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Investigating Agricultural Production Relations across Bangladesh, India and Pakistan Using Vector Error Correction and Markov-Switching Models

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Abstract

This paper has investigated the short- and long-term relationships as well as regime switching behaviour across the per-capita agricultural production of Bangladesh, India and Pakistan using vector error correction model (VECM) and Markov-switching VECM model (MS-VECM). These countries were selected due to their high agricultural economic importance to the South Asian region. The study has used FAO's statistical dataset and the study period was 1961–2010. The residual diagnostics have validated the models since there is no deficiency in normality, autocorrelation or heteroskedasticity. The empirical results have confirmed the existence of two long-term cointegrating vectors between the variables and have demonstrated that an unexpected shock to the respective log per-capita agricultural production of India and Pakistan cause transitory impacts. On the other hand, an unexpected shock to the log per-capita agricultural production of Bangladesh causes a permanent disequilibrium in all variables. Finally, MS-VECM model has shown two volatility regimes (i.e. low and high volatility). The Markov-switching impulse responses have indicated that, one, agricultural production adjustments in the first regime are smoother than those in the second regime, and two, these adjustments are faster in the case of a shock to the agricultural production of Pakistan than to the agricultural production of either Bangladesh or India.

Key words: SAARC, cointegration, VECM, MS-VECM, impulse response, per-capita agricultural production, Bangladesh, India, Pakistan

JEL Classification: O13; O53

Introduction

In 1985, seven South Asian countries (viz., Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka) formed the South Asian Association for Regional Cooperation (SAARC). With Afghanistan's joining the organization in 2007, the SAARC has eight member countries now. The SAARC countries have about 15 per cent of the world's arable land and about 23 per cent of the world's population, which is mostly shared by Bangladesh, India and Pakistan. The increase in population is creating obstacles to the development of the economy as well as causing a reduction in arable land area in these three countries. A recently published report (http://maplecroft.com/about/news/ccvi.html) ranking global climate change states that Bangladesh, India and Pakistan (among others) will be extremely affected by the effects of climatic change. Thus, when coping with the agricultural challenges of keeping production growth stable, it is important to investigate the agricultural production relationships of Bangladesh,

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India and Pakistan. Based on these issues, this study has analyzed the short-term and long-term relationships between these countries' agricultural production since agriculture is their economic lifeline. Bangladesh, India and Pakistan were selected for analyzing the short-term and long-term relationships of their agricultural production since they represent about 80 per cent of the agricultural economy of the region. The agricultural sector constitutes a significant proportion of GDP of the selected countries; for instance, according to the World Factbook of CIA, 17.3 per cent, 17.0 per cent and 20.1 per cent of the GDP of Bangladesh, India and Pakistan is accounted for by the agricultural sector, respectively. Most of the population of these three countries live in rural areas (72%, 70% and 64%, respectively). The agricultural sector is thus considered to be the principal source of employment, which accounts for 45 per cent, 53 per cent and 45.1 per cent share, respectively.

The investigation of the short-term and long-term relationships, switching behaviours of regimes and effects of unexpected shocks are the crucial issues in econometric time-series analyses. These issues are valuable sources of information for matters regarding production mechanisms and their transmission patterns, the nature of unobserved regimes and the effects of unexpected shocks, which are important for many contemporary policy and agricultural production analyses.

A number of studies have investigated short-term and long-term relationships as well as causality in the SAARC countries. For example, Chowdhury (2012) has examined the nexus of foreign aid and the real exchange rates in SAARC countries and found the existence of a long-run relationship between the real exchange rate and aid flow, government consumption to GDP, terms of trade, trade openness and independent policy variables for six SAARC countries, namely Bangladesh, India, Maldives, Nepal, Pakistan and Sri Lanka. Pradhan and Bagchi (2012) have investigated the relationship and causality between government expenditure, economic growth and exports for seven SAARC countries, namely Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. This study has concluded that only Bhutan, Maldives and Nepal have cointegrating relationships with government expenditure, economic growth and exports. Furthermore, Granger causality tests have suggested mixed evidence of causality in these seven SAARC countries. Chowdhury (2011) has studied the effects of remittances on the development of the financial sector in Bangladesh by employing the Johansen maximum likelihood cointegration and vector error correction model (VECM). The study has identified one long-run relationship between financial development (i.e., private domestic deposits to GDP, bank credit to GDP and M2 to GDP) and remittance flow. The study has concluded that 1 per cent increase in remittance flow would cause more than 1 per cent increase in financial development.

Joshi (2013) has examined the long-term and short-term relationships between GDP and exports in India. This study has evidenced cointegrating relationships and short-term causality between the variables, but has found no long-term causality between GDP and exports in India. Khan and Sajid (2007) have examined the interest rate linkages among four SAARC countries (Bangladesh, India, Pakistan and Sri Lanka) in relation to the US. The empirical results have indicated the existence of a single cointegrating relationship between SAARC countries' interest rates and the US interest rate. The results of the cointegration test within SAARC countries have further suggested that one cointegrating vector indicates a low degree of money market integration in the SAARC region. The authors have concluded that in the short-run only India, Pakistan and Sri Lanka's interest rates play a significant role, whereas the long-run interest rates of SAARC countries are closely related. Rashid *et al*. (2012) have investigated the effects of export instability on economic growth in four SAARC countries (viz. India, Nepal, Pakistan and Sri Lanka). The study has suggested the existence of cointegration between real GDP, the real exports of goods and services, real gross fixed capital and an export instability index. It has also reported that export instability has negative and significant effects on economic growth of these four SAARC countries.

