Journal of Economics and Sustainable Development
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.5, No.5, 2014

Farm Size and Output in Bangladesh Agriculture: Evidence from Cointegration, Vector Error Correction, Granger Causality and Investigating Returns to Scale

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Abstract

The foremost objective of the paper is to analyze the cointegration, vector error correction mechanism, vibrant causal relationship between farm size and output and investigating returns to scale in Bangladesh agriculture. Applying all requisite time series econometric techniques and covering the period from 1979 to 2013 establishes a stable long run relationship among the considered variables. The paper performs Augmented Dicky Fuller (ADF) and Phillips-Perron (PP) tests to verify the whether the time series are stationary and the long run stable relationship by Johansen and Juselius cointegration test. The paper examines short-term dynamic relationship among the considered variables using a vector error-correction model and Granger causality test is also occupied to find out causal relationship between farm size and output. The paper found short run and long run dynamic stable relationship, unidirectional pair wise Granger causal relationship and decreasing returns to scale among considered variables.

Keywords: Farm Size, Output, Integration, Cointegration, Vector Error Correction Model, Granger Causality and Returns to Scale.

1. Introduction

Agricultural output is low in most of the developing countries including Bangladesh. Moreover, dawdling and in the order of agricultural growth is unable to keep pace with the fast and persistently growing population demands in these countries. That in turn has continued to result in malnutrition and recurrent famines (Cornia, 1985).

Relationship between farm size and output in developing countries is one of the most important issues in the academic arena for analyzing the agrarian structure. The debate on farm size and output relationship was intensified when Sen (1962, 1966) observed an inverse relationship between farm size and output per hectare in Indian agriculture i.e., small farms are more productive compared to large ones.

An inverse relationship between farm size and output in the agricultural sector, as observed in many developing countries' economic studies, for instance Barret (1996), Benjamin and Brandt (2002), and Berry and Cline (1979).This hypothesis has important policy implications; it implies that economic efficiency and equity can be achieved simultaneously. In addition, if an inverse relationship is identified, one should be careful to note automatically interpret this as a mere reflection of small-scale farmers' higher efficiency. On the side of the larger farmers, it may be that they have enough alternatives to earn their livelihoods, which decreases their incentive to fully exploit the potential of their land. They may hold it for other than productive purposes. They may also consider land as a 'relatively abundant resource'; even in a land-scarce environment, given they face a lower implicit price for land compared to other production factors (Ellis, 1990). Turning to the side of the smaller farmers, peasants may be obliged to overexploit the land at their disposal. Akram-Lodhi (2007: 560) mentions that the greater output of small scale farmers may be a 'survival mechanism of the poor' rather than a 'mechanism of potentially poverty-eliminating accumulation'. Other authors have elaborated examples of these survival mechanisms. Binswanger and Rosenzweig (1986), for example, point to the possibility that imperfections on the labour market may prevent labour-selling households from allocating their labour force in the most optimal way, resulting in over employment on the own farm that leads to an inverse relationship. Barrett (1996) adds that food price risks may incite small-scale peasant households to deliberately opt for employing their labour force in an excessive way, "beyond even their shadow valuation of labor" (Barrett, 1996). Assunção and Ghatak (2003) however, point to the possibility that the inverse relationship might be the result of self-selection among the peasants, where efficient small-scale peasants have higher opportunity costs to engage in wage labour. All these theories provide household-specific explanations, either pointing to opportunities, either to constraints to which these households are confronted, to provide explanations for the inverse land size–output relationship.

The specific objective of the paper is to examine the linkage between various components of farm size i.e., land, labour, seeds, credit, fertilizer, pesticide and irrigation with level of output in Bangladesh agriculture incorporating required time series properties, short -run dynamic and long- run relationship, pair wise Granger causal relationship and returns to scale.

