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Agricultural Output and Economic Growth Nexus: A VECM Approach on Bangladesh

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ABSTRACT
Agriculture is the engine of an economy. In Bangladesh, 50% of the entire labor force is employed in farming, and around 87% of rural families depend on agriculture for any part of their wages. Considering the importance of the agriculture sector in Bangladesh, the study examines the nexus between agricultural output and economic growth. In the finding of this causality, the VECM test was applied, and the long-run relationship between variables was found, where the rate of restoring the disequilibrium into equilibrium was 66.4%. The research applies the impulse response function and variance decomposition, where, in both cases, the result implies that the agricultural output is much more significant in economic growth than industrial output, meaning that to be a sustainable economy, the agriculture sector cannot be ignored. The study also provides insights to the policymakers that the agriculture sector should be given much more priority in terms of budget, and the academicians should do more research to develop sustainable agro-based products.

Keywords: Agriculture, Industrial Output, GDP, VECM, Impulse Response Function, Variance Decomposition

1. Introduction

Agriculture is the center area for the economy of Bangladesh since its independence and as yet contributing around 13% to GDP. Other than giving work to 40.62 percent of the workforce, this area gives convenience 62% labor of the country, and 84 percent of the inhabitants in Bangladesh living in country regions straightforwardly or by implication relies on agribusiness for their business. It is one of the major sources of business, work, and food security for most local individuals. On the other hand, industry is also a major parts of economic development (Lewis 1954). Raw materials for industries are coming from agricultural sector which is undeniable (Johnston & Mellor 1961). It likewise gives crude material to industry and adds to nation's prices. So any technique change for agricultural area will influence the economy and a huge segment of population in the nation (Alam 2008). In any case, because of the fast turn of industrialization, transformation of a country, the agriculture area has been continuously disregarded. All things considered, understanding the part of agriculture and its linkages to economic development is significant.

As stated by development economists, improved agricultural productivity is the key to an effective national strategy (Lewis 1954; Mellor 1976; Nurkse 1953; Rostow 1990). Lewis (1954) posits that industrialization is linked to agricultural growth and productivity. Johnston & Mellor (1961) and Mellor (1976) believes that agriculture is essential to industrial and domestic growth. This has to do with food production, purchasing power, labor, and the multiplier effect on the countryside. According to Adelman (1984), 'agricultural demand-led' industrialization is a viable alternative to other models of industrialization.

During recent years, Bangladesh's GDP has exhibited a substantial upward trajectory, yet the agricultural sector's growth has decelerated, marking a decline from an average growth rate of 9.21% to 3.92% per annum from 1990 to 2019. This shift indicates a gradual transition from an agrarian economy towards one where the industrial and service sectors play dominant roles. Despite this transition, the importance of agriculture in economic stability and poverty reduction remains undiminished, thanks to its contributions to food production and rural employment. The evolving dynamics of Bangladesh's economy, marked by significant growth in the service and industrial sectors, beckon a reassessment of agriculture's contribution to economic growth.

The primary aim of this research is to explore the relationship between agricultural output and economic growth in Bangladesh, focusing on understanding how economic growth responds to fluctuations in the agriculture sector. This understanding is crucial for identifying effective strategies to stimulate economic growth.

Specifically, the study aims to address the following objectives:

1. Evaluate the impact of agricultural output on economic growth in Bangladesh, recognizing its critical role in the nation's development.

2. Compare the influences of agricultural and industrial outputs to determine which has a more significant effect on the country's economic growth, considering the theories of 'agricultural demand-led' industrialization.

3. Examine the short-term and long-term dynamics of the variables involved, shedding light on their interplay and implications for policy formulation.

2. Literature Review

The literature indicates an intricate correlation between agricultural production and economic development, with certain studies highlighting a positive and co-integrated association, while others highlight subtleties and discrepancies in this correlation based on diverse contexts and methodology. Specifically, within the framework of Bangladesh, a developing nation, this part provides a meticulous examination of the agricultural sector in Bangladesh and its role in contributing to economic growth in a comparative scenario. The existing research gaps necessitate a fresh study to investigate the impact of agricultural output on the economic growth of Bangladesh.

Siddique & Selvanathan (2012) found that remittances have a substantial impact on economic growth in Bangladesh, highlighting their vital role in driving the economy. In their study, Nath & Mamun (2005) examined the correlation between exports and economic growth, emphasizing the significance of exports in driving economic progress in Bangladesh. Adhikary (2010) investigated the relationship between foreign direct investment (FDI), trade openness, capital formation, and economic growth rates. The study emphasized the significance of these elements in influencing the country's economic growth path. In addition, Shahbaz et al. (2014) examined the direct relationship between labour and economic growth, while Hossain & Wadood (2020) highlighted the significance of interest rate deregulation in promoting financial depth and economic growth in Bangladesh. FDI has been a central topic in studies on economic growth, with research conducted by Rajib & Rahman (2020) and Asaduzzaman (2019) emphasizing the beneficial effects of FDI on the economy of Bangladesh. In addition, Hossain et al. (2018) recognised human resource development and trade openness as crucial elements that have a favourable impact on economic growth in Bangladesh. The research conducted by Hossain & Wadood (2020) explored the capacity of tourism to stimulate economic growth and generate employment opportunities within the nation.

Agriculture plays a significant role in Bangladesh's GDP, accounting for around 18.70% during the fiscal year of 2012 to 2013 Hasan et al. (2017). Although agriculture is important, the Readymade Garment (RMG) business has emerged as a significant source of foreign currency in Bangladesh (Islam et al. 2018). Moreover, there exists a well-established mutual reliance between agriculture and other sectors in Bangladesh, wherein the industrial and construction sectors make a good contribution to agriculture (Hossain et al. 2012). The findings underscore the importance of agriculture in reducing poverty and its interconnectedness with other sectors of Bangladesh's economy.

The agriculture sector in Bangladesh is of paramount importance to the nation's economy and population. The study conducted by Rahman & Salim (2013) examined the changes in total factor productivity and the sources of growth in the agricultural sector of Bangladesh over a period of six decades. The research highlights the significant role of this sector in the overall development of the country. In addition, Ghimire et al. (2021) emphasize that Bangladesh's economy is highly reliant on agriculture, which makes a substantial contribution to both employment and the country's gross domestic product (Ghimire et al. 2021).

