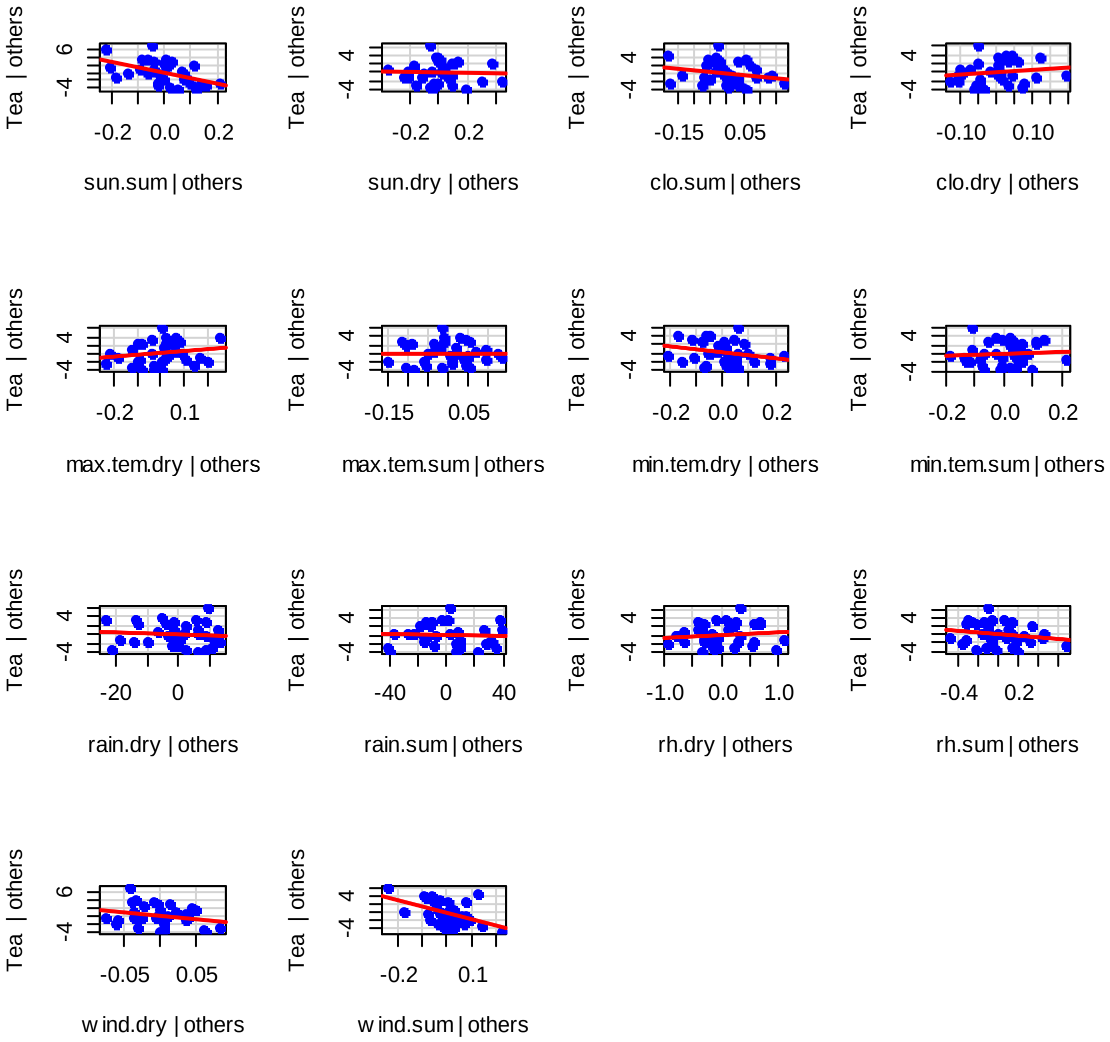

Figure-3: Added Variable plot for tea productions model

To check different assumptions for a multiple regression model is shown in the following table-6

Table-6: Residuals Diagnostic test for Assumptions Checking

Residuals Diagnostic	Test Name	Test statistics	P-value
Constant Variance test	Breusch-Pagan	17.0609	0.2529
Auto-correlation test	Box-Ljung test	0.3392	0.5603
Normality Test	Shapiro-Wilk	0.9674	0.3928

From table-6, based on the p-value it is clear that residuals of the fitted model have constant variance, have no auto-correlation and they are follow normal distributions at 5% level of significance which implies the fitted model's assumptions are very well satisfied. These all test are made based on Chi-square test.

