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Full Length Research Paper

Co-integration analysis on all-variety Boro rice yields

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The Boro rice is one of the most important rice in Bangladesh. It has three varieties namely: high yielding, local and Pajam. The all-variety Boro rice yield of Rajshahi and Rangpur districts have been selected for the period from 1985 to 2007 to measure the relationship between them. Our study shows a cointegrating relationship exist between the yields. The speed of adjustment coefficient of the error correction model (ECM) for Rajshahi is 0.311. This indicates that there is about 31.1% of any deviation from the long-run path is corrected within a year by the yield of Rangpur. This ECM is adequate from the statistical view point.

Key words: Boro rice, long-run relation, co-integration, error correction, speed of adjustment.

INTRODUCTION

Rice is the principal crop and it dominates the cropping pattern of Bangladesh. Based on the seasons and climatic conditions there are three types of rice namely: Aush, Aman and Boro which are grown in the country. Each of the types has two varieties. These varieties are called transplanted variety and broadcast variety. Normally the harvest period for Aman is from December to January, Boro is from March to May and Aush is from July to August. Transplanted Aman (T. Aman) covers about 46.30% of the paddy area, followed by Boro (26.85%), Aush (17.59%) and broadcast Aman (B. Aman) (9.26%) (BBS, 2008). Boro is grown in every district of the country. With the spread of small-scale irrigation technology, Boro rice has gained its importance because yields of Boro rice are higher than yields of any other types of rice. This crop now accounts for a disproportionately large share of rice production. High yielding variety, local variety and Pajam are the three Boro rice varieties grown in Bangladesh. Water, soil fertility, weeds, pests, diseases and post-harvest processing are the steps of an integrated crop management approach. This is vital to maximize the productivity and profitability of rice farmers (Balasubramanian et al., 2000). Besides this other factors like biophysical, socio-economic, management, institutional and policy factors can influence the yield of any crop. These factors have positive role in the productivity of high yielding Boro rice of Bangladesh. Even if we consider a homogeneous domain there may be high variability in rice yields. So it seems to be a target for most of the researchers or experimenters to find out or judge the effect of fertilizer, irrigation, pest management, etc. on Boro rice of Bangladesh. Although they have established these impacts on the production though traditional regression technique, they have not considered technological break-through or development.

Besides these factors technology transfer and bridging of knowledge gap between researchers and farmers may also have a positive significant role in rice cultivation. Productivity may be increased through viable mechanisms to transfer new knowledge and techniques from researchers to farmers. Farmers need adequate training and technical support to improve their production capacity so that they can improve their skill with the new techniques. The training procedure, technology capturing techniques, farmers experience and new approaches in agricultural techniques can be helpful for increasing the regional productivity of rice in Bangladesh. However, all of these are not equally acceptable to all regions in

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Bangladesh. The high productivity of rice in a particular region may also attract other regions to follow the pattern of cultivation and technology as practiced in the high productive regions. Karmokar and Shitan (2011) studied panel co-integration test on the HYV Boro rice production to investigate the relationship amongst six selected districts of Bangladesh using a data set for the period of 1980 to 2000. They discovered a panel co-integration between the production of Rajshahi and the production of Rangpur within the error correction model (ECM) framework. They also found that the speed of adjusted coefficient for Rajshahi justifies that approximately 20% of any deviation from the long-run path is adjusted within a year. Therefore, the aim of our study is to investigate the interrelationship of yield of all-variety Boro rice between Rajshahi and Rangpur districts of Bangladesh by Co-integration technique.

MATERIALS AND METHODS

Description of data and variables, Dickey-Fuller (DF) and augmented Dickey-Fuller (ADF) unit root test and ECM are discussed here.

Description of data and variables

The yield of 'high yielding variety', local variety and Pajam variety are aggregated together and in this paper we shall refer it to as 'all-variety Boro' yield. The secondary data on the annual yield of all-variety Boro rice (mt/hect) of Rajshahi and Rangpur for the year from 1985 to 2007 have been selected in this study. The data were collected by the Bangladesh Bureau of Statistics, Government of Bangladesh (BBS, 1985-2008). We denote the variables y_{1t} and y_{2t} for the districts Rajshahi and Rangpur respectively.