Agriculture continues to play a crucial role in ensuring food security and sustaining livelihoods in Bangladesh, as shown by Rezvi (2018) and Bishwajit et al. (2014). The agricultural sector remains a crucial component of the nation's economy, attracting significant focus and playing a pivotal role in supporting the population and guaranteeing food security, as highlighted by Das and Hossain (2020) and Rahman et al. (2022).

Various econometric methodologies have been used to evaluate the impact of agricultural output on economic growth in different nations. Kelikume & Nwani (2020) employed dynamic econometric tools to examine the connections between agricultural sector output and real GDP in Nigeria. Salim et al. (2019) conducted a study in Bangladesh to examine the interconnections between research and development (R&D) spending, climate change, human capital, and total factor productivity (TFP) growth in agriculture. In addition, Dey (2022) utilised many econometric tools, including the augmented

Dickey-Fuller test, Johansen cointegration test, and ordinary least squares (OLS) method, to evaluate the effects of significant crop output on the agricultural sector in Bangladesh.

In their econometric analysis, Hasanov et al. (2022) utilised Autometrics with super saturation to find the factors that contribute to agricultural growth in Azerbaijan. The study found that land, labour, and capital have a considerable positive effect on agricultural productivity in the long run. In addition, Wang et al. (2010) performed an econometric research using a model in China, indicating a favourable correlation between agricultural and economic expansion.

Ultimately, the interplay of remittances, exports, FDI, trade openness, human capital development, and interest rate policy are pivotal in driving economic growth in Bangladesh. Agriculture has a crucial role in the economic development of Bangladesh, as numerous studies have shown. However, most research in Bangladesh have not concentrated on using econometric analysis to analyse the agricultural sector in the country. Furthermore, the exploration of the roles played by the industrial and agricultural sectors in Bangladesh has not yet been undertaken in a comparable context. The primary objective of this study is to address the deficiencies in the current literature and provide policy recommendations for the agriculture sector in Bangladesh.

3. Theoretical Framework

The theoretical framework of this study on the nexus between agricultural output and economic growth in Bangladesh is anchored on several key economic theories and models. This framework seeks to integrate these theories to explore and understand the dynamics between agriculture productivity and economic development, providing a structured lens through which the research objectives can be examined.

3.1. Dual-sector model (Lewis 1954)

The dual-sector model, proposed by Arthur Lewis, suggests that the transition of labor from a traditional agricultural sector to a more productive industrial sector is essential for economic development. According to this model, surplus labor from the agricultural sector is absorbed by the industrial sector, leading to increased productivity and overall economic growth. This model underlines the significance of the agricultural sector as a foundational base for providing the initial labor force necessary for industrial growth.

3.2. The theory of agricultural demand-led industrialization (Adelman 1984)

Adelman's theory posits that the expansion of the agricultural sector can stimulate demand for industrial goods, thereby driving industrialization and economic growth. This approach suggests that improvements in agricultural productivity and income lead to increased consumption and demand for diverse products, including those produced by the industrial sector. The theory emphasizes the interdependence between the agricultural and industrial sectors and their joint role in advancing economic development.

3.3. The linkage approach (Johnston & Mellor 1961)

Johnston and Mellor highlighted the importance of linkages between agriculture and the rest of the economy. They identified both forward linkages (where agricultural outputs are used as inputs in other sectors) and backward linkages (where the growth of other sectors increases the demand for agricultural inputs). This approach suggests that the agricultural sector's growth can have a multiplier effect, stimulating economic activity across various sectors through supply and demand linkages.

4. Methodology

4.1. Test of stationarity

The time series, the statistical properties of a series of mean and time variance are known as its stationary characteristics. If both are constant, the range is considered to be stationary (i.e. there is no random walk/no unit root), otherwise the random walk/has unit root is characterized as non-stationary. Other observations are created when a set is differentiated by differentiating, such as first differentiated values, second differentiated values, and so on.

When a series is stationary at level, it is referred to be integrated at order 0 or I (0), and the first differenced stationary is referred to as integrated at order 1 or I (1). The Dickey-Fuller Generalized Least Square (DF-GLS) by Elliott et al. (1992) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root test by Kwiatkowski et al. (1992) is used in this study to assess the stationarity of data series.

Dickey-Fuller test modifies by Elliot, Rothenberg and Stock known as the DF-GLS test. This unit root test is stronger than the ADF test. The function of regression is:

$\Delta X_t^d = \alpha_0 X_{t-1}^d + \alpha_1 \Delta X_{t-1}^d + \ldots\ldots + \alpha_p \Delta X_{t-p}^d + \epsilon_t$

Where; ΔX_t^d represents the detrended series. While the DF-GLS only comprise the intercept, the value of t is the same as the ADF test and its critical value is the same as in the ADF test. When DF-GLS tests have trends as well as an intercept, they are different in their distribution and their critical value is in accordance with the ERS test.

4.2. The Johansen test for cointegration estimate

After determining the stationarity of these series, the study applies Johansen (1988) technique to test for cointegration between agriculture, industry, the service sector, and GDP growth. Cointegration means that a linear combination of two or more time series data can be stationary even if they are not stationary individually (Gujarati 2011). Cointegration occurs when a linear combination of non-stationary variables becomes stationary. However, a linear combination of integrated variables can also become stationary. In this scenario, the variables are considered to be cointegrated. The cointegration technique estimates the number of cointegration vectors by using two tests: maximal Eigen value statistics and trace statistics. The trace statistic assesses the null hypothesis of at most r cointegrating vectors, while the maximal Eigen value test analyzes the null hypothesis of exactly r cointegrating vectors.

4.3. Vector error correction model

When cointegration between series is observed, Vector Error Correction Model (VECM) (Sargan 1964) is used to determine the properties of the cointegrated series. We know that there is a long-term balance between the series when cointegration is observed. We use VECM to establish the short-term characteristics of the cointegrated series.