A number of studies have used VECM, MS-VECM and impulse response analysis to investigate the short-term and long-term relationships between variables, regime switching behaviours and effects of transitory and permanent shocks by using time-series data. Most of these studies have examined GDP, price series, monetary policy and output data. For example, Rezitis *et al*. (2009) have investigated long-run price relationships between the farm, domestic wholesale, imported wholesale, and retail levels of the Greek lamb market. These authors have found three long-run price relationships between (i) producers and domestic wholesale, (ii) imports and consumers, and (iii) domestic wholesale and consumers. They have also reported that retail price was the driving force of the price marketing chain. This study has discovered three regime shifting behaviours that might be due to various common agricultural policies changes. Rezitis and Pachis (2013) have investigated the price transmission mechanism of the Greek fresh tomato market by employing MS-VECM and evidenced three switching states. They have concluded that the retailers exercise some degree of market power in high volatility periods, but no market power in low or medium volatility periods. Krolzig *et al*. (2002) have analyzed the UK labour market and found that MS-VECM provided a good characterization of the sample data and evidenced three switching regimes closely related to changes in the phases of the UK business cycle.

Ben-Kaabia *et al*. (2002) have studied the most important relationships among four variables, namely the real exchange rate, real money supply, real firm output prices, and real agricultural exports, in Tunisia. This study has found two cointegrating vectors: the first indicates that a permanent increase in money supply leads to increasing agricultural prices and the second indicates that an increase in the exchange rate stimulates an increase in agricultural exports. Assadzadeh and Nasab (2012) have examined the relationship between the tourism industry and GDP in Iran. They have used the Johansen–Juselius cointegration method (Johansen and Juselius, 1990) and Granger (Granger, 1969) and Hsiao (Hsiao, 1981) causality test to investigate the relationship between the variables. Their study has suggested a long-run positive relationship between income obtained from the tourism industry and the GDP. The study has evidenced bidirectional causality between the two variables, allowing them to conclude that the tourism industry can increase the GDP and vice versa. Gunes (2007) has analyzed the long-run behaviour of functional income distribution in Turkey by using the Johansen–Juselius cointegration model, VECM, and impulse response analysis. The study has indicated that wage income, non-wage income, agricultural earnings and operating surplus are cointegrated. The findings have also confirmed the presence of a causal relationship among the variables and have indicated that the variables are responsive to various corresponding shocks.

The main objective of this study is to explore the short-term and long-term relationships between the per capita agricultural production of Bangladesh, India and Pakistan by modelling their respective production mechanism and transmission. The second objective of this study is to investigate the unobservable regimes and identify the switching behaviour of agricultural production. The responses of agricultural production to sudden shocks are also to be investigated. To achieve these objectives, this study has used several econometric models such as the vector error correction model (VECM), and Markov-switching VECM (MS-VECM). The VECM is used when the assumptions of the stationarity of the vector autoregressive (VAR) model are rejected, but the linear combinations of a set of variables of the system are stationary. The MS-VECM examines the behaviour of different regimes characterized by the volatility of the regime and probability of staying in the same regime or switching to another one. It also examines the effects of impulse responses that might be generated from the unexpected shock to the residuals of the endogenous variables.

Frey and Manera (2007) have mentioned that a regime switching model is part of the family of models in which the relationship between the variables of interest depends on the state of a variable, which can be either part of the explanatory variables or not. This variable is called the transition variable. The level of transition variable s_t, with respect to a threshold, describes different states of the world or regimes. Therefore, the regime switching model has the property to account for the behaviour of economic actors under different circumstances. A further categorization defines two different models, according to the nature of the state variable which can be deterministic or stochastic. In the case of the MS-VECM model, the agricultural production mechanism passes through different states according to an unobserved transition state variable, which follows a first-order ergodic Markov chain. Therefore, the transition variable is stochastic and the shift from one regime to another is random. Additionally, as the transmission variable is unobservable, it can be defined by the data itself and not by the researcher. In the case of the threshold vector error correction model, the transition variable is deterministic and defined by the researcher.

The stochastic characteristics of the aforementioned approaches provide an important econometric tool for performing better statistical analysis as well as improving upon traditional interpretations of the short-term and long-term relationships of the per capita agricultural production of Bangladesh, India and Pakistan. Furthermore, in the related literature, there is abundant evidence on the examination of agricultural production linked to these three SAARC countries. However, there is limited evidence of investigations using the VECM and MS-VECM approaches to examine these relationships, regime switching behaviour and the effect of impulse responses of the per capita agricultural production of these countries.

Empirical Model

This study has used various econometric models to examine the relationships between the per capita agricultural production of India (*lpcapi*), Pakistan (*lpcapp*) and Bangladesh (*lpcapb*) which are being introduced here before proceeding to the empirical analysis.