2. Literature Review

The extensive literature that illustrates an inverse relationship between farm size and output. The debate began with the work of Sen (1962), the Study of India's Farm Management Surveys sparked in the 1960s on an observed inverse relationship between farm size and output. The influential research of Berry and Cline (1979), Bharadwaj (1974) and Cornia (1985) also pointed to a strong inverse relationship. The studies which did not find inverse relationship or had inconclusive results Chattopadhyay and Rudra (1976). Dyer (2004), however, found significant flaws in the approach of Berry and Cline, and pointed to the importance of disaggregating data. Johnston and Le Roux (2007) gave a short overview of disaggregated studies and found a diverse pattern of results, "… with some finding a clear inverse relationship, others a positive relationship and still others describing a convex or concave relationship."

Hossain, M. (1974) examined the relationship between farm size and output in Bangladesh agriculture for the year October 1969 to June 1970 by using simple linear regression model. He used land, labour, chemical fertilizer and capital as independent variables and output per cultivated acre as dependent variable. The major finding of this paper was that the inverse relationship between farm size and output areas such as Phulpur farms is essentially due to the allocation of relatively large amounts of land to the more productive crops than the larger farms and only to a slighter extent due to higher output per acre of individual crops.

Salam, A. (1976) examined factor inputs use and farm output on different farm categories in Punjab for the time period 1976 by using multiple regression model. He used fertilizer, farm size, bullock, farmyard manure, as inputs and per acre labor use on important crops as dependent variable. The major finding was that small farmers used higher amounts of factor inputs. The inputs, which he used, did not appear to be significant among various farm size categories. The farmers operating small farms were obtained lower crop yields. This trend was more pronounced in case of Mexi-Pak wheat. Owner operated farms generally obtained higher per acre yields than the tenant-operated farms.

Deolalikar, A. B. (1981) examined the output and farm size for India, for the years 1962- 72 by using simple regression model. He used farm size, fertilizer, and modern technology as independent variables and gross value of output (of 22 major crops valued at constant prices) per hectares of cropped area as a dependent variable. The major findings of this paper was that the small farm sector as a whole enjoyed higher yield per unit of land then the large farm sector in Indian agriculture but the yield advantage of small farm sector diminishes and in fact even reverse with the technical change in agriculture.

Mahmood, M. and Haque, N.U. (1981) examined the farm size and output for the year 1973 by using Cobb Douglas production function. They used the variables including land output, cultivated acreage irrigation, fertilizer, labor, tractor, bullocks, seeds, current expenditure, cropping intensity, farm size, district dummies, as independent variables and value of aggregate output per cultivated acre as dependent variables. The major finding of this paper was that negative but insignificant correlation was found between output per cultivated area and farm size. The smallest and largest farm size had the highest land output while middle farmers using inefficient combinations of inputs that yield lower marginal output. Smallest farmers managed to produce output per acre equivalent to those obtained by the largest farmers.

Toufique, K.A. (1998) examined the relationship between farm size and output in Bangladesh agriculture by using simple linear regression model. He used hired labor and family labor as input variables and labor hours per decimal by sites and by crops as dependent variable. The major finding of this paper was that the large farms were more efficient in a high growth area such as Madhupur and small farms were more efficient in low growth area such as Chandina. Labor cost is low in high growth area then in low growth area. The larger the farm size the lower will be the capability to use family labor for supervising hired labor. Thus, the labor market institutions in Chandina were relatively inefficient as compared to the labor market institutions in Madhupur.

In the light of above-mentioned studies it is very clear that farm size and output are highly correlated but in different directions in some negative and in some positive. Another important observation is that in most of the studies simple regression model was used for estimation. This paper applies all standard time series econometric techniques and establishes short run dynamic long run relationship, pair wise Granger causal relationship and returns to scale between farm size and output.

3. Data and Methodology

The study used annual data set over the period 1979-2013. Most of the statistical data on inputs and output are taken from various issues of Bangladesh Bureau of Statistics (BBS) i.e., Agricultural Statistical Yearbook and Bangladesh Economic Review. The Data obtained from different sources have been adjusted to obtain in a specific fashion.