It is our main undertaking to assess the impact of agriculture on the overall economy. In this context, the model of long-run economic growth and agricultural output is defined as follows:

$GDP_t = \beta_0 + \beta_1 AGRIOUTPUT_t + \beta_2 INDOUTPUT_t + \beta_3 GCF_t + u_t$

Where; β's represents the estimated coefficient, t and u represent the time trend, stochastic error term respectively.
Here,

GDP = Gross Domestic Product Growth,
AGRIOUTPUT = Agricultural value added per worker,
INDOUTPUT = Industrial value added per worker
GCF = Gross capital formation.

Consequently, VECM was applied to explore the short run dynamics to investigate the impact of agricultural output on economic growth. The model to be applied is expressed below:

$\Delta GDP_t = \gamma_0 + \gamma_1 \Delta AGRIOUTPUT_t + \gamma_2 \Delta INDOUTPUT_t + \gamma_3 \Delta GCF_t + \gamma_4 u_{t-1} + \varepsilon_t$

Where; γ's represents the coefficient to be estimated, ε is the white noise error term. u_{t-1} is the lagged of error correction term and γ_4 are the coefficient of error correction which is expected to be negative.
If the ECM (u_{t-1}) coefficient is negative and significant, any short-term deviations between independent and dependent variables lead to a stable, long-term relationship between variables.

4.4. Granger causality test

The general specification of the bivariate (X, Y) sense Granger causation test is:

$Y_t = \alpha_0 + \alpha_1 Y_{t-i} + \ldots\ldots\ldots\ldots + \alpha_i Y_{t-i} + \beta_1 X_{t-i} + \ldots\ldots\ldots \beta_i X_{t-i} + \mu$

$X_t = \alpha_0 + \alpha_1 X_{t-i} + \ldots\ldots\ldots\ldots + \alpha_i X_{t-i} + \beta_1 Y_{t-i} + \ldots\ldots\ldots \beta_i Y_{t-i} + \mu$

The model's subscriptions are time intervals, and the error represents white noise. The overall co-integration movements between X and Y following the unit root process might be seen as pattern in these variables (Granger 1969). The first investigates the null hypothesis that X does not cause Y in the grangers, whereas the second investigates the null hypothesis that Y does not cause X. This research generates two tests. If we do not reject the latter but manage to dismiss it, we might infer that the changes in X are caused by the change in Y. If one of Equations' null assumptions is rejected, unidirectional causation between two variables will emerge. If both null assumptions are rejected, bidirectional causality exists; otherwise, there is no causality when no hypothesis is rejected of equations.

4.5. Data types and data collection methods

The study examines the nexus between agricultural output and economic growth in Bangladesh. Annual time series data on agricultural output, gross capital formation, industrial output, and economic growth proxy by GDP growth over the period from 1991 to 2019 was collected from secondary sources. The data obtained from World Bank-Bangladesh Development Indicators website include agricultural output, gross capital formation, industrial output and GDP growth.

5. Results and Discussion

This section of the study goes into great detail about the data, the relevance of the relationship between the variables, and the conclusion about the hypothesis that the researcher draws from the results. To investigate the connection, we first tested its stationarity using a unit root test, which revealed that it was significant at first order differences, and then we performed a cointegration test, which revealed that the underlying variables had a long run influence. Furthermore, we use VECM to determine the type of effect.

5.1. Test of stationary: unit root test

The study uses Dickey-Fuller GLS and KPSS test statistics to evaluate unit root of the data series. Table 1 shows that there is no unit root for the underlying data of GDP growth. Because the values of DF-GLS and KPSS are too little in relation to the tabular MacKinnon (1996) and Kwiatkowski (1992) value respectively. From the table we can find that the value for MacKinnon is too negative for DF-GLS and value for Kwiatkowski (1992) too less for KPSS estimates, for which -1.953858 and 0.463000 were drafted in MacKinnon and Kwiatkowski-Phillips-Schmidt-Shin, of DF-GLS and KPSS estimates -4.087676 and 0.145998 in the first difference. On the other hand, the level values are insignificant as the values are not negative enough and lesser. The values are measured at 5% level of significance. Therefore, in terms of DF-GLS, the null hypothesis for the unit root has been rejected, meaning the data is stationary in first difference.

In LOGAOUTPUT (agriculture value added per worker), the value of DF-GLS and KPSS test statistics can be shown to be enough negative and too lesser to exceed the formulated value of MacKinnon and Kwiatkowski-Phillips-Schmidt-Shin respectively. The DF-GLS and KPSS test results are -1.975657 and 0.258281 where MacKinnon and Kwiatkowski-Phillips-Schmidt-Shin tabular results are -1.953858 and 0.463000 respectively in first difference. Conversely, you can see the level values are not negative enough and too lesser to be significant. All the estimated values consider the level of significance at 5%, which means that the null hypothesis is rejected in case of DF-GLS alternatively failed to reject by KPSS and the information is stationary in first difference.

GCF (gross capital formation) thus demonstrates, as with previous results, that DF-GLS and KPSS test statistics exceed the tabulated values of MacKinnon and Kwiatkowski-Phillips-Schmidt-Shin. The DF-GLS and KPSS test results at first difference are -4.074283 and 0.195871 where MacKinnon's and Kwiatkowski-Phillips-Schmidt-Shin results are -1.954414 and 0.463000, which reveal GCF is stationary at first difference. The results stimulated in the rejection on the other hand failed to reject of the null hypothesis and stationary data, is also significant at 5 percent in first difference.

Finally, if we scrutiny at the outcomes of INDOUTPUT (industrial output added per worker), it also includes a similar result. When compared to the value formulated by the MacKinnon and Kwiatkowski-Phillips-Schmidt-Shin for INDOUTPUT, the result of the DG-GLS and KPSS test is significantly too negative and less. In first difference the t-statistic of DF-GLS and KPSS have a value of -2.358984 and 0.178071, while those of MacKinnon and Kwiatkowski-Phillips-Schmidt-Shin have a tabular value of -1.953858 and 0.463000. On the contrary, the level values are not significant according to the test specifications. This means the data is stationary at 5% level of significance as the null hypothesis is rejected and vis-à-vis in first difference.

