Bangladesh
Journal of
Political
Economy

Vol. 31, No. 5, January 2017, pp. 133-146
Bangladesh Economic Association
(ISSN 2227-3182)

Causal Relationship between Sectoral Agricultural Output and Economic Growth in Bangladesh: An Econometric Analysis

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Abstract: *The study attempted to investigate the cointegration and causal relationships between sectoral agricultural output and economic growth by applying recent advances in econometric methods like cointegration and error correction model with careful attention to time series data for avoiding spurious regression of traditional econometric analysis. To estimate the relationships, this study used time series data from 1973-74 to 2012-13. Results of unit root tests confirm that the variables are integrated of order one in levels and integrated of order zero in first differences. Results of Johansen cointegration tests indicate that there are long-run equilibrium relationships among the variables. Results of Granger Causality tests imply that there is bidirectional Granger-causality between total agricultural output and economic growth. It can be concluded that agriculture makes a significant contribution to economic growth in both short-run and long-run and that agriculture serves as an engine of economic growth in Bangladesh.*

Keywords: Agricultural Output, Economic Growth, Cointegration, Granger Causality, Bangladesh

1. Introduction

The potential contribution of agriculture to economic growth has been an on-going subject of much controversy among development economists, while some economists contend that agricultural development is a precondition to industrialization which lead to economic growth, others strongly disagree and argue for a different path. Taking advantage of recent developments in time series econometric methods, this study re-examined the question of whether agriculture could serve as an engine of growth.

Two polar views regarding the centrality of agriculture's role in the process of economic growth are prominent in the literature of economic development. At one

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pole, a substantial literature argues that agricultural development is necessary for overall economic transformation of a country. The contribution of agriculture in food, raw materials, and financial surplus (including foreign exchange) is essential for the process of industrialization in the early stages of an economy, during which by definition, the industrial sector is small (Johnston, 1970). At the other pole of views, economists can often bypass the process of agricultural development and instead of investing to build an industrial base.

Bangladesh has a basically agrarian economy where rice, jute, tea, wheat, sugarcane, potatoes, meet, milk, poultry etc., are the major agricultural products. Agriculture comprises about 18 percent of the country's gross domestic product (GDP) and employed around 50 percent of the labour force (Bangladesh Economic Review, 2014). The agricultural sector in Bangladesh is divided into four subsectors which are crop, fisheries, livestock and forestry. The crop sub-sector dominates the agricultural sector contributing about 57 percent of total output (Bangladesh Economic Review, 2014). This is the single largest producing sector of the economy. Fisheries, livestock and forestry sub-sectors contribute 22 percent, 8 percent and 13 percent, respectively (Bangladesh Economic Review, 2014).

Bangladesh is one of the most impoverished countries in the world. It is the seventh most populous country and is among the densely populated countries in the world with high poverty rate. About 35.6 percent population live below the poverty line. The total GDP of Bangladesh is US$572 billion in 2014, GDP growth rate is 7.2 percent (in 2015-16 estimated) (Bangladesh Economic Review, 2015) and GDP per capita is US$1314 in 2015 (Bangladesh Economic Review, 2016). In 2014, the sector wise contribution to GDP of Bangladesh accounts 19 percent in agriculture, 30 percent in industry and 51 percent in services; and about 40 percent labour force is employed in agriculture, 30 percent in industry and 30 percent in services (Bangladesh Economic Review, 2015).

Much of the early work on this issue coincided with the debate on the role of agriculture in promoting economic development in low-income nations in the aftermath of extended periods of colonial rule ((Lewis, 1954, Fei and Ranis, 1961; Jorgenson, 1961; Johnston and Mellor, 1961; Schultz, 1964). Johnston and Mellor (1961), Timmer (2002), Memon et al., (2008) and Meijerink and Roza (2006) observe that agriculture contributes to economic growth and development through five inter-sectoral linkages. The sectors are linked via (i) supply of surplus labour to firms in the industrial sector, (ii) supply of food for domestic consumption, (iii) provision of market for industrial output, (iv) supply of domestic savings for industrial investment and (v) supply of foreign exchange from agricultural export earnings to finance import for intermediate and capital goods. The "Johnston-Mellor Linkages" allow market-mediated input, input-output interactions between agriculture and non-agriculture sectors, so that agriculture can contribute to economic development. Hwa (1988) argues that agriculture is an engine of growth and adds agriculture to the standard Solow-Swan growth equation as a measure of linkages between rural and industrial sector of the economy. Edwards (1993), Caporale and Pittis (1997), Frankel and Romer (1999), Gardner (2005), Shombe (2005), Tiffin and Irz (2006), Tsakok and Gardner (2007), Awokuse (2008) and Awokuse (2009) examine the dynamic causal linkages between agriculture and economic growth and report mixed results regarding causal relationship between agriculture and economic growth.

