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IMPACTS OF MAJOR CROP PRODUCTION ON THE AGRICULTURAL SECTOR IN BANGLADESH: A TIME SERIES ANALYSIS

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ABSTRACT

The main objective of this research article is to analyze the impact of the production of some major crops, namely rice, jute, wheat, sugarcane, and potato on the agriculture sector in Bangladesh. The agriculture sector is considered an important sector of the Bangladeshi economy, which supplies a significant proportion of the gross domestic product (GDP). Annual time-series data for the period 1988–2017 is used for the study. Several econometric techniques are employed to examine the data, including the augmented Dickey-Fuller (ADF) test, Johansen cointegration test, and ordinary least squares (OLS) method. To validate the model, some residual diagnostic tests, namely a normality test, heteroskedasticity test, serial correlation test, and stability diagnostic test are conducted. The findings of the study demonstrate that there are two cointegrating equations in the model. Furthermore, both wheat and jute production have a significant positive impact on the agriculture sector. Although the impacts of rice and potato production on the agriculture sector are positive, these are not significant at the 5 or 10 percent significance level. On the other hand, sugarcane production has a negative and significant impact on the agriculture sector, which was not expected. Based on the results, this paper recommends that the government of Bangladesh should focus on designing and implementing new funding policies and subsidies to improve the growth, production, and development of the sugarcane sector. Finally, the government should be concerned about climate change-related factors that negatively affect crop production in Bangladesh.

Contribution/Originality: This study is one of very few studies to have investigated the impacts of major crop (rice, wheat, potato, jute, sugarcane) production on the agricultural sector (value-added) in Bangladesh by applying different econometric methods.

1. INTRODUCTION

Rice, wheat, potato, jute, and sugarcane are considered the main agricultural crops of Bangladesh, and these crops have a considerable impact on the agricultural sector. Bangladesh is an agriculture-based developing nation and the most densely populated country in the world. The total population of Bangladesh is about 161.4 million (Word Bank, 2018). The economic development of Bangladesh is mainly dependent on the agricultural sector. The agricultural sector contributes the lion's share of the national income, forms the basis of foreign currency earnings, is a major source of food supplies, and generates employment opportunities in rural areas. Murshid and Yunus (2016) noted that about 70 percent of Bangladeshi people live in rural areas, and the agriculture sector remains their major source of income. According to Finance Division (2018) and Murshid and Yunus (2016), the agriculture

sector contributes 14.23 percent of the gross domestic product (GDP) and almost 70 percent of the agricultural gross domestic product (AGDP) of Bangladesh. Nonetheless, due to industrialization, the amount of land devoted to agriculture is declining year by year. Agricultural land took up 70.6 percent of the land area in Bangladesh (World Bank, 2018). Due to the large population, food security is the main issue. To meet the growing demand for food, major crops such as rice, potato, wheat, maize, and sugarcane play an important role in Bangladesh. The agriculture sector creates employment opportunities for men and women in rural areas and ensures Bangladesh's food security. The country's agricultural economy is entirely dependent on the production of these crops.

Rehman et al. (2015) investigated the economic impacts of main field harvests, namely wheat, sugarcane, rice, maize, and cotton in Pakistan from 1950 to 2015. Annual time series data were used in the study. Different econometric methods, such as the augmented Dickey-Fuller (ADF) test, ordinary least squares (OLS) method, and Johansen cointegration test, were employed to analyze the data. The results of the research demonstrated that wheat, rice, maize, and cotton had a positive influence on the agricultural gross domestic product (AGDP) of Pakistan. Here, the impacts of maize and cotton output were significant, but the impacts of rice and wheat output were not significant. Moreover, sugarcane had a negative, though not significant, influence on agricultural GDP. They suggested that the Pakistani government should implement new funding schemes for the agricultural sector.

Kyomugisha, Sebatta, and Mugisha, (2018) conducted a study to identify the factors limiting farmers' market entrance, the break-even point for potato farmers, and the market efficiency of potato market chains in Uganda. They selected two exoteric potato-producing areas in Uganda, Kabale and Mbale, and randomly selected potato farmers and traders from the two districts. The OLS method was used to identify the factors that affect potato smallholder farmers' market entrance. Break-even analysis was conducted to calculate the potato growers' break-even point for employing post-harvest price added actions. Finally, to identify the market efficiency, a value-added approach was employed. Their study revealed that having contracted with purchasers, land area owned, number of forked hoes owned and diversity of produce have a positive and significant impact on farmers' market access. They also indicated that adding value to potatoes on the farm generates comparatively more revenue for growers. Market chains where growers sell to local rural dealers were shown to be more effective than other selling options.