Table 1 shows that for an all-time series, null hypothesis is rejected and vis-à-vis as the unit root values of GF-GLS and KPSS are smaller than critical values in first difference. Therefore, the variables are stationary and integrated in the same order, i.e. I(1) . Briefly, all the variables are stationary and have no unit root in the first difference.

Table 1- (A): DF-GLS

Variables	*Level*		*First difference*	
	t-statistics	*5% critical values*	*t-statistics*	*5% critical values*
GDP Growth	-1.190232	-1.953381	-4.087676*	-1.953858
LOGAOUTPUT	0.117191	-1.953858	-1.975657*	-1.953858
INDOUTPUT	1.996544	-1.953381	-2.358984*	-1.953858
GCF	-0.176767	-1.953858	-4.074283*	-1.954414

*: indicates 5% level of significance

Table 1- (B): Kwiatkowski-Phillips-Schmidt-Shin (KPSS)

Variables	*Level*		*First difference*	
	t-statistics	*5% critical values*	*t-statistics*	*5% critical values*
GDP Growth	0.657029*	0.463000	0.145998	0.463000
LOGAOUTPUT	0.665894*	0.463000	0.258281	0.463000
INDOUTPUT	0.637055*	0.463000	0.178071	0.463000
GCF	0.683958*	0.463000	0.195871	0.463000

*: indicates 5% level of significance

5.2. The Johansen test for cointegration estimate

In order to find a relation scenario for these variables, we use the Johansen cointegration test. The optimal lag length for the VEC mechanism was determined before we took the test. To determine the optimal lag, we took the considerable value of the AIC criterion and found that there were 2 optimal lengths of lag. Therefore, we evaluated Johansen's cointegration and the result is stated below:

Table 2- Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	***Eigenvalue***	***Trace Statistics***	***Critical Value at 5%***	***Prob.*****
None *	0.759393	67.19754	47.85613	0.0003
At most 1 *	0.610763	30.15824	29.79707	0.0454
At most 2	0.192414	5.625502	15.49471	0.7393
At most 3	0.002656	0.069161	3.841466	0.7925

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.

Table 3- Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	***Eigenvalue***	***Max-Eigen Statistic***	***0.05 Critical Value***	***Prob.*****
None *	0.759393	37.03931	27.58434	0.0023
At most 1 *	0.610763	24.53274	21.13162	0.0159
At most 2	0.192414	5.556341	14.26460	0.6706
At most 3	0.002656	0.069161	3.841466	0.7925

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

Tables 2 and 3 describe the findings of the Johansen bivariate co-integration tests. The empirical results show that trace test values and max-eigan value tests are statistically significant (P>0.05) and above the critical values for the models underlying the data. In this regard, maximum eigan value and trace statistics reject the null hypothesis of no-co-integration (r = 0). In other words, there is a long run relationship between gross domestic product growth and agricultural output per worker and so on.

5.3. Serial correlation test

A good model can sometimes have the serial correlation problem, which causes the model to dilemma in terms of reliability. In this model, however, the VEC mechanism residual series shows that the model is not auto correlated. Using Breusch-Godfrey Serial Correlation LM Test, where we failed to reject the null hypothesis of no serial correlation at 5% level of significance (see table 8 in appendix).

5.4. Heteroskedasticity tests

The heteroskedasticity test is a method to determine whether or not anything is heteroskedastic. The lack of heteroskedastic is a prerequisite of a stable model in the variable distribution system. The Breusch-Pagan-Godfrey test shows that there is no problem of heteroskedasticity in the residual series because the study has failed to reject the null hypothesis of no heteroskedasticity at 5% significant level, reported in table 9 (appendix).

5.4. CUSUM and CUSUM of squares test

The study uses CUSUM and CUSUM of Squares recursive estimates of residuals to check the stability of the model. We can infer that the model is well stabilized on the basis of the graphic view, as the model's value is all between the red marked lines in figure 3 and 4 (appendix).

5.5. Normality test of residuals

The research also checks the distribution properties of the regression residuals. As the results shows that the Jarque Bera probability value is 80 which indicates the residual series of the estimated model is normally distributed, reported in figure 5 (appendix).

5.6. Vector error correction model (VECM) estimates

Long-term relationship or equilibrium between agricultural output, industrial output, gross capital formation and GDP is established through cointegration analysis. While in the short run, the economy may be in disequilibrium. Sargan (1964) error correction strategy was later incorporated into Engle and Granger and thrives in disequilibrium. The correction term directs the figures (GDP, LOGAGRIOUTPUT, INDOUTPUT and GCF to equalize once again. The error correction term has to be negative and significant. This value of negative error correction term means the speed of restoring the disequilibrium into equilibrium.

Table 4- Vector Error Correction Results

Standard errors in ( ) & t-statistics in [ ]				
Cointegrating Eq:	*CointEq1*			
GDP_GROWTH(-1)	1.000000			
LOGAGRIOUTPUT(-1)	-2.779156			
	(0.48919)			
	[-5.68113]			
INDOUTPUT(-1)	-0.000376			
	(0.00043)			
	[-0.87648]			
GCF(-1)	0.115935			
	(0.09763)			
	[1.18753]			
C	10.36032			
Error Correction:	D (GDP_GROWTH)	D (LOGAGRIOUTPUT)	D (INDOUTPUT)	D (GCF)
CointEq1	-0.663738	0.019801	129.5281	-0.071815
	(0.40704)	(0.00871)	(85.1104)	(0.20808)
	[-1.63066]	[2.27432]	[1.52188]	[-0.34513]
D(GDP_GROWTH(-1))	0.132613	-0.001196	-4.259410	0.238852
	(0.21724)	(0.00465)	(45.4235)	(0.11105)
	[0.61046]	[-0.25735]	[-0.09377]	[2.15080]
D(LOGAGRIOUTPUT(-1))	9.961722	0.323189	-870.7098	-8.095628
	(7.42976)	(0.15892)	(1553.55)	(3.79817)
	[1.34079]	[2.03368]	[-0.56047]	[-2.13146]
D(INDOUTPUT(-1))	-0.000807	-0.000127	0.167684	-0.000611
	(0.00135)	(2.9E-05)	(0.28220)	(0.00069)
	[-0.59798]	[-4.40815]	[0.59420]	[-0.88528]
D(GCF(-1))	0.240625	-0.010321	48.24023	0.250791
	(0.33406)	(0.00715)	(69.8505)	(0.17077)
	[0.72031]	[-1.44440]	[0.69062]	[1.46856]
C	-0.297915	0.041807	93.07227	0.681615
	(0.46190)	(0.00988)	(96.5819)	(0.23613)
	[-0.64498]	[4.23154]	[0.96366]	[2.88665]

The results of VECM demonstrates that the error correction coefficient is negative which is not significant at 5%. However, this implies that the system corrects previous term deviation of disequilibrium at the speed of 66.4% between the variables of GDP Growth, AGRIOUTPUT, INDOUTPUT and GCF.