The analysis is intended to be comprehensive in that it takes into account of various modeling issues that arise in causality framework. It examines the stationary properties of the considered variables in the context of Bangladesh by applying Augmented Dicky Fuller (ADF) and Phillips-Perron (PP) tests. Johansen-Juselius test has been applied to examine the cointegration properties of the variables. Finally, the paper examines both short-term dynamic relationships between the considered variables within a vector error-correction frame work and Granger causality test.

4. Analytical Framework

4.1 Unit Autoregressive Root Tests

In order to test for short run dynamics and long run relationship among time series variables, the time series properties of each variable are estimated by the unit autoregressive tests i.e., whether a time series variable is stationary. In this paper two procedures are engaged for detecting a unit autoregressive root: (i) The Augmented Dickey-Fuller (ADF) Test (Dickey and Fuller 1981) and the Phillips–Perron (PP) Test (Phillips and Perron 1988).

4.1.1 Augmented Dickey-Fuller Test

The ADF test for a unit autoregressive root tests the null hypothesis H_0: $\chi = 0$ against the alternative H_1: $\chi < 0$ in the following regression:

$$\Delta Y_t = \alpha_1 \; + \chi Y_{t-1} + \sum_{i=1}^{n} \rho_i \Delta Y_{t-i} + \varepsilon_t \qquad (1)$$

Where Δ is the first difference operator and ε_t is a white noise error term and n is the number of lags in the dependent variable. In the hypothesis testing H_0 implies Y_t has a stochastic trend, while H_1 implies Y_t is stationary. The ADF statistic is obtained from the OLS t-statistics testing $\chi = 0$ in equation (1).

If Y_t is stationary around a deterministic linear time trend, then the trend 't' i.e., the number of observation must be added as an explanatory variable.

Alternatively (1) can be written as

$$\Delta Y_t = \alpha_1 \; + \alpha_2 t + \chi Y_{t-1} + \sum_{i=1}^{n} \rho_i \Delta Y_{t-i} + \varepsilon_t \qquad (2)$$

In the equation (2) Y_t is a random walk with drift around a stochastic trend. Here α_2 is an unknown coefficient and the ADF statistic is the OLS t-statistic testing $\chi = 0$ in (2).

4.1.2 The Phillips–Perron Test

The results are also verified by Phillips and Perron (1988) test. The test regression for the PP tests is:

$$Y_t = \beta_1 \; + \delta_t + \chi Y_{t-1} + \sum_{i=1}^{n} \rho_i \Delta Y_{t-i} + u_t \qquad (3)$$

Where, δ_t may be 0, μ, or μ+ $\mu + \beta_t$ and u_t is I(0) and may be heteroskedastic. The PP tests correct for any serial correlation and heteroskedasticity in the error term u_t by directly modifying the test statistics t_π = *0* and $T\hat{\pi}$. The hypothesis testing procedure is the same asymptotic distributions as the ADF test.

4.2. Test for Cointegration

Having tested the stationarity of each time series, and confirmed that each series have the same order of homogeneity (*d*), the next step is to search for cointegration between farm size (*Xt*) and the level of output (*Yt*).In this step, this study would investigate whether there is a long run relationship between the stochastic trends of *Xt* and *Yt*. In order to find out any type of causality between *Xt* and *Yt*, they must be cointegrated in the Granger sense. This precondition can be confirmed by using either the Engle-Granger two-step cointegration procedure or Johansen-Juselius rank-based cointegration test. The Engle-Granger procedure is valid for two variables. In the case of three or more variables, Johansen (1988), and Johansen and Juselius (1990) have introduced an appropriate method for cointegration. Johansen (1988), and Johansen and Juselius (1990) have developed a maximum likelihood testing procedure on the number of cointegrating vectors, which also includes testing procedures for linear restrictions on the cointegrating parameters, for any set of variables. Two test statistics that are used to identify the number of cointegrating vectors, namely the trace test statistic and the maximum eigen-value test statistic. Let us consider a Vector Autoregressive (VAR) model of order k:

$$\Delta Q_t = \mu + \Gamma_1 Q_{t-1} + \Gamma_2 P_{t-2} + \cdots\cdots\cdots + \Gamma_{k-1} P_{t-k+1} \prod Q_{t-k} + \xi_t \qquad (4)$$