Residual Diaagonstics Plot for measuring climatic effects on Tea productions are shown in the figure-3

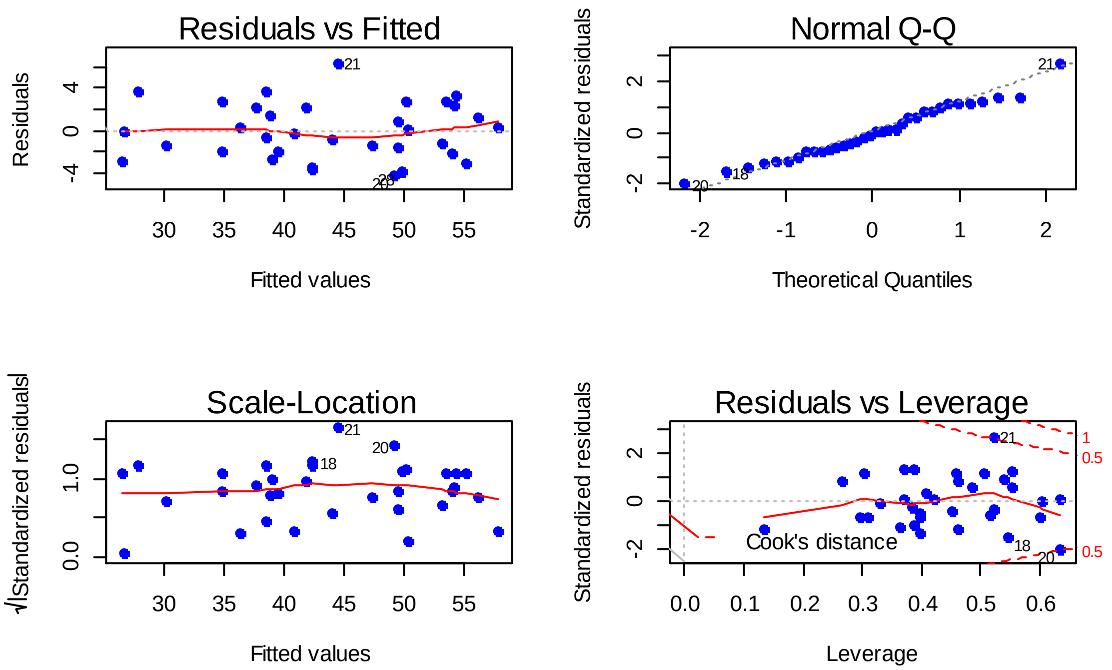

Figure-2: Residual diagnostic for the fitted model's residuals of Tea Productions

From the Figure-2 of residuals diagnostic test we can make the following comments

1) From the "Residuals vs Fitted", we observe that all of the points lie around the horizontal line and they create horizontal band and implies constant variance among the residuals.
2) From "Scale-Location" graph, that is, "fitted value" versus "squre root of the absolute value of the standard residuals" create a horizontal band implies equal variance
3) Fom the "Residuals vs leverage" plots it is clear that observations number 21 is a influential observations and according to the cookies distance it lies inside the approximalely 50% of the leverage points Cook's interval and very well accepted leverage points and which has small amounts of influence on model's properties.
4) In the "Normal Q-Q" plots we see that all of the points follow the Q-Q line that's why it can be said that residuals of the fitted model are normally distributed.

For validation checking of the fitted model, Globa test is used with 4 degrees of freedom at 5% level of significance. The results obtained from the "Golbal test" is shown in the Table-7 such as

Table-7: Globa model validation Checking for Tea productions

Parameters	Value	p-value	Decision
Global Stat	1.33821	0.8549	Assumptions acceptable.
Skewness	0.58358	0.4449	Assumptions acceptable.
Kurtosis	0.51104	0.4747	Assumptions acceptable.
Heteroscedasticity	0.06263	0.8024	Assumptions acceptable.

From the global test of the model validation checking, it is observed that the p- value of Global Stat is 0.8549 which implies that the assuptions of linearity of the parameters, Homoscedasticity, Autocorrelation and Normality test are very well satisfied at 5% level of significance, That is , the fitted model is valid model. Again, Skewness and Kurtosis of the fitted model's residuals are 0.58358 and 0.51104 respectively and their corresponding p-values are 0.4449 and 0.4747 which suggest that the assumptions of the skewness and kurtosos are very well acceptale to fit a linear model. At the same time, the heterocedasticity assumptions is also accepted with the p-value =0.8024 suggests to fit a good model. That's why we can easily say that the fitted model is the best fitted linear regression model for measuring the climatic effects on Tea productions in Bangladesh.