As total output of all sectors in Bangladesh is increasing and no econometric work, to the best of our knowledge, has been done on the causal relationship between agricultural sub-sectors and economic growth, this study was designed to evaluate the cointegrating and causal relationship between sectoral contributions of agriculture and economic growth in Bangladesh using econometric techniques like cointegration and Granger representation theorem.

The rest of the paper is structured as follows. Section 2 describes methodology; Section 3 explains data and variables; Section 4 reports empirical results and Section 5 gives conclusions and policy implications.

2. Methodology

In recent years, several econometric methodologies have been developed for econometric analysis of time series data. It is observed that time series data used in many econometrics studies create some critical problem to econometrician. It is assumed that the underlying time series data are stationary. If this assumption is not present in the estimation process, the traditional hypothesis testing, which is based on small sample or asymptotic distribution of the estimates, are no longer valid. Following this problem some approaches have already been developed, that are effective for estimation and specification of time series analysis. These tools allow relevant economic theory to enter into the information of long-run equilibrium levels with the short-run dynamics of the equation. The development of cointegration and error correction mechanism (ECM) in time series analysis has guided the tools to apply dynamic models that account explicitly for the dynamic of the short-run adjustment towards long-run equilibrium. The methods are expressed as follows.

2.1. Augmented Dickey – Fuller (ADF) test

It is started with the Dickey –Fuller (Dickey and Fuller, 1979) test which is applied to regression in the following forms to check whether the variables suffer from nonstationarity or not:

$$\Delta Y_t = \xi Y_{t-1} + u_t \tag{1}$$

$$\Delta Y_t = \delta_1 + \xi Y_{t-1} + u_t \tag{2}$$

$$\Delta Y_t = \delta_1 + \delta_1 t + \xi Y_{t-1} + u_t \quad (3)$$

The difference between (3) and other two regressions lie in the inclusion of the constant and the trend term. Where *t* is the time and trend variable. The next step here is to divide the estimated δ coefficient by its standard error to computed the Dickey-Fuller τ statistic and to refer to DF tables to see the null hypothesis δ =0 is rejected (there is a unit root). If the computed absolute value of the τ statistics is less than the absolute critical values, the time series is considered to be non-stationary (Gujarati, 1998).

The Augmented Dickey-Fuller (ADF) test is applied for test of stationary allowing the chance of autocorrelation of error term u_t . ADF test requires modifying equation (3) as follows:

$$\Delta Y_t = \delta_1 + \delta_2 t + \wp y_{t-1} + \theta \sum \Delta y_{t-i} + u_t \quad (4)$$

Where u_t are assumed to be identically, independently distributed random variable. This ADF test involves adding an unknown number of lagged first differences of the dependent variable to capture auto-correlated omitted variables that would otherwise enter the error term u_t . The numbers of lagged difference terms to be included are often determined empirically, the idea being to include enough terms, so that the error term in equation (4) is serially independent. This ADF test statistics checks the null hypotheses that the time series has a unit root, i.e., ξ = 0 under the alternative hypothesis of stationary time series. That ADF test statistic has the same asymptotic distribution as the DF test statistic, so the same critical values are used.

2.2. Phillips-Perron (PP) unit root test

The alternative test for existence of a unit root in the residuals of the cointegrating regression is that suggested by Phillips (1987) and extended by Perron (1988) and Phillips and Perron (1986). An important assumption of the DF test is that the error terms u_t are independently and identically distributed. The ADF test adjusts the DF test to take care of possible serial correlation in the error terms by adding the lagged difference terms of the regressand. Phillips and Perron use nonparametric statistical methods to take care of the serial correlation in the error terms without adding lagged difference terms. The asymptotic distribution of the PP test is same as the ADF test statistic.