Vector Error Correction Model (VECM)

The existence of long-run equilibrium relationships can be investigated by a vector autoregressive model (VAR), given by Equation (1):

$$x_t = \nu + \Pi_1 x_{t-1} + \dots \dots + \Pi_k x_{t-k} + \phi DUM_t + \varepsilon_t, \quad \text{with } t = 1, 2, \dots \dots, T \qquad \dots(1)$$

where, $x_{t-1}, \dots \dots, x_{t-k}$ are the lagged variables of x_t, x_t is a 3×1 vector with elements representing time series observations with T= 1 (1961), …………., 50 (2010); $\boldsymbol{\nu}$ is a 3×1 vector of constant term; Π_i are 3×3 matrices of parameters with i=1,…,k, and $\boldsymbol{\varepsilon_t}$ is a 3×1 vector of error-terms. The error-terms $\boldsymbol{\varepsilon_t}$ are normally distributed and follow a Gaussian distribution with zero mean and variance and covariance matrix Ω, i.e. $\varepsilon_t \sim \text{iid } N_p(0, \Omega)$. DUM_t is a vector of deterministic components containing dummies.

When the VAR model fails to prove its assumption of stationarity, but a linear combination between variables in the system is stationary, then these variables are supposed to be cointegrated. At this stage, a vector error correction model (VECM), instead of a vector autoregressive model (VAR) is used. The VECM is expressed in terms of differences and is given by Equation (2):

$$\Delta x_t = \nu + \Pi x_{t-1} + \Gamma_1 \Delta x_{t-1} + \dots \dots + \Gamma_k \Delta x_{t-k+1} + \phi DUM_t + \varepsilon_t \qquad \dots(2)$$

where, Δ is the first difference notation, x_t is a 3×1 vector containing the log per capita agricultural production of India *(lpcapi$_t$)*, log per capita agricultural production of Pakistan *(lpcapp$_t$)* and log per capita agricultural production of Bangladesh *(lpcapb$_t$)*. $\boldsymbol{\nu}$ is a 3×1 vector of a constant term, $\Pi = \sum_{i=1}^{p} A_i - I$, $\Gamma_i = -\sum_{j=i+1}^{p} \Pi_j$, and DUM_t is a deterministic component containing dummies. The dummies used in the model were $DS68_t$, $DP83_t$, $DP02_t$. $DS68_t$ is a dummy variable used to capture the structural break and it takes the value of one between 1968 and 2005 and zero otherwise. This structural break is clearly depicted in Figure 1 where during the period 1968-2005, there is a shift of the mean level of the data, especially for Bangladesh. $DP83_t$ and $DP02_t$ are outliers, which take the value of one for the years 1983 and 2002, respectively and zero otherwise. Π contains all information relating to the long-term period and Γ_is contain all information relating to the short-term period. $\boldsymbol{\varepsilon_t}$ is a 3×1 vector of error-terms which is normally distributed and follows a Gaussian distribution with zero mean and variance and covariance matrix Ω, i.e. $\varepsilon_t \sim \text{iid } N_p(0, \Omega)$.

Due to the presence of first differences (Δx_t), the left hand side of Equation (2) is considered as stationary. But, the right hand side of Equation (2) is not said so since it contains both stationary (Δx_{t-k}) and non-stationary (x_{t-1}) processes. For this, the coefficient matrix Π of the x_{t-1} must be either equal to zero or should have a reduced rank, because the outcome of the combination of stationary and non-stationary processes is considered as non-stationary process. The reduced rank of Π indicates the number of equilibrium relationships in the system and as a result, it confirms the existence of stationary relationships. Therefore, a linear combination of x_{t-1} would allow for the stationarity of Δx_t. This linear combination can be determined through the relationship of $\Pi = \alpha\beta'$, where α and β' are $p \times r$ matrices, p is the number of variables and r is the number of long-term equilibrium relationships. The matrix α is sometimes called the loading matrix and β' is called the cointegration matrix. On replacing $\Pi=\alpha\beta'$ in Equation (2), we get Equation (3):

$$\Delta x_t = \nu + \alpha\beta' x_{t-1} + \Gamma_1 \Delta x_{t-1} + ... + \Gamma_k \Delta x_{t-k+1} + \phi DUM_t + \varepsilon_t \quad ...(3)$$

where, x_t, ν, Γ_i, DUM_t, and ε_t are same as defined in Equation (2).

As mentioned above, after having non-stationary data series with cointegrating relationships between the variables, a VECM is preferred to apply. More specifically, non-stationarity of variables is checked by applying the standard methods. Then, a trace test procedure, proposed by Johansen and Juselius (1990), is applied to determine the number of cointegrating rank, which represents the number of cointegrating relationships. After confirming the cointegrating relationships, the imposition of restrictions (zero restriction) is required to identify the long-run structure. The imposed restrictions also yield empirically meaningful economic interpretations. It is also necessary to run some tests for checking the robustness of the variables. For example, the use of the variable exclusion test which provides useful information regarding which variables can and which cannot be excluded from the system. The weak exogeneity test provides information about the variables whether they are weakly exogenous or not.