Where $Q_t$is an 3x1 vector of the first order integrated [*I(1)*] variables;Γ_i are 3x3 coefficient matrices; ξ_t is a white noise error term. The existence of cointegrating vectors (r) implies $\prod$ is rank deficit. If $\prod$ is of rank r (0 < r < 5), then it can be decomposed as: $\prod = \alpha\beta^I$, where α and $\beta$are of (3 x r); and so the equation (4) can be rewritten as:

$$\Delta Q_t = \mu + \Gamma_1 Q_{t-1} + \Gamma_2 P_{t-2} + \cdots\cdots\cdots + \Gamma_{k-1} P_{t-k+1} + \alpha(\beta^I Q_{t-k}) + \xi_t \qquad (5)$$

The rows of β can be interpreted as the distinct cointegrating vectors from linear stationary processes. The α's are the error correction term that indicates the speed of adjustment towards long term equilibrium. In equation (5) β is unrestricted. Unless there is a unique cointegrating vector (i.e., r=1), the matrix of cointegrating vectors cannot be identified as typical long run equilibrium relationships. This is because any linear combination of cointegrating vectors forms another linear stationary relationship. Hence, the VAR can also be written as:

$$\Delta Q_t = \mu + \prod Q_{t-n} + \sum_{i=1}^{k-1} A_i Q_{t-i} + \Psi_t \qquad (6)$$

From the residual vector, Johansen-Juselius cointegration technique, two likelihood ratio test statistics are constructed. The First one is the trace statistics. The trace statistic tests the null hypothesis that the number of distinct cointegrating relationships is less than or equal to '*r*' against the alternative hypothesis of more than '*r*' cointegrating relationships.

The trace test statistic for the null hypothesis that there are atmost *r* distinct cointegrating vectors is:

$$\lambda_{trace} = -T \sum_{i=r+1}^{N} \ln(1-\lambda_i) \qquad (7)$$

Where λ_i's are the N-*r* smallest squared canonical correlations between Q_{t-k} and ΔQ_t and all the variables in Q_t are assumed I(1), corrected for the effects of the lagged difference of the *Xt* process.

The maximum eigen value statistic for testing the null hypothesis of at most r cointegrating vectors against the alternative hypothesis of r +1 cointegrating vectors is given by

$$\lambda_{max} = -T\ln(1-\lambda_{r+1}) \qquad (8)$$

Johansen (1988) and Juselius (1990) shows that equations (4) and (5) have non-standard distributions under the null hypothesis and provides approximate critical values for the statistic, generated by Monte Carlo methods. Table 2 shows the results of the application of Johansen procedure.

4.3. Vector Error Correction Model

If two time series $\{\mathcal{P}_t : t = 0,1, \ldots.\}$ and $\mathcal{Q}_t : t = 0,1, \ldots\ldots\}$ are *I(1)* processes, then in general, $\mathcal{V}_t = \mathrm{P}_t - \gamma\mathcal{Q}_t$ is *I(1)* process for any number of γ. Nevertheless, it is possible that for some $\gamma \neq 0, \mathcal{V}_t = \mathrm{P}_t - \gamma\mathcal{Q}_t$ is an I(0) process, which means it has constant mean, constant variance and autocorrelations that depend only on the time distance between any two variables in the series and is asymptotically uncorrelated. If such a γ exists, we can say that $\mathcal{P}_t$ *and* $\mathcal{Q}_t$ are cointegrated and γ is the cointegration parameter (Wooldridge, 2003). The cointegrating relationship $\mathcal{V}_t = \mathrm{P}_t - \gamma\mathcal{Q}_t$ represents a long run equilibrium or relationship among variables.