5.7. Testing the transmission of shocks:

Table 5- Impulse Response Function

Period	*GDP_GROWTH*	*LOGAGRIOUTPUT*	*INDOUTPUT*	*GCF*
1	0.636940	0.000000	0.000000	0.000000
2	0.347145	0.178194	-0.064065	0.047750
3	0.080491	0.205796	-0.163667	-0.026414
4	-0.080598	0.190073	-0.111042	-0.077518
5	-0.087564	0.154221	-0.081318	-0.104570
6	-0.025396	0.137050	-0.055321	-0.100573
7	0.033172	0.138550	-0.058256	-0.087768
8	0.054747	0.149978	-0.069689	-0.078172
9	0.046382	0.160211	-0.081019	-0.076520
10	0.028463	0.164939	-0.085729	-0.079777

Cholesky Ordering: GDP_GROWTH LOGAGRIOUTPUT INDOUTPUT GCF

To investigate the shock transmission of the variables the data of 29 years is converted into a period of ten years. The impulse response function is estimated between the variables to see the response of transmission of shocks. Where it shows that GDP responds positively only to shocks in LOGAGRIOUTPUT but negatively to INDOUTPUT and GCF. We notice from the table that shocks from the agricultural output per worker is higher than the others variables shocks which are negative. This is also shown in the graph below. That means the agricultural output has positive impact and higher influence on GDP growth of Bangladesh. Similarly, Figure 1 depicts that shocks in LOGAGRIOUTPUT positively influences GDP. However, shocks in INDOUTPUT and GCF negatively respond to GDP.

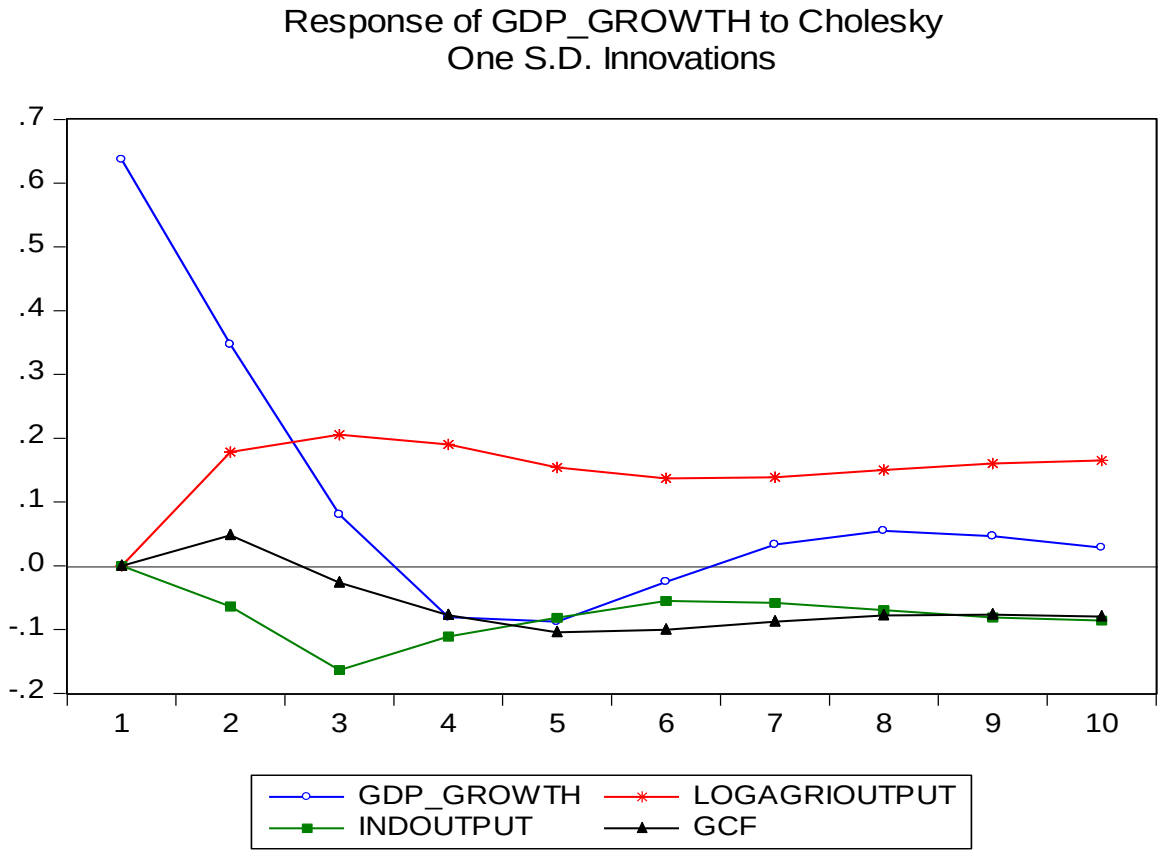

Figure 1- Response of GDP_GROWTH to Cholesky One S.D. Innovations

Table 6- Variance Decomposition

Period	*S.E.*	*GDP_GROWTH*	*LOGAGRIOUTPUT*	*INDOUTPUT*	*GCF*
1	0.636940	100.0000	0.000000	0.000000	0.000000
2	0.751226	93.24211	5.626592	0.727280	0.404014
3	0.800410	83.14631	11.56706	4.821837	0.464793
4	0.837627	76.84763	15.71122	6.160291	1.280861
5	0.866382	72.85264	17.85421	6.639104	2.654042
6	0.884998	69.90235	19.50914	6.753488	3.835022
7	0.902560	67.34355	21.11376	6.909837	4.632855
8	0.922536	64.81088	22.85223	7.184477	5.152416
9	0.944093	62.12635	24.70031	7.596584	5.576749
10	0.965940	59.43467	26.51137	8.044524	6.009441