Impulse Response Functions of VECM

The impulse response function is given by Equation (4):

$$R(n) = response\,(x_{t+n}, u_t) = \tilde{C} + \tilde{C}_n^*,\ i \in N \quad ...(4)$$

where, $R(n)$ is the response to x_{t+n} from a shock to u_t which represents the orthogonalized residuals of the VECM in Equation (3), $\tilde{C}$ is a matrix of long-term impacts, and $\tilde{C}_n^*$ is a matrix of contemporaneous impacts after n periods (Dennis, 2006). The impulse response functions measure the degree of impulse response of a transitory or permanent shock to each of the endogenous variables. Thus, the impulse response functions can estimate the present and future responses of the per capita agricultural productions which are due to an unexpected shock of one or more standard deviations.

Markov-Switching Vector Error Correction Model (MS-VECM)

The application of MS-VECM is required for identifying the regime switching behaviours during the transmission of per capita agricultural production of three SAARC countries. A MS-VECM is given by Equation (5):

$$\Delta x_t = \nu(s_t) + a(s_t)(\beta' x_{t-1}) + \Gamma_1(s_t)\Delta x_{t-1} + ... + \Gamma_{k-1}(s_t)\Delta x_{t-k+1} + \varepsilon_t \quad \text{with } t = 1, 2, ..., T \quad ...(5)$$

where, x_t is a vector containing the log per capita agricultural production of India *(lpcapi$_t$)*, log per capita agricultural production of Pakistan *(lpcapp$_t$)* and log per capita agricultural production of Bangladesh *(lpcapb$_t$)*; β´ is the cointegration matrix; while the parameter shift functions $a(s_t)$, $\Gamma_1(s_t)$ and $\nu(s_t)$ describe the dependence of the parameters on a stochastic and unobservable regime s_t. Specifically, $a(s_t)$, $\Gamma_1(s_t)$ and $\nu(s_t)$ represent the shifts in the loading matrix of the equilibrium correction mechanism, the shifts in the short-run dynamics, and the regime-dependent intercept-term, respectively. $\boldsymbol{\varepsilon_t}$ is a vector of error-term which is normally distributed and follows a Gaussian distribution with zero mean and variance and covariance matrix, Σ i.e. ~ NID [0, $\Sigma(s_t)$], where the error variance $\Sigma(s_t)$ is allowed to change across regimes (s_t).

The regimes s_t generating process has to be formulated since the parameters of Equation (5) are based upon a regime that is considered to be stochastic and unobservable. This regime-generating process is called ergodic Markov chain because it is possible to go from one regime to another. The matrix of transition probabilities P is given by expression (6):

$$P = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1M} \\ p_{21} & p_{22} & \cdots & p_{2M} \\ \vdots & \vdots & \ddots & \vdots \\ p_{M1} & p_{M2} & \cdots & p_{MM} \end{bmatrix} \quad ...(6)$$

where, $p_{ij} = \Pr(s_{t+1} = j \mid s_t = i)$, $\sum_{j=1}^{M} p_{ij} = 1$, and $\forall i, j \in \{1, ..., M\}$

with M corresponding to the number of feasible regimes. More specifically, p_{ij} represents the probability of being the ergodic Markov chain at the next time-point in regime j; given that it is at the present moment in regime i (Krolzig, 1996). The sum of each row of P

must be equal to one, while the probability of being in one regime should not be too high (near or equal to one), as in that case the regime would never or hardly ever be left (Giese, 2005). Furthermore, the regime-switching probabilities vary over time depending on how far the process moves away from the long-term equilibrium mean (Rahbek and Shephard, 2002).

Generally, a two-stage procedure is applied to estimate the MS-VECM. Firstly, the Johansen and Juselius maximum likelihood (ML) multiple cointegration analysis (Johansen, 1996; Juselius, 2006) is employed to determine the number of long-run relationships as well as to estimate the cointegrating parameters. Secondly, the cointegrating relations found are then included in the MS-VECM as exogenous variables, and the ML procedure of the MS-VECM model is used to estimate the result which is based on a version of the expectation-maximization (EM) algorithm developed by Krolzig (1996). This version is an iterative ML estimation technique which is formulated for a general class of models where the observed time series depends on some unobservable stochastic variables, i.e. the unobservable regime variable s_t. The expectation and the maximization are the two steps of EM procedure.

Therefore, the MS-VECM approach can be followed according to the parameters that are allowed to switch. In this study, the coefficients and variances were allowed to switch and 2 regimes were accepted with *a-priori* basis. Moreover, one lag was accepted based on Hannan-Quinn (HQ) criterion (Hannan and Quinn, 1979). Thus, the estimated model was MS (2)–VECM (1).

Finally, the short- and long-term causality was tested among the per-capita agricultural production of the countries under consideration. In particular, the examination of causality between the per-capita agricultural production of India (*lpcapi*), Pakistan (*lpcapp*) and Bangladesh (*lpcapb*) would offer a deeper insight about the relationships of the per-capita agricultural production of these countries. In the short-run, the causality between *lpcapi*, *lpcapp* and *lpcapb* was examined by testing the statistical significance of the lags of the per-capita agricultural production of these countries. The null hypothesis of the short-term causality for regime *i* was H_0: $\Gamma_i (s_t = i) = 0$ (i = 1,2,3), while the alternative hypothesis for the regime *i* was H_1: $\Gamma_i (s_t = i) \neq 0$ (i = 1,2,3). In the long-term, causality was examined by testing the statistical significance of the estimated parameter of the error correction terms obtained from the equation of India, Pakistan and Bangladesh. The null hypothesis of the long-term causality for regime *i* was H_0: $\alpha (s_t = i) = 0$, while the alternative hypothesis for regime *i* was H_1: $\alpha (s_t = i) \neq 0$ (i = 1,2,3). The above tests can be provided by either simple t-tests obtained with the estimation of the MS (2)-VECM (1) or with the use of Wald tests.