Jahan (2019) conducted a study to discover the environmental, economic, and social factors of jute and its contribution to the sustainable development of Bangladesh. She also illustrated the environmental and economic benefits of jute. Data was collected through interviews, and qualitative methods were chosen to analyze the data. Her study revealed that jute contributes to the environment in many ways. In addition, novel jute products create many economic opportunities in markets. Jute has a bright future in the geotextile, automobile, infrastructure, and packaging sectors. It has also created employment opportunities in Bangladesh. Approximately 25 million people are directly or indirectly linked to the jute industry. Malaiarasan, Paramasivam, Thomas Felix, and Balaji (2020) studied the interdependency between sugar supply and demand in India from 1970-1971 to 2013-2014. A simultaneous equation model and time series data were used in their research. To calculate the elasticity of demand and supply equations for sugar, a three-stage least square regression model was employed. Their results demonstrated that the price of sugar has a positive impact on sugar supply while sugar price negatively affects sugar demand. The recovery rate and quantity of cane crushed are positively related to sugar production in India. Changes in the area harvested in the current year, yield, and FRP determine the future area under sugarcane cultivation. Rainfall and technological progress have a positive relationship with sugar production, and there is a direct link between population rate and sugar consumption. Rehman and Jingdong (2017) investigated the relationship between some main crops in China, namely rice, wheat, cotton, corn, sugarcane, and tubers, and agricultural gross domestic product (AGDP) in the period 1980–2015. Annual time-series data and the ordinary least squares (OLS) technique were used to analyze the relationship. The results of the study illustrated that cotton, wheat, sugarcane, corn, and tubers have a positive and significant effect on AGDP. On the other hand, rice production has an insignificant and negative impact on AGDP. Rahman, Kazal, Begum, and Alam (2017) analyzed

the posterior dynamic of the jute sector in Bangladesh. They collected national time-series data from 1974 to 2013. In addition, they selected 289 farmers from two jute cultivation zones in Bangladesh to supply farm survey data. To determine jute's future potentiality they considered its growth performance, universal competitiveness, profitability, and production proficiency. The results of the study demonstrated that the jute sector has experienced significant growth in area, production, productivity, prices, and exports. From 2004 to 2013 productivity stagnated, although from 1973 to 2003 jute grew at a rate of 1.3 each year. Furthermore, they opined that customary jute cultivation was universally competitive, but the monetary profitability of white jute was comparatively higher. Land, labor, and irrigation all play an important role in jute production, and marginal farmers were comparatively inefficient. In none of the studies in the above literature review did the researchers include the agriculture sector as a dependent variable. A comprehensive and econometric analysis-based study of the impacts of major crop production on the agricultural sector (value-added) has never before been carried out in the Bangladeshi context. Thus, this research paper will fill the research gap in the exploratory literature.

2. MATERIALS AND METHODS

2.1. Data Collection

The annual time-series data (1988–2017) of the variables is collected from various secondary sources. Agricultural value-added (in current US dollars) (AGR) data is taken from World Bank and OECD national accounts data files. Rice production data (in 1,000 metric tons) is collected from the United States Department of Agriculture. In addition, the production data for jute, wheat, potato, and sugarcane (in 1,000 metric tons) comes from the Finance Division (2018), Department of Finance, Ministry of Finance.

2.2. Econometric Methods

An augmented Dickey-Fuller (ADF) test was utilized to examine the stationarity of dependent and independent variables. After investigating the stationarity of the variables, the long-run relationships between the agricultural sector and the independent variables (rice production, jute production, wheat production, potato production, and sugarcane production) were checked using the Johansen cointegration test. The ordinary least squares (OLS) method was employed to test the impacts of rice production, jute production, wheat production, potato production, and sugarcane production on the agriculture sector of Bangladesh in the period 1988–2017. Finally, some residual diagnostic tests, namely the Jarque-Bera test, Breusch-Pagan Godfrey test, Breusch-Godfrey serial correlation LM test, and stability test, were conducted to justify the model.