2.3. Cointegration

The concept of cointegration was introduced by Granger in 1981 and the statistical analysis of cointegrated process was organized by Engle and Granger (1987). Cointegration means that despite being individually non-stationary a linear combination of two or more time series can be stationary (Gujarati, 1998). When a linear combination of non-stationary variables is stationary, the variables are said to be cointegrated, and the vector that defines the stationary linear combination is called a cointegrating vector. Thus it is quite possible for a linear combination of cointegrated variables to be stationary. In this case, the variables are said to be cointegrated. If the variables become stationary by differencing once, i.e., *I(1)*, then the error term originated from the cointegration regression is stationary, i.e., *I(0)* (Johansen, and Juselius, 1990 and Johansen, 1998). Now consider the following cointegrating regression:

$$Y_t = \alpha + \beta X_t + u_t \quad (5)$$

If the series Yt and Xt are I (1), and the error term u_t is I (1, 0). The coefficient β measures the equilibrium relationship between the series *Y* and *X*. The term ut indicates the variation from the long-run equilibrium path of Y_t and X_t. When a time series Y_t is said to be integrated of order one, it is denoted by *I(1)*. Taking first difference of the time series leads to a non-stationary process. At the same way if the original nonstationary series has to be differenced *d* times before it becomes stationary, the original series is integrated of order *d*, it is denote by *I(d)*. Yt is integrated of order *I(0)*, when if is stationary in level form. Following this way, in the case where original series, let X_t and Y_t are integrated of order one *I(1)*, as is frequently the case with economic variables (Nelson and Plosser, 1982), constancy in error correction mechanism requires all of terms to be integrated of order zero, *I(0)*. This is only the case if X_t and Y_t are cointegrated, i.e., there is a linear combination of *X* and *Y*, such as $X_t = Y_t + u_t$, which is stationary.

2.4. Granger causality test

When variables are cointegrated, there is a general and systematic tendency for the series to return to their equilibrium value: short-run discrepancies may be constantly occurring but they cannot grow indefinitely. This means that the dynamics of adjustment is intrinsically embodied in the theory of cointegration. The Granger representation theorem (Granger, 1986 and Gujarati, 1998) states that if a set of variables is cointegrated *(1,1)*, implying that the residual of the cointegrating regression is of order *I(0)*, then there exists an error correction mechanism (ECM) describing that relationship. This theorem is a vital result as implies that cointegration and ECMs can be used as a unified empirical and theoretical framework for the analysis of both short-run and long-run behavior. The ECM specification is based on the idea that adjustments are so as to get closer to the long-run equilibrium relationship. Hence, the link between cointegrated series and ECMs is intuitive: error correction behavior induces cointegrated stationary relationships and vice-versa (Mckay *et al*., 2002).

Let Y_t and X_t variables are cointegrated, and then the relationship between the two can be expressed as ECM. The ECM can be written as:

$$\Delta InY_t = \alpha_0 + \alpha_1 \Delta InX_t + \alpha_2\, ECT_{t-1} + \varepsilon_t \quad (6)$$

Where Δ as usual denotes the first difference operator and ε_t is a random error term. The term ECT_{t-1} is the one period error correction term from the cointegrating regression. The ECM regression states that, ΔY depends on ΔX, and also on the error correction term *(ECT)*. If the later is non zero then the model is out of the equilibrium. Suppose ΔX is zero and ECT_{t-1} is positive. That means Y_t is above its equilibrium value. Since α is expected to be negative, the term $\alpha_2 ECT_{t-1}$ is negative and therefore ΔY_t becomes negative to restore the equilibrium. That is, if Y_t is above its equilibrium value, it starts falling in the next period to correct the equilibrium error, hence the name ECM (Gujarati, 1998).

The Granger causality test augmented with a lagged error-correction term (ECM) is also conducted in the final stage. If long-run relationship exists among the variables specified, there must be Granger causality in at least one direction (Engle and Granger, 1987). The Granger Causality test involves the estimation of an error correction model (ECM).

According to Granger representation theorem, a cointegrated system can be estimated as an ECM. While cointegration tests provide information about long-run relationships among variables, Granger causality tests provide information on both short-run and long-run dynamics relationships among variables.

3. Data and Variables Description

The success of any econometric analysis ultimately depends on the availability of the appropriate data. The empirical analysis of the study has been conducted using national data of agricultural output and GDP in Bangladesh from 1973-74 to 2012-2013. The data utilized are obtained from various publications of Bangladesh Bureau of Statistics (BBS). A summary statistics of variables of agricultural output and GDP is given in Table 1 and detailed data are shown in Appendix 1.