Unit root tests

A time series $\{x_t\}_{t=1}^{T}$ is defined to be completely stationary if its joint distribution is time-invariant. That is, a stationary series is generally characterized by a time-invariant mean, variance and co-variances. However, most of the econometric time series are found to be non-stationary. This non-stationarity of the variable can be tested by some standard tests for example KPSS, Perron, Sargan-Bhargava, DF and ADF. Among them DF and ADF tests have been developed by Dickey and Fuller (1979, 1981) are well known and widely used. The DF and ADF unit root tests have been used for this study. With reference to the two time series variables namely: yield of Rajshahi and the yield of Rangpur districts if the variables are found to be stationary then the standard regression method can be applied to estimate the relationship between them. If however, the variables are found to be integrated of order 1, denoted I(1), that is, the variables are non-stationary in levels then we apply the Engle-Granger (1987) co-integration method to test the relationship between these variables.

The Engle Granger (EG) method of co-integration

The concept of co-integration among non-stationary variables was introduced by Granger in 1981. If the variables y_t and x_t are integrated of order 1 (I(1)) then they are said to be co-integrated if there exists β such that $y_t - \beta x_t$ is integrated of order 0 (I(0)). This is denoted by saying that y_t and x_t are CI(1, 1). More generally, if y_t is I(d) and x_t is I(d), then y_t and x_t are CI(d, b) if $y_t - \beta x_t$ is I(d–b) with b>0. Engle and Granger (1987) developed four steps procedure to determine the relationship between two or more non-stationary variables known as co-integration analysis. The first step of the EG procedure is to pretest the study variables for their order of integration. This can be achieved by DF and ADF unit root tests (Enders, 2004). This test can perform easily by some standard econometrics packages like, RATS, MICROFIT, E-Views and SHAZAM. The second step is to estimate the long-run equilibrium relationship between the I(1) variables as:

$$y_{1t} = \alpha_{11} + \alpha_{12} y_{2t} + \varepsilon_{1t}\,, \qquad (1)$$

$$y_{2t} = \alpha_{21} + \alpha_{22} y_{1t} + \varepsilon_{2t}\,, \qquad (2)$$

Where, y_{1t} is the yield of Rajshahi district at time *t*, y_{2t} is the yield of Rangpur district at time *t*, α_{11} α_{12}, α_{21} and α_{22} are the parameters, and ε_{1t} ε_{2t} are the long-run equilibrium errors. Therefore, to test the co-integrated relationship between the variables, the estimated residuals ($\hat{\varepsilon}_{it}$) must be tested for unit root. This test can be done by DF unit root test. Therefore, if the series, ($\hat{\varepsilon}_{it}$) is found to be stationary, then the test concludes that there exist a co-integrating relation between the study variables. When once, the variables are found to be co-integrated then the third step of EG procedure should be followed. In this step we are to estimate the ECM. The ECM of the study variables are as follows:

$$\Delta y_{1t} = \beta_{10} + \alpha_1 \hat{\varepsilon}_{1,t-1} + \sum_{i=1}^{p} \alpha_{11}(i) \Delta y_{1t-i} + \sum_{i=1}^{p} \alpha_{12}(i) \Delta y_{2t-i} + \eta_{1t} \qquad (3)$$

$$\Delta y_{2t} = \beta_{20} + \alpha_2 \hat{\varepsilon}_{1,t-1} + \sum_{i=1}^{p} \alpha_{21}(i) \Delta y_{1t-i} + \sum_{i=1}^{p} \alpha_{22}(i) \Delta y_{2t-i} + \eta_{2t} \qquad (4)$$

Where, β_{10}, α_1, $\alpha_{11}(i)$, $\alpha_{12}(i)$ are the parameters and η_{1t} is the random disturbance term of the ECM for y_{1t}. Similarly, β_{20}, α_2, $\alpha_{21}(i)$, $\alpha_{22}(i)$ are the parameters and η_{2t} is the random disturbance term of the ECM for y_{2t}.

The aforementioned ECM models can be represented in matrix form. In that case it is known as vector error correction (VEC) model. The ECM or the VEC model can be estimated by the ordinary least square (OLS) method. The appropriate number of lags, *p* to be included in the ECM equations can be determined by the likelihood-ratio (LR) test, the AIC criterion or by the rule of thumb. In the rule of thumb we use value $p = 0.75T^{1/3}$, where T is the sample size under study. The fourth step of the EG

Table 1. The τ_μ - statistic with the critical value for DF test.