2.3. Model Specification

2.3.1. Multiple Regression Model

To explore the relationship between the agricultural sector (dependent variable) and the independent variables (rice, jute, wheat, potato, and sugarcane), the following model was established:

$$Y = AX_1^{\alpha_1} X_2^{\alpha_2} X_3^{\alpha_3} X_4^{\alpha_4} X_5^{\alpha_5} \quad (1)$$

Equation 1 depicts the model of the study. Applying the natural logarithm (LN) of Equation 1 and incorporating five explanatory variables, Equation 1 was altered to:

$$LNY = \alpha_0 + \alpha_1 LNX_1 + \alpha_2 LNX_2 + \alpha_3 LNX_3 + \alpha_4 LNX_4 + \alpha_5 LNX_5 + e_t \quad (2)$$

Equation 2 presents the logarithmic form of the model, in which α_0 = Natural logarithm of intercept, LNY = Natural logarithm of agriculture, value-added, LNX_1 = Natural logarithm of rice production, LNX_2 = Natural logarithm of jute production, LNX_3 = Natural logarithm of wheat production, LNX_4 = Natural logarithm of potato production, LNX_5 = Natural logarithm of sugarcane production, e_t = error term.

Equation 2 can be written as follows:

$$LN(AGR) = \alpha_0 + \alpha_1 LN(RICE) + \alpha_2 LN(JUTE) + \alpha_3 LN(WHEAT) + \alpha_4 LN(POTATO) + \alpha_5 LN(SUGARCANE) + e_t \quad (3)$$

Equation 3 represents the form of the estimated model.

3. RESULTS AND DISCUSSION

3.1. Unit Root Test

The augmented Dickey-Fuller (ADF) test was applied to check the stationarity of the dependent and independent variables. The results of the ADF test are reported in Table 1. Table 1 illustrates that at the level form all the variables are non-stationary, but after taking the first difference they become stationary. Therefore, the variables follow the integrated order one, which can be written as I (1).

Table 1. Augmented Dickey-Fuller test.

Variables	Test critical values			At level		At first difference	
	t-statistics			t-statistic	Prob.	t-statistic	Prob.
	1%	5%	10%				
LNAGR	-3.6210	-2.9434	-2.6102	2.1182	0.9998	-3.3616	0.0214
LNRICE				-1.4702	0.5341	-5.3835	0.0001
LNJUTE				0.1033	0.9605	-6.3136	0.0000
LNWHEAT				-2.1261	0.2365	-3.1228	0.0363
LNPOTATO				-0.2633	0.9189	-7.1424	0.0000
LNSUGARCANE				1.5363	0.9990	-8.4210	0.0000

3.2. Cointegration Test

Cointegration means that the series in question are interrelated and can therefore be grouped in rows. This means that even short-term shocks, which can affect movement in a given series, converge in the long run. Cointegration can estimate both long-term and short-term models (Adeleye, 2018). Applying the Johansen cointegration test, it is found that there are two long-run relationships or two cointegrating equations among the variables. To run the Johansen cointegration test, the optimum lag length is considered, which was selected according to the Akaike (2011) information criterion (AIC) and the Schwarz (1978) criterion (SC). The results of the Johansen cointegration test are represented in Table 2. Table 2 shows that the values of trace statistics are 115.8984 and 74.3484, which are greater than their critical values of 95.7536 and 69.8188 respectively.

Table 2. Johansen cointegration test.

Hypothesized No. of CE(s)	Eigen value	Trace statistic	0.05 critical value	Prob.**	Max-Eigen statistics	0.05 critical value	Prob.**
None*	0.7732	115.8984	95.7536	0.0010	41.5489	40.0775	0.0339
At most 1*	0.7062	74.3484	69.8188	0.0208	34.2974	33.8768	0.0445
At most 2	0.4759	40.0520	47.8561	0.2207	18.0941	27.5843	0.4873
At most 3	0.3712	21.9578	29.7970	0.3008	12.9938	21.1316	0.4528
At most 4	0.2501	8.9640	15.4947	0.3687	8.0613	14.2646	0.3725
At most 5	0.0317	0.9026	3.8414	0.3421	0.9026	3.8414	0.3421

Note:
Trace test and Max-Eigen value test indicate 2 cointegrating equations at the 0.05 level.
*Denotes rejection of the hypothesis at the 0.05 level.
** MacKinnon, Haug, and Michelis (1999) p-values.