Cholesky Ordering: GDP_GROWTH LOGAGRIOUTPUT INDOUTPUT GCF

To explore the transmission of shocks received by GDP Growth to its essential sources, we further apply the variance decomposition test. The result is demonstrated through table and graphical view. The major influence to variation in GDP is caused by its feedback to shocks. For the first two years, agricultural output accounts for 2% of GDP, but for the next ten years, it's about 27% of GDP. Though the analysis of impulse response demonstrate that industry output and capital have negative impact on economy, this analysis demonstrates the opposite results. As a whole, industrial output is contributed to shocks in GDP Growth for the first three years is almost 5 percent and remained at 8 percent at the ten years period.

Capital contribution to shocks in GDP is about 1 percent for the first four years and 6 percent for the ten years period. This is also shown in Figure 2. Thus, apart from feedback and industrial output shocks, GDP is most influenced by agricultural output (AGRIOUTPUT).

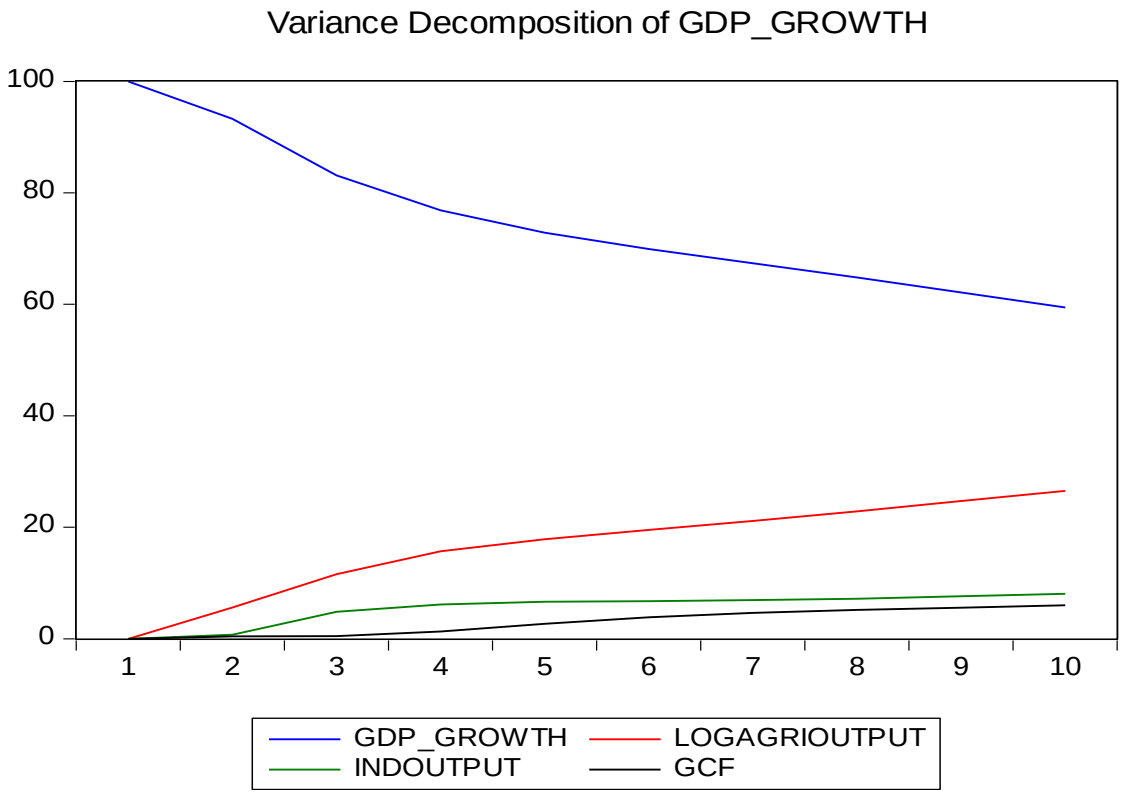

Figure 2- Variance Decomposition of GDP_GROWTH

5.8. Granger causality test

Since we cannot determine the causal direction of the variable through the cointegration test, we use the granger causality mechanism. In this case we use pairwise granger causality test in the model equation to know the causal direction among variables. The causality in pairs shows the variable unidirectional, bidirectional or no directional cause at all.

Table 7 shows the results of estimates of granger causality for the same variables. F-Statistics and the probability of causality between variables were used in this research. Under the non-causality hypothesis, statistics from F-Statistics and probable values determined under the null non-causality hypothesis demonstrate the causal relationship of certain variables. The results of pairwise analysis are shown in Table 7. The null hypothesis is rejected when the probability is less than 5%; otherwise, the null hypothesis is not rejected when the probability value is greater than 5%. The study concludes that the causal relationship between LOGAGRIOUTPUT and GDP Growth is one-way. Where the causality runs from LOGAGRIOUTPUT to GDP Growth. Consequently, the other variables also enclose unidirectional causal relationship except the INDOUTPUT and GDP growth has bidirectional causality but in the case of the INDOUTPUT and GCF there exists no causality. Therefore, we can suppose that the model has a variety of causal relationships, and therefore the causal results are consistent over the long term.