Table 1: Summary Statistics of Variables

Variables	Variable notation	Mean	Standard deviation	Maximum	Minimum
Crop output	Cp	6068.846	1825.324	10162.58	2604.18
Forestry Output	Fp	979.2065	569.7405	2061.61	136.91
Livestock Output	Lp	833.4703	324.5704	1671.84	287.76
Fisheries Output	Fip	1533.497	1055.733	3147.9	341.7
Total Agricultural Output	Tp	9417.106	3593.022	17043.32	3479.26
Gross Domestic Product	GDP	40394.88	34345.12	140425	6830.09

Table 1 provides information on mean, standard deviation, maximum value and minimum value of agricultural variables and GDP in Bangladesh for a period of 40 years.

4. Results and Discussion

4.1. Results of unit roots tests

This study used unit root test to check whether variables of agricultural output and GDP are non-stationary. All variables are used in logarithmic form. Two types of unit root tests used are augmented Dickey-Fuller (ADF) test and Phillips-Perron test.

Results of Augmented Dickey-Fuller (ADF) tests are presented in Table 2. Akaike Information Creation is used to determine the optional lag length for the augmented terms. Results show that for all variables, the null hypothesis (non-stationary) of unit root cannot be rejected at 5 percent level for both cases with intercept and without trend and intercept. This means that the variables are integrated of order one. When the first difference is tested, the null hypotheses (non-stationary) are rejected at 5 percent level for both cases. That means the variables are integrated of order zero in first difference. But for the variable GDP, the null hypothesis cannot be rejected at 5 percent level. When the first difference is tested, the null hypothesis (non-stationary) is rejected at 10 percent level. But for without intercept, when we take second difference, the null hypothesis is rejected. Therefore, result confirms that, GDP variable is integrated of order one in levels but integrated of order zero in first differences. For without intercept, this variable is integrated of order zero in second difference.

Table 2: Results of Augmented Dickey-Fuller (ADF) tests

Variables	Levels		1st Difference	
	With intercept	Without intercept	With intercept	Without intercept
lnCp	-0.016	0.229	-7.256	-6.779
lnFp	0.342	2.109	-3.854	-2.553
lnLp	-1.479	0.553	-5.341	-4.878
lnFip	0.236	1.455	-2.889	-2.229
lnTp	0.290	1.190	-6.526	-5.450
lnGDP	2.700	3.727	-2.870*	-5.721*

Note: The 1% critical value for Level is -3.64, 5% CV -2.95 and 10% CV -2.61. The 1% critical value for first difference is -3.65, 5% CV -2.96 and 10% CV -2.62. For without trend the 1% CV for level is -2.64, 5% CV -1.95 and 10% CV -1.62. The 1% critical value for Difference is -2.64, 5% CV -1.95 and 10% CV -1.62.

Phillips-Perron unit root test results for the logarithms of levels and first differences of all variables are presented in Table 3.

Table 3: Results of PP unit root tests

Variables	Levels		1st Difference	
	With intercept	Without intercept	With intercept	Without intercept
lnCp	-2.296	1.851	-9.051	-9.017
lnFp	0.546	2.779	-4.204	-3.711
lnLp	-0.523	4.099	-4.488	-7.090
lnFip	-0.059	1.347	-3.986	-3.573
lnTp	0.276	3.958	-8.541	-7.896
lnGDP	4.133	7.092	-4.118	-3.376

Note: The PP unit root tests reported here are estimation with intercept and without trend and intercept. If the computed absolute value of the PP test statistics is less than the absolute critical values, the time series is considered non-stationary. The 1% critical value for Level is -3.64, 5% CV -2.95 and 10% CV -2.61. The 1% critical value for first difference is -3.64, 5% CV -2.95 and 10% CV -2.61. For without trend the 1% critical value for level is -2.64, 5% CV -1.95 and 10% CV -1.62. The 1% critical value for first Difference is -2.63, 5% CV -1.95 and 10% CV -1.62.

Table 3 shows that for all variables, the null hypothesis (non-stationary) of unit root cannot be rejected at 5 percent level for both cases with intercept and without trend and intercept. This means that the variables are integrated of order one. When the first difference is tested, the null hypotheses (non-stationary) are rejected at 5 percent level for both cases. This means that the variables are integrated of order zero in first difference.