Data

The data set used was yearly data on the logarithm of per-capita agricultural production of India (*lpcapi*), Pakistan (*lpcapp*) and Bangladesh (*lpcapb*) from 1961 to 2010 with 2004–2006 =100; it was obtained from the FAOSTAT statistical data set (http://faostat.fao.org, accessed in October 2012). As per FAO indications, the net per-capita agricultural production was derived from the gross production after subtracting quantities used for seed and feed. The descriptive statistics of the data set used in this paper are reported in Table 1.

Figure 1 depicts the evolution of the per-capita agricultural production of India, Pakistan and Bangladesh from 1961 to 2010. The per-capita agricultural production of India has shown a downward trend until 1966, then gained an upward pace with some fluctuations, before reaching a high point in 2010. The per-capita agricultural production of Pakistan has kept its upward trend (with some fluctuations) until 2010.

Table 1. Descriptive statistics

Variables	Means	Standard deviation	Variables (logarithms)	Means	Standard deviation
pcapi, Per-capita agricultural production of India	88.05	11.33	*lpcapi*	4.47	0.13
pcapp, Per-capita agricultural production of Pakistan	85.31	10.41	*lpcapp*	4.44	0.12
pcapb, Per-capita agricultural production of Bangladesh	93.73	10.00	*lpcapb*	4.54	0.10

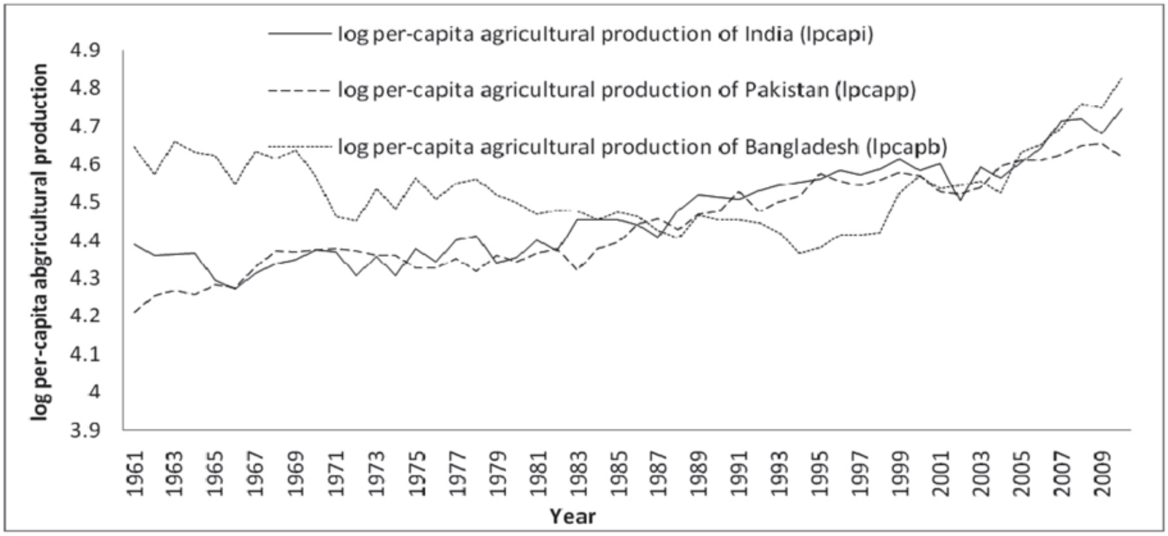

Figure 1. The evolution of per-capita agricultural Production Index Number (PIN) of *lpcapi, lpcapp* and *lpcapb* 1961-2010

However, during the previous year, it has displayed a downward trend. The per-capita agricultural production of Bangladesh has experienced a downward trend (with fluctuations) until 1972, then increased slightly, but reached its lowest level in 1994, after which, it dramatically regained pace, and reached its highest point in 2010.