On the other hand, the values of the Max-Eigen statistics are 41.5489 and 34.2974, which are also above their critical values of 40.0775 and 33.8768 respectively. These serve to reject the null hypothesis of no cointegration equation(s) in the model. As a result, both Trace and Max-Eigen statistics state that there are two cointegrating equations in the model at the 5 percent significance level.

3.3. Regression Analysis

To analyze the effects of rice, jute, wheat, potato, and sugarcane production on the agriculture sector of Bangladesh, the ordinary least squares (OLS) method was utilized. The results of the multiple regression analysis are provided in Table 3. Here the calculated value of R-squared is 0.9740 or 97.40%. This indicates that roughly 97.4 % of the total variation in the agriculture sector can be illustrated by rice, jute, wheat, potato, and sugarcane. Moreover, the computed value of F-statistics is 180.26, and the probability value is 0.0000, indicating the fitness of the multiple regression model.

The results of the multiple regression analysis illustrate that the coefficient of jute production is highly significant (at 1 or 5 percent significance level), and there is a solid positive (Rehman et al., 2015) relationship between jute production and the agriculture sector. This means that every 1 percent rise in jute production raised the agricultural value addition by 0.165 percent. The analysis also revealed a positive (Rehman et al., 2015) relationship between rice, wheat, and potato production and the agriculture sector. Although the impact of wheat production is significant at the 10 percent level of significance, the effects of rice and potato are not significant at the 5 or 10 percent significance level. Nonetheless, the results imply that every 1 percent increase in rice production, wheat production, and potato production leads, respectively, to a 0.392 percent, 0.1137 percent, and 0.0381 percent increase in agricultural value addition. Furthermore, the relationship between sugarcane production and the agriculture sector is negative and highly significant at the 1 or 5 percent significance level. This means that a 1 percent increase in sugarcane production leads to a 0.8305 percent decrease in agricultural value added in Bangladesh. Through the implementation of nuclear and biotechnology, the government of Bangladesh has provided farmers with salt-tolerant and short-term crop varieties. Nowadays, in the coastal (southern) areas of Bangladesh, most farmers grow salt-tolerant crops. In addition, high-quality seeds are another key input to increase crop yields. In Bangladesh, the government, non-governmental organizations, and different seed production organizations are providing high-quality hybrid crop seeds to growers. The 75 contract planting areas also provide certified crop seeds. The country only provides 15-20% additional production for high-quality seeds (Finance Division, 2018). The 9 horticultural development centers and 14 agricultural service centers of the Bangladesh Agricultural Development Corporation (BADC) produce and distribute seeds, seedlings, and other planting materials across the country. Yet, on the other hand, the agricultural sector is facing different kinds of problems. The high prices of agricultural inputs, lack of subsidies and funding, dearth of irrigation facilities, poor agricultural marketing system, and underdeveloped infrastructure facilities are the main challenges. The study has shown that the impact of sugarcane production on the agriculture sector is negative (Rehman et al., 2015) and significant. This result is unexpected but might be due to unfavorable climatic conditions and support price fluctuations.

Table 3. Results of multiple regression analysis, dependent variable: LNAGR.

Method: Least Squares				
Variables	**Coefficients**	**Std. Error**	**t-Statistics**	**Prob.**
C	24.33728	2.93085	8.3038	0.0000
LNRICE	0.39221	0.27617	1.4201	0.1684
LNJUTE	0.16505	0.03074	5.3688	0.0000
LNWHEAT	0.11379	0.06429	1.7697	0.0895
LNPOTATO	0.03819	0.11610	0.3289	0.7451
LNSUGARCANE	-0.83053	-0.23772	-3.4937	0.0019

Note: R^2 = 0.9740, Adj. R^2 = 0.9686, S.E. of regression = 0.0724, F-Statistic = 180.2609, Prob (F-Statistic) = 0.0000, Durbin-Watson Stat = 1.4401.