Variable	τ_μ-test value	Critical value of the test
y_{1t}	–1.936	–2.57
y_{2t}	–2.410	–2.57

Table 2. Repeated DF test for order of integration of the variables.

Variable	τ_μ - test values		Critical value of test
	Δy	$\Delta^2 y$	
y_{1t}	–4.792	–2.391	–2.57
y_{2t}	–4.315	–5.943	–2.57

$\Delta Y = Y_t - Y_{t-1}$, where Y is the variable of interest.

procedure is to test the adequacy of the model. This can be tested by the Ljung-Box Q-statistic (Ljung-Box, 1978) based on the residuals of Models 3 and 4. The speed of adjustment coefficients of Models 3 and 4 can be estimated and tested for statistical significance. To the stability of any system, it is required that these estimates to be less than 1 in absolute value.

RESULTS AND DISCUSSION

The DF unit-root test was applied to each of the series in levels for their stationarity test. The test values and 10% critical values are reported in Table 1. The DF test indicates that all of the observed values falls in the acceptance region. Therefore the null hypothesis of non-stationarity for each of the variables is accepted. Hence we may conclude that the variables y_{1t} and y_{2t} are non-stationary in level. The test values for the order of integration are reported in Table 2. The long-run relationship between y_{1t} and y_{2t} given in Equations 1 and 2 are estimated by the OLS method using SHAZAM version 10 package as follows:

$$\hat{y}_{1t} = -0.303 + 2.430\, y_{2t} \qquad (5)$$

(*t*-ratio) (-0.448) (4.907)
(*p*-value) (0.659) (0.000)

$$\hat{y}_{2t} = 0.700 + 0.220\, y_{1t} \qquad (6)$$

(*t*-ratio) (5.146) (4.904)
(*p*-value) (0.000) (0.000)

The essence of the EG co-integration test is to determine whether the residuals from Equations 5 and 6 are stationary. There is, however, no theoretical consideration that, which one of the two residuals is preferable to the other in performing the test. We have used the DF unit root test on the residuals obtained from Equations 5 and 6 to perform the co-integration test. In order to do so we have estimated the following DF regressions:

$$\begin{aligned} \Delta\hat{\varepsilon}_{1t} &= -0.635\hat{\varepsilon}_{1,t-1} \\ \tau - statistic &\quad (-3.440) \end{aligned} \qquad (7)$$

$$\begin{aligned} \Delta\hat{\varepsilon}_{2t} &= -0.844\hat{\varepsilon}_{2,t-1} \\ \tau - statistic &\quad (-4.173) \end{aligned} \qquad (8)$$

Comparing the $\tau-$statistics obtained from Equations 7 and 8 with the EG 5% critical value of -3.350 (Enders, 2004), the test concludes that both the residuals series are stationary and hence the two series are co-integrated. Therefore, the Granger representation theorem indicates that there exists error correction model between these variables. The third step of EG procedure is to estimate the short-run dynamics and the error correction model. Since the variables are co-integrated, we proceed to estimate the error correction models

Table 3. Error correction for Rangpur.

Right hand- side variable	Estimated coefficient	Standard error	t-ratio 16 df	p-value
$\lvert\hat{e}_{1t-1}\rvert$	0.138	0.118	1.165	0.262
Δy_{1t-1}	-0.109	0.150	-0.727	0.479
Δy_{1t-2}	-0.275	0.145	-1.893	0.078
Δy_{2t-1}	-0.126	0.266	-0.472	0.644
Δy_{2t-2}	-0.004	0.267	-0.016	0.988
Constant	0.032	0.028	1.140	0.272

Table 4. Error correction for Rajshahi.