Empirical Results

Stationarity Test

To check the stationarity of the data, this study applied various unit root tests; these were the Augmented Dickey–Fuller (ADF) test proposed by Dickey and Fuller (1981), the Phillips–Perron (PP) test proposed by Phillips and Perron (1988), the Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test proposed by Kwiatkowski *et al*. (1992), and the Elliott–Rothenberg–Stock (ERS) test proposed by Elliott *et al*. (1996). These four unit root tests provided evidence that the variables, namely the log per-capita agricultural production of India (*lpcapi*), Pakistan (*lpcapp*) and Bangladesh (*lpcapb*), were stationary in their first difference. However, only the ERS test showed the non-stationarity of all variables in their levels. The ADF, PP and KPSS tests showed that *lpcapi* was non-stationary in the level when only the intercept was considered. The ADF and PP tests also displayed that *lpcapp* and *lpcapb* were non-stationary in the level when the intercept as well as the trend and intercept were considered. On the other hand, KPSS test showed that *lpcapp* was non-stationary in the level when only the intercept was considered, whereas *lpcapb* was stationary in levels. Thus, the aforementioned four unit root tests provided the evidence that the variables were non-stationary in levels, but stationary in the first differences. As a result, the current study proceeded further to test the cointegration. The results of the unit root tests for the three variables, viz. *lpcapi*, *lpcapp* and *lpcapb,* are reported in Table 2, in which the last column provides the details of the unit root tests. In particular, SIC is the Schwartz Information Criterion used for the selection of lags and NW is the Newey–West bandwidth choice criterion used for the choice of the bandwidth, while B and SOLS are the Bartlett kernel suggested by Newey and West (1994) and Autoregression Spectral Ordinary Least Squares spectral estimation methods, respectively.

Vector Error Correction Model (VECM)

After estimating Equation (3), a residual analysis was carried out to conduct misspecification tests. Table 3 reports some of the misspecification test results such as the Lagrange multiplier autocorrelation test following the chi-squared test with 9 degrees of freedom, normality test following the chi-squared test with 6 degrees of freedom, and heteroskedasticity test following the chi-squared test with 36 and 72 degrees

Table 2. Unit root test results of three variables

Variables	Test	Level	First difference	Details
lpcapi	ADF	0.42	-9.85***	SIC, Int
lpcapi	ADF	-3.99**	-10.05***	SIC, Int, Tr
lpcapi	PP	0.82	-10.82***	NW, B, Int
lpcapi	PP	-3.88**	-12.95***	NW, B, Int, Tr
lpcapi	KPSS	0.89	0.37**	NW, B, Int
lpcapi	KPSS	0.17**	0.14**	NW, B, Int, Tr
lpcapi	ERS	37.99	1.99**	SIC, SOLS, Int,
lpcapi	ERS	11.84	4.73**	SIC. SOLS, Int, Tr
lpcapp	ADF	-1.25	-8.25***	SIC, Int
lpcapp	ADF	-2.98	-8.16***	SIC, Int, Tr
lpcapp	PP	-1.19	-8.89***	NW, B, Int
lpcapp	PP	-2.95	-8.75***	NW, B, Int, Tr
lpcapp	KPSS	0.91	0.12*	NW, B, Int
lpcapp	KPSS	0.09*	0.09*	NW, B, Int, Tr
lpcapp	ERS	61.38	2.25**	SIC, SOLS, Int,
lpcapp	ERS	7.78	4.69**	SIC. SOLS, Int, Tr
lpcapb	ADF	-0.70	-8.31***	SIC, Int
lpcapb	ADF	-0.59	-8.97***	SIC, Int, Tr
lpcapb	PP	-0.47	-8.26***	NW, B, Int
lpcapb	PP	0.18	-9.49***	NW, B, Int, Tr
lpcapb	KPSS	0.21*	0.56***	NW, B, Int
lpcapb	KPSS	0.21***	0.14**	NW, B, Int, Tr
lpcapb	ERS	9.22	2.93**	SIC, SOLS, Int,
lpcapb	ERS	26.88	4.79**	SIC. SOLS, Int, Tr

Notes: lpcapi,*lpcapp* and *lpcapb* are the log per-capita agricultural production of India, Pakistan and Bangladesh, respectively. SIC is Schwartz Information Criterion, Int is Intercept, Tr is linear trend, NW is Newey-West bandwith choice, B is Bartlett kernel, SOLS is Spectral OLS.
***, **, and * represent that variables are stationary at 1 per cent, 5 per cent , and 10 per cent significant levels, respectively.

of freedom. The results of the residual analysis have shown that the residuals were not autocorrelated, as the *p*-values of the Lagrange multiplier of order 1 and 2 were not significant. The chi-squared test has shown that there was normality of the residuals and that they did not suffer from heteroskedasticity, as according to the ARCH test, the null hypothesis of homoscedasticity cannot be rejected at any level of significance. The results of the univariate analysis of the three variables have also shown a good fit of the model.

The results of the misspecification tests encouraged us to provide additional information on the issue of the determination of the cointegrating rank, which refers to the long-run equilibrium relation determined by using the trace test. The trace test requires determining which eigenvalues correspond to stationary and which to non-stationary relations. A small eigenvalue is an indication of a unit root and this suggests a non-stationary process. The trace test was corrected by using the Bartlett factor for small samples, which was represented by the starred trace statistics and *p*-values. According to the results, and taking into consideration the Bartlett factor for small samples (Table 4), the hypothesis of zero cointegration rank (r=0) was rejected, but the hypothesis of one

Table 3. Residual analysis

Tests for autocorrelation			Test for normality		Test for ARCH	
LM(1):Chi square (9) = 9.838 [0.364] LM(2):Chi square (9) = 8.662 [0.469]			Chi square (6) = 5.162 [0.523]		LM(1):Chi square (36) = 42.246 [0.219] LM(2):Chi square (72) = 78.088 [0.292]	
First difference	Mean	Std Dev.	Skewness	Kurtosis	ARCH(2)	Normality
Δlpcapi	0.001	0.030	-0.505	3.040	2.701 [0.259]	2.386 [0.303]
Δlpcapp	0.001	0.022	0.140	3.275	3.652 [0.161]	1.580 [0.454]
Δlpcapb	-0.001	0.042	-0.100	3.010	0.210 [0.900]	0.656 [0.720]

Notes: Δlpcapi, *Δlpcapp* and *Δlpcapb* are the first differences of the per-capita agricultural production of India (*lpcapi*), Pakistan (*lpcapp*) and Bangladesh (*lpcapb*) in logs. The values within the brackets correspond to the *p*-values of each variable.