Therefore, this study suggests that the government of Bangladesh should focus on implementing new funding policies and subsidies to improve the growth, development, and production of sugarcane. Additionally, the government should be concerned about climate change-related factors negatively affecting crop production in Bangladesh.

4. RESIDUAL DIAGNOSTIC TESTS

The Jarque and Bera (1980) test of the model acknowledges that the sample data matches a normal distribution. Furthermore, the results of the heteroskedasticity test (Breusch, 1978; Breusch & Pagan, 1979) reveal that the estimated model is homoscedastic, and the serial correlation LM test (Breusch, 1978; Breusch & Pagan, 1979) confirms that there is no serial correlation in residuals. The outcomes of the diagnostic tests are provided in Table 4.

Table 4. Diagnostic tests results.

Normality test: Jarque-Bera test			
Probability value	Level of significance	Jarque-Bera test statistic	
0.8153	5%	0.4083	
Heteroskedasticity test: Breusch-Pagan-Godfrey			
F-statistic	2.2345	Prob. F(5, 24)	0.0837
Obs. R-squared	9.5295	Prob. Chi-Square (5)	0.0897
Scaled explained SS	4.8451	Prob. Chi-Square (5)	0.4351
Breusch-Godfrey serial correlation LM test			
F-statistic	0.8480	Prob. F(2, 22)	0.4418
Obs. R-squared	2.1472	Prob. Chi-Square (2)	0.3418

4. 1. Stability Diagnostics Test

The result of the CUSUM square test (Brown, Durbin, & Evans, 1975) is provided below. Figure 1 shows that the blue line is between the two red lines, meaning that the econometric model is stable.

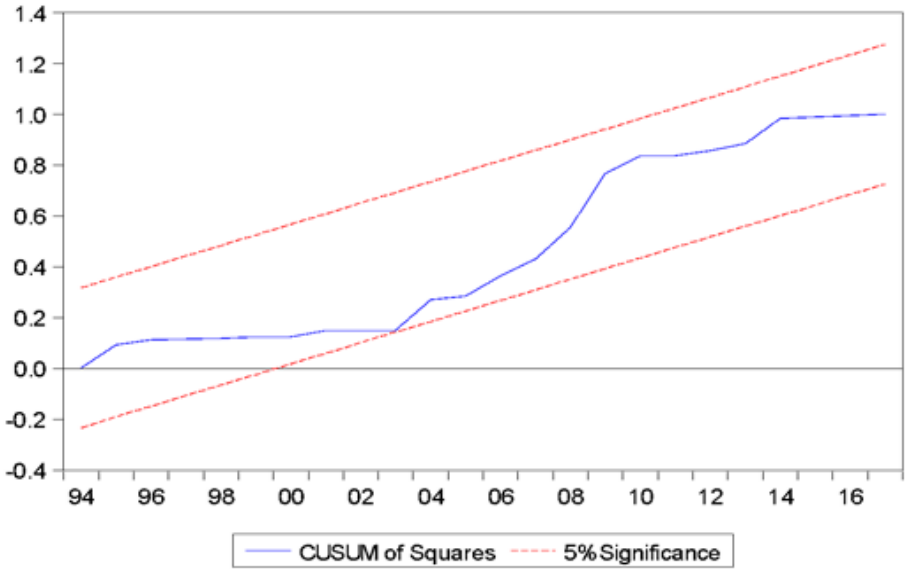

Figure 1. The result of the CUSUM square test.

5. CONCLUSION

This study examined the impacts of rice, wheat, jute, potato, and sugarcane production on the agriculture sector in Bangladesh in the period 1988–2017. Annual time series data was utilized to conduct the study. The econometric outcomes of the Johansen cointegration test demonstrate that there is a long-run relationship between

the agricultural sector (dependent variable) and the independent variables (rice, jute, wheat, potato, sugarcane). The results of the ordinary least squares (OLS) method revealed that both jute and wheat production have positive and significant impacts on the agriculture sector. Furthermore, although the impacts of rice and potato production are positive, these are not significant at the 5 or 10 percent significance level. In addition, the impact of sugarcane production on the agricultural sector is negative and significant. The results of the diagnostic tests reveal that the model is free from problems of heteroskedasticity and serial correlation and that the data matches a normal distribution. Finally, the CUSUM square test (Brown et al., 1975) demonstrates that the model is stable for the study period.

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