Right hand- side variable	Estimated coefficient	Standard error	t-ratio 16 df	p-value
$\lvert\hat{e}_{1t-1}\rvert$	0.311	0.143	-2.174	0.046
Δy_{1t-1}	0.050	0.182	0.275	0.787
Δy_{1t-2}	-0.342	0.176	-1.939	0.071
Δy_{2t-1}	0.135	0.323	0.416	0.683
Δy_{2t-2}	1.362	0.322	4.224	0.001
Constant	0.058	0.034	1.373	0.100

Equations 3 and 4. According to the rule of thumb we used $p=2$ lags in estimating the ECMs. The ECMs are estimated by the OLS. The results of the estimated coefficients with their *t* and *p*-values are reported in Tables 3 and 4 respectively. In Table 3, the value of the speed of adjustment coefficient for Rangpur is 0.138. This value is statistically not significant at 5% level of significance and all other coefficients of this ECM model are also insignificant. The absolute value of the speed of adjustment coefficient from Equation 3 of $\hat{\varepsilon}_{1,t-1}$ is 0.311 which is significant at 5% level. Since this value is found to be less than 1 which indicates that the system is stable. This value of the speed of adjustment indicates that approximately 31.1% of any deviation from the long–run path is corrected within a year. The coefficient term, β_{10}, $a_{11}(2)$ are significant within 10% level whereas $a_{12}(2)$ is significant at 1% level; but the other two terms $a_{11}(1)$ and $a_{12}(1)$ are insignificant.

The DW tests for both the Models 3 and 4 indicate no significant positive or negative serial correlation in the residuals. Moreover, the Ljung-Box Q-statistics are statistically insignificant at the conventional level. The R^2 and $\overline{R}^2$ of the ECM of Equation 3 are 0.669 and 0.559 respectively, indicating that about 66.9% (by R^2) and 55.9% (by $\overline{R}^2$) of total variation is explained by the independent variables.

Conclusions

The yield of rice is based on some well-established variables like irrigation, fertilizer, soil moisture, temperature, rainfall, weed and pest management, etc. Besides these variables some other hidden causes or variables like knowledge gap or some technology transfer may also affect the yield of rice. When these factors (knowledge gap or some technology transfer) contribute to a higher yield of any region, then the other regions may also tend to emulate the steps taken by the more productive region. In this paper, we have considered the yield of all-variety Boro rice of two particular districts, Rajshahi and Rangpur of Bangladesh to test such interrelationship for the period from 1985 to 2007. ADF test confirms that both the variables are unit root non-stationary processes in level but stationary in first difference. We then applied the EG four steps procedure in order to determine whether or not there is any long-run relationship between the variables. The results from the co-integration tests support the existence of long-run equilibrium between the yields of all-variety Boro yields of Rajshahi and Rangpur. The speed of adjustment coefficient of the ECM indicates that approximately 31.1% of any deviation from the long–run path is corrected within a year by the yield of Rangpur. The DW test indicates that the data are not affected with the autocorrelation problem. Moreover, the Ljung-Box Q-statistics shows the adequacy of the ECM.

The R^2 value of the ECM for Rajshahi explains about 66.9% of total variation by independent variable but the adjusted R^2 value of the ECM explains about 55.9% of the total variations.

REFERENCES

Balasubramanian V, Bell M, Sombilla M (2000). Yield, profit, and knowledge gaps in rice farming: causes and development of mitigration measures. In Bridging the rice yield gap in the Asia-Pacific region. Papademetriou MK, Dent MK, Herath EM (Eds.) Food and Agriculture Organization (FAO) of United Nations (UN), Regional office, Bangkok, Thailand. RAP publication, 16:163-177.

Bangladesh Bureau of Statistics (BBS). Yearbook of Agriculture Statistics of Bangladesh from the years 1985 to 2008. Bangladesh Bureau of Statistics, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Dickey DA, Fuller WA (1979). Distribution of the Estimates for Autoregressive Time Series with a Unit Root. J. Am. Statist. Assoc., 74: 427-431.

Dickey DA, Fuller WA (1981). Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. Econometrica, 49:1057-1072.

Enders W (2004). Applied Econometric Time Series. Second Edition, John Wiley & Sons.

Engle RF, Granger CWJ (1987). CoIntegration and Error Correction: Representation, Estimation, and Testing. Econometrica, 55(2): 251-276.

Granger CWJ (1981). Some Properties of Time Series Data and Their Use in Econometric Model Specification. J. Econometrics, 16: 121-130.

Karmokar PK, Shitan M (2011). Panel Cointegration Analysis and Generalized Causality Test of HYV Boro Production of Six Different Districts of Bangladesh. Pak. J. Statist., 27(3): 299-305.

Ljung G, Box G (1978). On a Measure of Lack of Fit in Time Series Models. Econometrica, 65: 297-303.