Finally, from all of the test, assumptions of residuals like Homoscedasticity, Autocorrelation Normality are very well satisfied and model validation test “Global Tesst” also satisfied all of the assuptions of a linear model and the fitted model is a valid model. Without any kind of loss of generality, it can be said that this fitted Regression model is the best fitted model for measuring the climatic effects on Tea productions in Bangladesh based on the sample data.

Stochastic frontier modeling for measuring efficiency of Tea productions

Summary statistics of the fitted stochastic frontier model of Cobb-Douglas type for the Rice productions is given in the Table-8 such as

Table-8: Summary statistics of the frontier model for Tea productions model

Coefficients	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	32.7104481	0.9999076	32.7135	<0.0001
sun.sum	-3.2113146	0.9997133	-3.2122	0.00132
sun.dry	0.094408	0.9996203	0.0944	0.92476
clo.sum	-1.9358428	0.9997782	-1.9363	0.05283
clo.dry	0.4759781	0.9999716	0.476	0.63408
max.tem.dry	5.4850871	0.99897	5.4907	<0.0001
max.tem.sum	-5.3003497	0.9988904	-5.3062	<0.0001
min.tem.dry	-4.1236984	0.9992582	-4.1268	<0.0001
min.tem.sum	3.4730079	0.9990602	3.4763	0.00051
rain.dry	-0.0447677	0.9986332	-0.0448	0.96424
rain.sum	-0.2506022	0.9969552	-0.2514	0.80153
rh.dry	1.8513377	0.9982578	1.8546	0.06366
rh.sum	-5.9505299	0.9982111	-5.9612	<0.0001
wind.dry	-0.2576939	0.9999896	-0.2577	0.79664
wind.sum	-0.8003103	0.9999749	-0.8003	0.42352
sigmaSq	0.0034912	0.1599896	0.0218	0.98259
gamma	0.0499999	0.9999997	0.05	0.96012

From the summary statistics it is clear that sun.sum, clo.sum, max.tem.dry, max.tem.sum, min.tem.dry, min.tem.sum, rh.dry and rh.sum have statistically significance effects on frontier Tea productions due to Climates covering the whole county Bangladesh at 6% level of significance.

From the calculated results, Average Technical Efficiency is 0.98954. The highest value of the efficiency is 0.9917273 which occurs in the year 1993 and the lowest is 0.9871755 which occurs in the year 1992. These result indicate the majority of year are relatively well in achieving maximum Tea productions. Efficiency rate approximately 99 percent gives sense that almost all of the year can achieve maximum Tea productions. At the same time, according to the Coelli’s test $H_0: \gamma = 0$, gives the value of gamma is 0.0499 and it’s p-value for testing the hypothesis is 0.96012 indicates highly insignificance and all of the deviations arises due to Stochastic error. It also means that there is a little opportunity to increase Tea production in Bangladesh by increasing technology. Again, from the likelihood ratio test, p-value = Pr($|\chi^2| > 0$)= 0.5 which implies to accept the null hypothesis that there is no production inefficiency, that is, there is no production inefficiency of the Tea productions due to climates.

Conclusion and Recommendations

The main objective of this study is to develop Multiple Regression model to measure the Climatic effects Cotton and Tea productions and to measure productions efficiency due to Climates using Stochastic Frontier model. From the analysis of the Multiple Regression model, gives the R-square values 0.7709 and .9228 for measuring the Climatic effects on Cotton and Tea productions respectively. These model imply that by the climatic variable cotton productions explained 77% variations and Tea productions explained 92% variations, that is, these model are good fitted model. At the same time, all other assumptions and model validation checking test are very well satisfied which implies these fitted model are the best fitted Multiple Regression model to measure the climatic effects in Bangladesh. Again, From the Stochastic Frontier model the mean efficiency of the Cotton productions is 0.59749 implies there is a huge opportunity to increase production by increasing Technology and mean efficiency of Tea productions is 0.98954 which implies it almost achieve maximum productions. Again from the Colli and Wald Likelihood ratio test there is no technical inefficiency in the frontier Tea productions but technical inefficiency exist in Cotton productions. After conducting this analysis the following recommendation can be made

- The policy makers and researchers can use these model to make a decision for agricultural productions under consideration of climatic effects on agricultural productions.
- The climatic zone similar to the Bangladesh can also use these model.

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