The notion of cointegration provides the basis for modeling both the short run and long run relationship simultaneously. It is found that the considered variables are cointegrated, then the relationship among land(LD), labour (LB), seeds(SD), credit(CD), fertilizer(FR), pesticide(PD), irrigation(IR) and output (Y) can be expressed as the error correction mechanism as follows:

$$\Delta Y = \mu_{11} + \mu_y V_{t-i} + \sum_{i=1}^{k} \delta_{11,i} \Delta Y_{t-i} + \sum_{i=1}^{k} \delta_{12,i} \Delta LD_{t-i} + \sum_{i=1}^{k} \delta_{13,i} \Delta LB_{t-i} + \sum_{i=1}^{k} \delta_{14,i} \Delta SD_{t-i} + \sum_{i=1}^{k} \delta_{15,i} \Delta CD_{t-i} + \sum_{i=1}^{k} \delta_{16,i} \Delta FR_{t-i} + \sum_{i=1}^{k} \delta_{17,i} \Delta PD_{t-i} + \sum_{i=1}^{k} \delta_{18,i} \Delta IR_{t-i} + v_1 \qquad (9)$$

$$\Delta LD = \mu_{21} + \mu_y V_{t-i} + \sum_{i=1}^{k} \delta_{21,i} \Delta Y_{t-i} + \sum_{i=1}^{k} \delta_{22,i} \Delta LD_{t-i} + \sum_{i=1}^{k} \delta_{23,i} \Delta LB_{t-i} + \sum_{i=1}^{k} \delta_{24,i} \Delta SD_{t-i} + \sum_{i=1}^{k} \delta_{25,i} \Delta CD_{t-i} + \sum_{i=1}^{k} \delta_{26,i} \Delta FR_{t-i} + \sum_{i=1}^{k} \delta_{27,i} \Delta PD_{t-i} + \sum_{i=1}^{k} \delta_{28,i} \Delta IR_{t-i} + v_2 \qquad (10)$$

Analogously, the VECM of ΔLB, ΔSD, ΔCD, ΔFR, ΔPD, ΔIR can also be found.

This equation system constitutes VAR in first differences, which also has error correction terms and allows examining the short run dynamics of long run relationship among the variables. The coefficient of the error correction term must be seen as correcting towards equilibrium subspace, i.e., how adjustment is taking place in the short run to maintain stable long run equilibrium relationship among the considered variables. The coefficients of the lagged values of the variables show whether the independent variables cause the corresponding dependent variable.

4.4. Granger Causality Test

The direction of causality between variables can be explained by Granger Causality test. The basic idea is that a time is said to Granger cause another time series Y if the prediction error from regressing Y on X declines by using past values of X in addition to past values of Y (Gujarati,2003). In the two variable systems, the test is based on the following regression:

$$Y_t = p + \sum_{i=1}^{m} e_i Y_{t-1} + \sum_{i=1}^{n} o X_{t-i} + \varepsilon_t \qquad (11)$$

$$X_t = s + \sum_{i=1}^{m} a_i Y_{t-1} + \sum_{i=1}^{n} g_i X_{t-i} + \mathrm{V}_t \qquad (12)$$

Where, ε_t and V_t are white noise error term and assumed to be stationary, and m and n are the number of lags to be specified. Equation (11) postulates that current Y is related to past values of itself as well as that of X and equation (12) proposes a similar behavior for X. X is said to Granger cause Y if computed F statistics is statistically significant at the conventional level. The same procedure can be applied to test causality from Y to X. Granger model is very sensitive to lag lengths. The lags have been chosen based on the information provided by the minimum Akaike Information Criterion (AIC). Econometric estimations were done using E-Views version 7.

4.5. Relationship between Farm Size and Output[5] -Returns to Scale

The farm size and output relationship can be studied using returns to scale approach. Where Y is the output and land (LD), labour (LB), seeds (SD), credit (CD), fertilizer (FR), pesticide (PD) and irrigation (IR) are considered as the farm size. It allows one to interpret the coefficient as elasticity, representing the percentage changes in the dependent variable when the independent variable increases by one percent. A significant positive or negative β's coefficients would indicate a positive or negative elasticity between farm size and output, the summation of the coefficients βi (i = 1 to 7) which would provide support for the returns to scale.