Table 7- Pairwise Granger Causality Test

Null Hypothesis:	*Obs.*	*F-Statistic*	*Prob.*	*Decision*
LOGAGRIOUTPUT does not Granger Cause GDP_GROWTH	27	6.13118	0.0076	Reject
GDP_GROWTH does not Granger Cause LOGAGRIOUTPUT		1.56520	0.2314	Do not Reject
INDOUTPUT does not Granger Cause GDP_GROWTH	27	3.96691	0.0338	Reject
GDP_GROWTH does not Granger Cause INDOUTPUT		3.93326	0.0346	Reject
GCF does not Granger Cause GDP_GROWTH	27	5.07265	0.0154	Reject
GDP_GROWTH does not Granger Cause GCF		1.41384	0.2645	Do not Reject
INDOUTPUT does not Granger Cause LOGAGRIOUTPU	27	7.05561	0.0043	Reject
LOGAGRIOUTPUT does not Granger Cause INDOUTPUT		1.38943	0.2702	Do not Reject
GCF does not Granger Cause LOGAGRIOUTPUT	27	3.49441	0.0481	Reject
LOGAGRIOUTPUT does not Granger Cause GCF		1.91444	0.1712	Do not Reject
GCF does not Granger Cause INDOUTPUT	27	2.63447	0.0943	Do not Reject
INDOUTPUT does not Granger Cause GCF		1.66185	0.2127	Do not Reject

6. Discussion

The utilization of VECM in this study offers a sophisticated analytical lens for understanding the dynamic interaction between agricultural output and economic growth over the long and short term. This approach is particularly relevant given the complexities inherent in Bangladesh's economy, which is characterized by a transitioning agrarian base towards more industrial and service-oriented sectors. Previous studies such as Siddique and Selvanathan (2012) and Nath and Mamun (2005), while insightful, primarily focused on specific economic factors like remittances and exports using simpler econometric models. This study's comprehensive methodological framework allows for a more detailed examination of the multifaceted relationship between agriculture and economic growth, considering both immediate and gradual effects.

The findings reveal a significant long-run relationship between agricultural output and economic growth, with agriculture exerting a more pronounced influence on economic prosperity than industrial output. This underscores the pivotal role of agriculture in sustaining economic development, a theme that resonates with the theory of "agricultural demand-led" industrialization posited by Adelman (1984). In contrast, earlier research such as that by Hossain et al. (2018) and Hossain & Wadood (2020) primarily highlighted the contributions of sectors like finance and tourism to economic growth, with less emphasis on agriculture. This study thus reinstates the agricultural sector's foundational significance in Bangladesh's economic prosperity, advocating for policies that synergize agricultural productivity with overall economic development strategies.

The emphasis on agriculture's primordial role in economic prosperity derived from this study suggests a strategic pivot towards agricultural investment and modernization, aligning with insights from Rahman and Salim (2013) and Ghimire et al. (2021), who also underscored agriculture's critical contribution to GDP and employment. However, the specific recommendation for a balanced funding approach towards both agriculture and industry presents a nuanced policy perspective not extensively covered in earlier works. This suggests an integrated development model where agriculture remains a central focus, even as industrial and service sectors are nurtured for a holistic economic advancement.

This study contributes uniquely to the literature by:

a) Employing a VECM Approach: Offering a refined understanding of the temporal dynamics between agricultural output and economic growth.
b) Emphasizing Agriculture's Central Role: Reinforcing the importance of agriculture for sustainable economic development in the context of Bangladesh's transitioning economy.
c) Advocating Balanced Development Strategies: Proposing nuanced policy recommendations that advocate for simultaneous investments in agriculture and industry to foster sustainable development,

7. Conclusions

The study contributes to find a long-run link between agricultural production, capital, industrial output, and GDP. At a speed of 66.4 percent, the short run disequilibrium will be reached at a settled point. Aside from feedback almost equal industrial output and capital shocks, agriculture sector shocks have a noticeable impact on economic growth. This implies that the agriculture sector is primordial to economic prosper of Bangladesh. Notably, through industrial output has moderate impact on economic growth, the agricultural output has much more robust influence on economic development. The findings give insights to policy guidelines. Economically, as the agriculture in Bangladesh has a significant role in the economy, it requires to do enough investment from private and public sector to boost agriculture. And the government should bring new technologies to make agriculture more efficient and productive, which will ensure food security for all. In addition, policymakers take a balanced approach to flow funds for both agriculture and industrial sectors. This balanced strategy will pave the way for achieving sustainable development, maintaining food security by minimizing inflationary pressure, which will bring social stability. It is also recommended that the government and other pertinent authorities take a more active role in bringing the agricultural sector to the forefront of planning related to economic policy, acknowledging its vital role in driving economic growth and serving as a pillar of sustainable development in Bangladesh. On the other hand, the study has some limitations, despite doing extensive research on this field. The conclusion is drawn only using a certain period's data. Secondly, the study only focuses on Bangladesh economy, but the panel data could provide better result and understanding in the context. Thirdly, the study did not consider the ecological and environmental issues. Future studies can consider all issues to overcome the shortcomings, including the ecological footprint.

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APPENDIX

Table 1- Serial correlation test, H_0*: No serial correlation,* H_1*: Serial correlation*

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.109455	Prob. F(2,19)	0.8969
Obs*R-squared	0.307540	Prob. Chi-Square	0.8575

Table 2- Heteroskedasticity test, H_0: No heteroscedasticity, H_1: Heteroskedastic

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.326100	Prob. F(8,18)	0.2926
Obs*R-squared	10.01222	Prob. Chi-Square(8)	0.2642
Scaled explained SS	5.079983	Prob. Chi-Square(8)	0.7490