Table 4. Trace test of cointegrating rank

p-r	*r*	Eigenvalue = λ	Trace	Trace*	Frac 95	*p*-value	*p*-value*
3	0	0.318	29.392	27.474	24.214	0.009	0.018
2	1	0.189	11.017	10.395	12.282	0.082	0.103
1	2	0.020	0.952	0.696	4.071	0.383	0.466

Note: The trace test considering the Bartlett factor for small samples is represented by Trace* and *p*-value*.

Table 5. Roots for cointegrating rank, *r* = 2

Roots	Real	Imaginary	Modulus	Argument
Root 1	1.000	0.000	1.000	0.000
Root 2	0.940	0.000	0.940	0.000
Root 3	0.504	0.000	0.504	0.000

cointegration rank (*r* =1) was very close to rejection at the 10 per cent significance level (viz. 10.3%). In this case, an additional indicator was considered, namely the roots for the cointegrating rank test (Table 5). The roots for the cointegrating rank test suggested *r* =2 and the existence of one unit root (*p-r* =1) as the modulus value (0.94) of root 2 was smaller than 1.

After confirming the two cointegrating ranks (*r* =2), we conducted some additional tests, namely weak exogeneity and variable exclusion. The weak exogeneity test was employed to check the importance of each variable for the long-run equilibrium relationship. The results of the weak exogeneity test with rank (*r* =2) provided evidence that none of the variables was weakly exogenous, as their corresponding *p*-values with the chosen rank (*r* =2) were significant at the 5 per cent level (Table 6). Furthermore, the variable exclusion test provided evidence that none of the variables was excluded from the system, as their corresponding *p*-values with the chosen rank (*r* =2) were significant at the 5 per cent level (Table 7).

It is widely accepted that the imposition of restrictions in an econometric model may produce plausible economic conclusions. The imposition of zero restrictions on β is justified, as the likelihood ratio (LR)

Table 6. Test of weak exogeneity

r	DF	5% C.V.	*lpcapi*	*lpcapp*	*lpcapb*
1	1	3.841	7.671 [0.006]	2.448 [0.118]	1.919 [0.166]
2	2	5.991	13.347 [0.001]	7.406 [0.025]	10.120 [0.006]

Note: The values within the brackets correspond to the *p*-values, *r* stands for rank, DF stands for degrees of freedom.

Table 7. Test of exclusion

r	DF	5% C.V.	*lpcapi*	*lpcapp*	*lpcapb*
1	1	3.841	6.766 [0.009]	7.877 [0.005]	2.412 [0.120]
2	2	5.991	14.326 [0.001]	16.544 [0.000]	7.015 [0.030]

Note: The values within the brackets correspond to the *p*-values, *r* stands for rank, DF stands for degrees of freedom.

test was equal to 0.952 with a *p*-value of 0.621. Further, these zero restrictions provided the following relations:

(i) Between the per-capita agricultural production of Pakistan and India

$$lpcapp = \underset{(215.878)}{0.994}\ lpcapi \qquad \ldots(7)$$

where, *lpcapp* is the log per-capita agricultural production of Pakistan and *lpcapi* is the log per-capita agricultural production of India, while the value within the parentheses corresponds to the *t*-value. From Equation (7), it is observed that 1 per cent increase in the log per-capita agricultural production of India would increase the log per-capita agricultural production of Pakistan by 0.994 per cent.

(ii) Between the per-capita agricultural production of India and Bangladesh

$$lpcapi = \underset{(35.309)}{0.994}\ lpcapb \qquad \ldots(8)$$

where, *lpcapi* is the log per-capita agricultural production of India and *lpcapb* is the log per-capita agricultural production of Bangladesh, while the value within the parentheses corresponds to the *t*-value. From Equation (8), it is observed that 1 per cent increase in the log per-capita agricultural production of Bangladesh would increase the log per-capita agricultural production of India by 0.906 per cent.

Impulse Response Functions of VECM

Figure 2 shows the impulse response functions under VECM of the three variables within a time interval of 70 periods. Transitory shock (1) and transitory shock (2) represent transitory shocks and permanent shock (1) represents the permanent shock of the system. The first column [Transitory shock (1)] of Figure 2 shows that an unexpected shock to the per-capita agricultural production of India has transitory positive effects on it and on the per-capita agricultural production of Bangladesh, while the per-capita agricultural production of Pakistan is negatively influenced. The second column [Transitory shock (2)] of Figure 2 again shows that a sudden shock to the per-capita agricultural production of Pakistan has transitory positive impacts on it and the other two variables. These transitory shocks are said to be short-term effects that converge later on. Finally, the third column [Permanent shock (1)] of Figure 2 shows that an unexpected permanent shock to the per-capita agricultural production of Bangladesh will cause a long-term disequilibrium of *lpcapi*, *lpcapp* and *lpcapb*.