5. Empirical Results and Discussion

The results of Augmented Dickey–Fuller test (ADF) test and Phillips-Perron (PP) test are presented below:

Table 1. Testing for Integration in the period of 1978/79 to 2012/13

Variables	Augmented Dickey–Fuller test (ADF) test		Phillips Perron (PP) test	
	Level	Difference	Level	Difference
ln (Y)	-1.390	-5.480***	-1.452	-5.469***
ln(LD)	-2.481	-5.533***	-2.508	-5.535***
ln(LB)	-1.768	-7.200***	-2.270	-7.185***
ln(SD)	-3.348	-8.433***	-3.348	-8.532***
ln(CD)	-2.327	-6.061***	-2.314	-6.065***
ln(FR)	-0.656	-6.304***	-1.925	-7.065***
ln(PD)	-2.420	-7.429***	-4.258	-7.632***
ln(IR)	-2.146	-11.165***	-3.337	-10.737***

Notes: i. * ,** and *** denote rejection of the unit root hypothesis at 10%,5% and 1% level of significance; ii. The optimal lag length has been considered to be 1 according to the Akaike Information Criterion (AIC); iii. The results carried out by STATA (Version 10).

Table 1 shows that the time series are nonstationary i.e., *I (0)* at their levels, while first difference makes them stationary. That is each of the considered time series are integrated of order 1, *I (1)*.

[5] Output (Y) as a dependent variable and Farm Size as an independent variable (i.e., (land (LD), labour (LB), seeds (SD), credit (CD), fertilizer (FR), pesticide (PD), and irrigation (IR)).

Table 2. Unrestricted Cointegration Rank Test

		Trace : λ_{trace}			Maximum Eigen value : Λ_{MAX}		
Null Hypothesis	Eigen value	Trace Statistic	5% Critical Value	1% Critical Value	Max-Eigen Statistic	5% Critical Value	1% Critical Value
r = 0	0.96089	334.689***	156.00	168.36	110.205***	51.42	57.69
r ≤ 1	0.89339	224.484***	124.24	133.57	76.110***	45.28	51.57
r ≤ 2	0.82204	148.374***	94.15	103.18	58.690***	39.37	45.10
r ≤ 3	0.65758	89.683***	68.52	76.07	36.438**	33.46	38.77
r ≤ 4	0.61688	53.2447**	47.21	54.46	32.6197***	27.07	32.24
r ≤ 5	0.31902	20.6250	29.68	35.65	13.0638	20.97	25.52
r ≤ 6	0.18540	7.5612	15.41	20.04	6.9720	14.07	18.63
r ≤ 7	0.01718	0.5892	3.76	6.65	0.5892	3.76	6.65

Note: i. r denotes the number of cointegrating vectors; ii. * ,** and *** denote the level of significance at 10%,5% and 1% respectively; iii. The optimal lag length has been considered to be 1 according to the Akaike Information Criterion (AIC); iv. The results carried out by STATA (Version 10).

From Table 2 the trace and max tests of Johensen and Juselius (1991) suggest that the considered time series are cointegrated. This implies that there are long run relationship exists among land, labour, seeds, credit, fertilizer, pesticide, irrigation and output in Bangladesh. That is the farm size has some important long run implications for changes in output in Bangladesh.

Table 3. Error Correction Model

	Coefficient	Standard Error	P-value	Chi 2
VECM(-1)	-.2152449	.088108	0.015	
D(LNY (-1))	.2913113	.2082535	0.162	32.74738***
D(LNLD) (-1))	-.3813569	.384112	0.321	18.8655**
D(LNLB)(-1))	.0352894	.0359179	0.326	4.85885
D(LNSD (-1))	-.0781475	.0327421	0.017	24.95036***
D(LNCD (-1))	-.0190625	.0141188	0.177	29.75405***
D(LNFR (-1))	.0779905	.0674913	0.248	32.52512***
D(LNPD (-1))	-.006567	.0232556	0.778	72.15766***
D(LNIR (-1))	.2315705	.1386707	0.095	81.72107***
C	-.001193	.0099097	0.904	