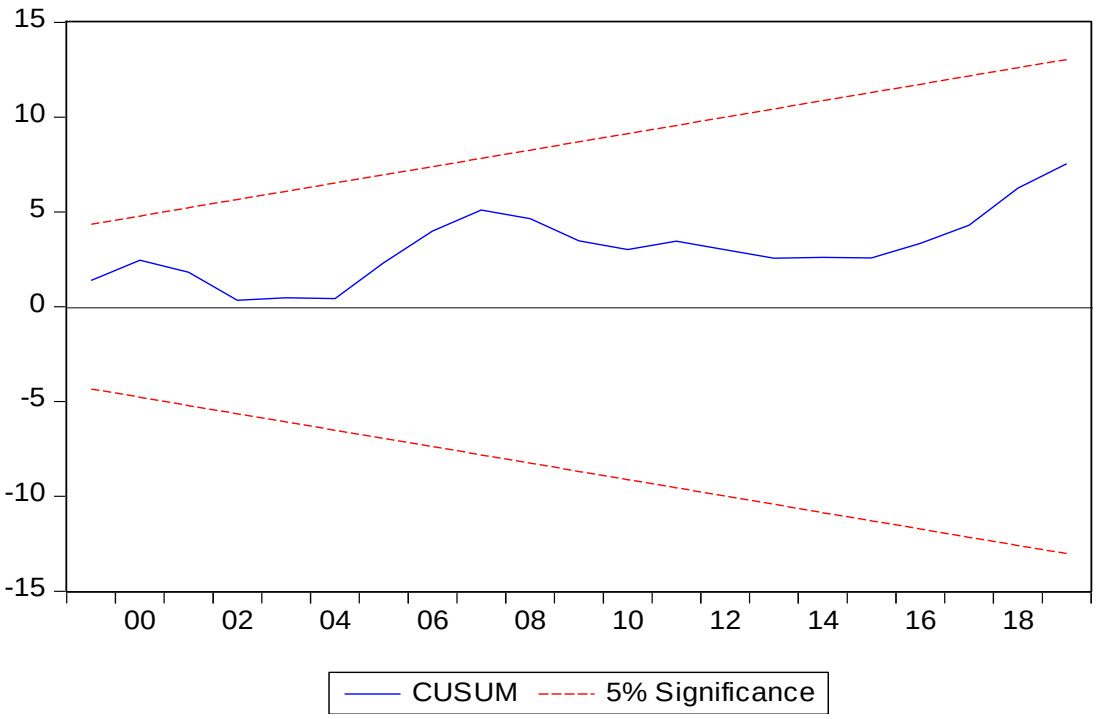

Figure 3 - CUSUM test

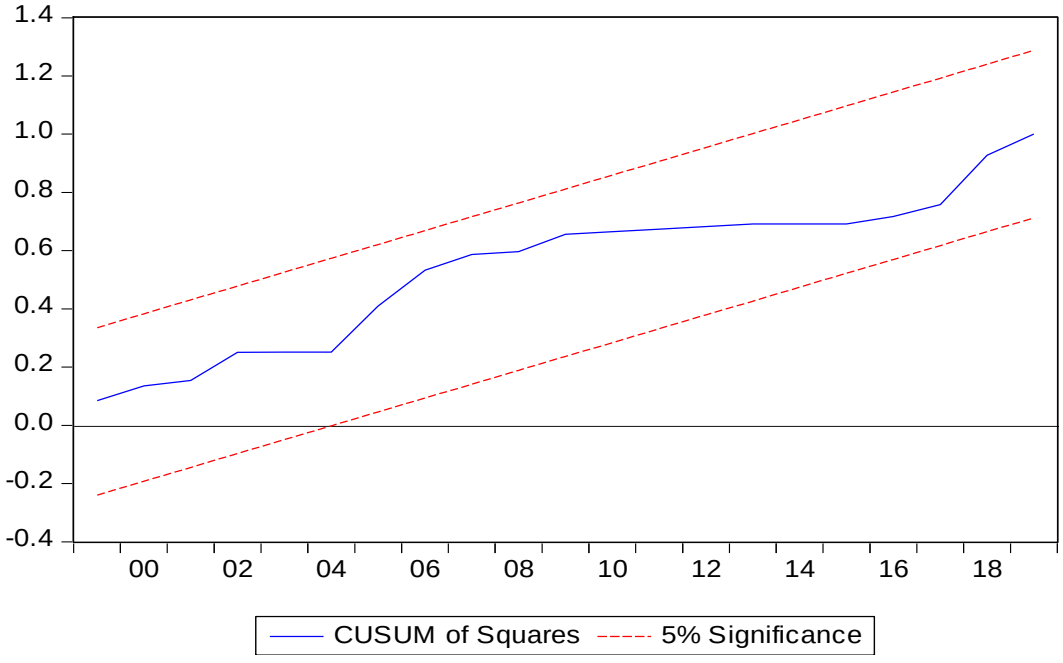

Figure 4- CUSUM of Squares test

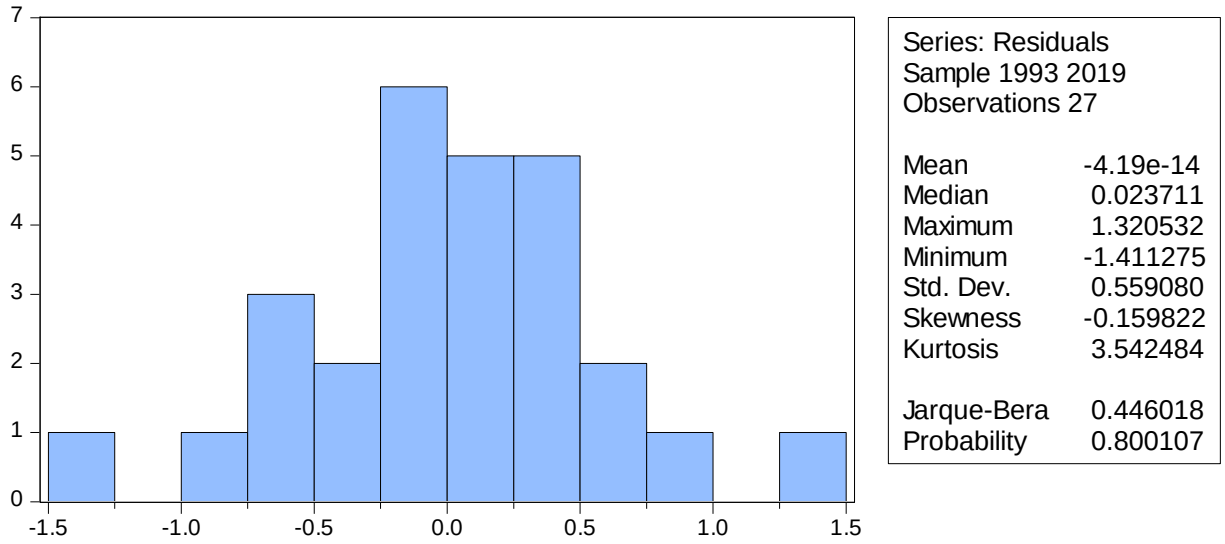

Figure 5- Normality test of residuals