Results from both tests, therefore, confirm that all variables are integrated of order one in levels but integrated of order zero in first differences. Thus we can now proceed for cointegration and Granger causality.

4.2 Results of Cointegration

Cointegration of two (or more) time series suggests that there is a long-run, or equilibrium, relationship between them. Following the steps of Johansen procedure, hypothesis testing procedures are carried out to select the order of vector autoregression (VAR), starting with a maximum lag length four. A lag length of more than four is not considered because of the limited sample size. If the residuals do not suffer from serial correlation, it is appropriate to select a lower lag length although incorporating additional coefficients reduces the degree of freedom. Results from the lag length test suggest that possible lag lengths lie between one and four. The rank of the cointegration, i.e., the number of cointegrating vectors, is selected by using the maximum eigenvalue test. The second step in the Johansen procedure is to test for the presence of the number of cointegrating vectors among the series in the model. Results of cointegration are presented in Table 4.

Table 4: Result of Johansen's Cointegration test between agricultural variables and GDP

Variables	Cointegration rank	Eigen Value	Likelihood ratio	5% critical value	Decision
Crop output and GDP	r □ 0	0.61	36.67	25.32	None
	r □ 1	0.17	6.26	12.25	At most1
Forestry output and GDP	r □ 0	0.53	35.81	25.32	None
	r □ 1	0.28	10.83	12.25	At most 1
Livestock output and GDP	r □ 0	0.40	18.99	15.41	None
	r □ 1	0.10	3.41	3.76	At most 1
Fisheries output and GDP	r □ 0	0.41	16.51	15.41	None
	r □ 1	0.02	0.66	3.76	At most 1
Total agricultural output and	r □ 0	0.44	27.71	25.32	None
GDP	r □ 1	0.27	9.62	12.25	At most 1

Note: Likelihood Ratio test indicates cointegrating equation at 5 percent significance level.

Results show that since the likelihood ratio (LR) value is greater than the critical value at 5 percent level, the null hypotheses of no cointegration is rejected. The hypotheses of one cointegrating vector are accepted. The Johansen cointegration results in Table 4 indicate that agricultural variables and GDP have one cointegrating vector. It means unique long-run equilibrium relationships exist between the variables.

4.3 Results of Granger Causality Test

If the cointegration exists, the next step is to investigate the short-run dynamics via the analysis of Granger causality tests. While cointegration tests provide information about long-run relationships among the variables, Granger causality tests provide information on short-run dynamics. We estimate two ECMs in order to test for Granger causality where the first equation has GDP as the dependent variable and the second has sectoral agricultural output as the dependent variable. Two null hypotheses are examined: a) agricultural output does not Granger-cause GDP; b) GDP does not Granger-cause agricultural output. The direction of Granger causality is captured through the joint significance tests of the coefficients of the lagged-differences of the explanatory variables. Results of Granger causality test are presented in Table 5.

Table 5: Results of Granger causality test

Null Hypotheses	Observations	F-Statistic	Probability
GDP does not Granger Cause Crop Output	40	12.2308	0.00015
Crop output does not Granger Cause GDP		3.82012	0.03412
GDP does not Granger Cause Forestry Output	40	0.47750	0.62529
Forestry output does not Granger Cause GDP		1.87893	0.17151
GDP does not Granger Cause Livestock Output	40	3.30272	0.05155
Livestock output does not Granger Cause GDP		2.28809	0.12012

GDP does not Granger Cause Fisheries Output Fisheries output does not Granger Cause GDP	40	3.02584 1.65364	0.06461 0.02950
GDP does not Granger Cause Total Agricultural Output Total Agricultural output does not Granger Cause GDP	40	9.10858 3.86991	0.00090 0.03282

Results of the Granger Causality tests suggest that agriculture makes a significant contribution to economic growth in both short-run and long-run as the null hypotheses are rejected at 5 percent significant level. Specifically, the null hypothesis that "agricultural Output does not 'Granger-cause GDP' is rejected at the 5 percent level. So it can be concluded that results from the empirical analysis provide strong evidence indicating that agriculture is an engine of economic growth.