Note: i. * ,** and *** denote the level of significance at 10%,5% and 1% respectively; ii. The results carried out by STATA (Version 10)

The results of error correction model reveal in Table 3 that of all the variables (land (LD), labour (LB), seeds (SD), credit (CD), fertilizer (FR), pesticide (PD), irrigation (IR)) of the model do not have significant effect on output (Y) in the short term, unlike the long run results. As expected, the error correction term ECM (-1) is found to be negative and is statistically significant. ECM (-1) is one period lag value of error terms obtained from the long-run relationship. It is statistically significant and their negative coefficients confirm the presence of a stable long run relationship among the variables and reaffirm the existence of cointegration relationship. Further, the coefficient of error correction term ECM (-1) being -0.2152449 indicates that short-term dynamics convergence annually 21.52% towards the long run equilibrium.

Table 4. Direction of Causality (Granger Causality Test)

Null Hypothesis:	Observations	F-Statistic	Probability
Y does not Granger Cause LD	33	2.15434	0.1176
LD does not Granger Cause Y		0.17357	0.9133
Y does not Granger Cause LB	33	0.24072	0.8671
LB does not Granger Cause Y		1.63604	0.2053
Y does not Granger Cause SD	33	3.83915**	0.0212
SD does not Granger Cause Y		0.78740	0.5119
Y does not Granger Cause CD	33	3.07526**	0.0452
CD does not Granger Cause Y		0.08318	0.9686
Y does not Granger Cause FR	33	0.37710	0.7703
FR does not Granger Cause Y		0.14558	0.9316
Y does not Granger Cause PD	33	3.09533**	0.0443
PD does not Granger Cause Y		0.71170	0.5538
Y does not Granger Cause IR	33	0.69600	0.5629
IR does not Granger Cause Y		2.67579*	0.0680

Note: i. * ,** and *** denote the level of significance at 10%,5% and 1% respectively.

The results of Granger causality test shows that Y causes SD, CD, and PD. The Table also shows that IR causes Y.

Table 5. Farm Size – Output and Returns to Scale 1978/79 to 2012/13

Cointegrating Coefficient Estimates		
Parameter	Coefficient	Standard-error
β_0	1.228639	___.
β_1	0.7493712***	.0248299
β_2	-0.1745615***	.002496
β_3	-0.0500583***	.0026111
β_4	-0.0482731***	.0018571
β_5	-0.124272***	.0042902
β_6	0.1871712***	.0034975
β_7	0.3311322***	.0092276

Note: i. * ,** and *** denote the level of significance at 10%,5% and 1% respectively.

Table 5 represents farm size is statistically significant. Land, pesticide and irrigation are positively related to output level and labour, seeds, credit and fertilizers are inversely related to output level. The positive β's coefficients indicate a positive elasticity and negative β's coefficients indicate a negative elasticity between farm size and output. The sum of βi (i.e., i = 1 to 7) is equal to 0.871(i.e., <1), which exhibits decreasing returns to scale.

6. Conclusion

The paper applies cointegration, error correction mechanism and Granger causality test to explore the dynamic causal relationship between farm size (i.e., land, labour, seeds, credit, fertilizer, pesticide, irrigation) and output in Bangladesh. The central purpose of the paper is to investigate the short run dynamics of the long run relationship between farm size and output in a multivariate framework for the Bangladesh economy using annual time series data for the period 1979-2013. The trace and max tests of Johensen and Juselius (1991) suggest that there are stable long run relationship exists between farm size and output in Bangladesh. That is the farm size has some important long run implications for changes in output in Bangladesh. The error correction term ECM (-1) in the error correction model is negative and statistically significant which confirms the existence of short run relationship. The value of the estimated coefficient of error correction term indicates short term dynamic convergence towards the long run equilibrium occurs at an annual rate 21.52 percent. Moreover, the paper establishes unidirectional causal relationship i.e., output causes seed, credit, and pesticide. On the other hand, irrigation causes output. The paper also provides evidence of the existence of decreasing returns to scale in Bangladesh agriculture.

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