5. Conclusion and Policy Recommendations

This research applies an econometric framework to estimate relationship between agricultural output and economic growth in Bangladesh. Secondary time series annual data have been used for the period of 1973-74 to 2012-13. Six variables have been selected for model specification of agricultural output and economic growth. This study uses cointegration and ECM to investigate the causality between agricultural output and economic growth at national level. Results suggest that outputs of agricultural sectors are cointegrated with economic growth both in the short and long-run. This implies that short-run disequilibria are corrected in the long-run within this framework. Results of Granger causality suggest that sectoral outputs of agriculture help boost economic growth implying that agriculture can still be considered as an engine of economic growth in Bangladesh. The policy implication of this research is that the government of Bangladesh should continue taking appropriate policies for fostering production of crops, livestock, forestry and fisheries sectors of agriculture.

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Appendix 1: Annual Agricultural Output and GDP of Bangladesh

Year	Agricultural output (In Million US$)					GDP (in Million US$)
	Crop	Forestry	Livestock	Fisheries	Total output	
1973-74	4169.38	216.91	393.77	429.43	5209.51	8923.23
1974-75	7594.30	260.39	466.13	537.90	8858.73	14167.64
1975-76	2996.80	139.09	287.76	385.21	3808.86	7138.12
1976-77	2604.18	136.91	291.33	446.84	3479.26	8923.23
1977-78	3538.71	268.84	514.26	457.50	4779.31	8618.89
1978-79	3718.30	312.28	689.81	452.34	5172.73	9510.15
1979-80	4418.53	313.75	839.12	451.78	6023.18	11132.99
1980-81	5143.86	369.68	765.81	431.89	6701.25	14347.05
1981-82	4730.68	326.44	633.58	381.46	6072.15	13214.12
1982-83	4390.36	357.26	620.67	341.70	5709.99	12121.01
1983-84	5205.36	476.11	669.87	431.06	6427.60	14028.47
1984-85	5957.27	528.28	644.06	563.91	8079.07	16128.32
1985-86	4667.35	635.11	515.32	485.54	6303.33	15600.13
1986-87	5386.17	670.73	529.62	588.32	7174.84	17604.03
1987-88	5366.08	812.17	572.14	663.46	7413.79	19113.12
1988-89	5490.59	752.55	661.66	730.31	7635.12	20522.71
1989-90	5899.23	805.83	768.49	782.17	8255.72	22404.00
1990-91	6105.73	802.77	744.61	772.81	8425.91	23388.57
1991-92	5831.15	812.81	737.05	809.20	8190.73	23764.45
1992-93	4718.00	828.88	807.70	1025.23	7389.81	24218.40
1993-94	4691.22	843.46	902.25	1210.10	7647.03	25758.55
1994-95	5600.40	968.72	1004.29	1415.71	8989.12	29110.61
1995-96	5875.26	1313.06	775.11	2093.72	10037.15	40729.25
1996-97	6088.29	1334.14	784.95	2257.92	10465.31	42318.01
1997-98	6253.04	1330.86	805.67	2392.23	10781.81	44037.15
1998-99	6740.02	1340.51	863.74	2597.64	11541.91	45708.51
1999-00	6642.22	1363.04	877.92	2717.84	11601.02	47123.82
2000-01	6312.88	1277.43	866.28	2484.49	10941.08	46988.54
2001-02	5901.73	1239.36	868.60	2419.62	10429.30	47567.24
2002-03	6221.73	1290.77	915.45	2462.66	10890.66	51913.66
2003-04	6597.66	1343.08	953.62	2508.40	11402.76	56498.08
2004-05	6756.68	1413.64	978.22	2517.58	11661.64	60381.73
2005-06	6875.14	1443.37	957.53	2432.45	11708.48	61975.22
2006-07	7579.83	1557.40	993.39	2569.01	12699.64	68257.28
2007-08	8830.37	1766.42	1094.00	2884.76	14575.54	79565.89
2008-09	8954.46	1797.56	1305.27	2890.78	15025.29	81067.50
2009-10	9417.07	1875.02	1340.79	2967.07	15599.96	101067.50
2010-11	9531.00	1871.84	1571.63	3086.90	16061.37	113404.40
2011-12	9790.24	1910.18	1655.50	3115.021	16470.94	129121.37
2012-13	10162.58	2061.61	1671.84	3147.90	17043.32	140425.24

Source: Statistical Yearbook of Bangladesh, BBS.