Markov-Switching Vector Error Correction Model (MS-VECM)

To account for the structural breaks in the per-capita agricultural production of Bangladesh, India and

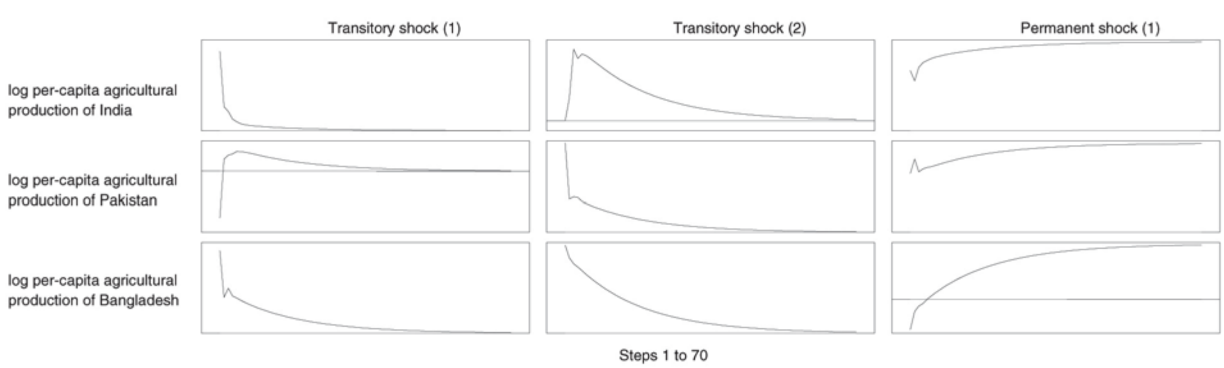

Figure 2. Impulse response functions of VECM

Table 8. Coefficients of the MS(2)-VECM(1)

Variable	Regime 1			Regime 2		
	Δlpcapi Coefficient	*Δlpcapp* Coefficient	*Δlpcapb* Coefficient	*Δlpcapi* Coefficient	*Δlpcapp* Coefficient	*Δlpcapb* Coefficient
Constant	0.009 (0.659)	-0.031 (0.024)	-0.027 (0.165)	0.012 (0.361)	0.010 (0.353)	-0.025 (0.221)
Δlpcapi_1	0.361 (0.108)	-0.155 (0.304)	0.637 (0.002)	-0.733 (0.000)	0.194 (0.164)	-0.721 (0.007)
Δlpcapp_1	-0.405 (0.069)	-0.215 (0.166)	0.324 (0.118)	0.430 (0.072)	0.242 (0.217)	0.855 (0.027)
Δlpcapb_1	0.142 (0.438)	-0.309 (0.022)	-0.060 (0.733)	0.197 (0.078)	-0.107 (0.235)	-0.115 (0.508)
Ect1	0.846 (0.000)	-0.557 (0.000)	0.118 (0.497)	0.263 (0.103)	-0.056 (0.640)	-0.061 (0.798)
Ect2	0.024 (0.656)	0.098 (0.007)	0.031 (0.533)	-0.023 (0.501)	-0.017 (0.532)	0.112 (0.036)
Variance	0.0007(0.001)	0.0003(0.001)	0.0006(0.001)	0.0007(0.001)	0.0005(0.000)	0.0018(0.001)
Duration		6.757			8.333	
No. of observations		24			24	
P		0.852			0.880	

Note: Δlpcapi, *Δlpcapp* and *Δlpcapb* are the first differences of the per-capita agricultural production of India (*lpcapi*), Pakistan (*lpcapp*) and Bangladesh (*lpcapb*) in logs, *Δlpcapi_1*, *Δlpcapp_1* and *Δlpcapb_1* are the variables of lag one, *Ect* is error correction term, *P* is the probability, while the values within the parentheses correspond to the *p*-values of each variable.

Pakistan, the study used MS-VECM. The structural breaks are the regime switches over the period, where certain parameters are allowed to vary between the periods. This study considered two regimes and included one lag that had produced two variance-covariance matrices as well as one transition matrix. The estimated results of MS(2)-VECM(1) are reported in Table 8. A perusal of Table 8 reveals that the estimated coefficients differed between these two regimes. It is also observed that regime 1 is characterized as a low volatility regime since the variances of *lpcapi*, *lpcapp* and *lpcapb* are 0.0007, 0.0003 and 0.0006, respectively, which are lower than the corresponding variances of regime 2. Thus, regime 2 is characterized as a high volatility regime. The average duration of the low volatility regime (regime 1) is 6.757 years and that of the high volatility regime (regime 2) is 8.333 years, which was calculated by using the formula $d = (1–P)^{-1}$, where P is the probability of the agricultural production transmission staying in the same regime. The number of observations for each regime was 24, which was selected considering the smoothed probability, which is higher than 0.5. Moreover, there is a high probability of regime 2 staying in the same regime compared with regime 1, since the probability of regime 2 (0.880) is higher than that of regime 1 (0.852).

The smoothed probabilities of regime 1 are given in Figure 3. From this graph, it is clearly identified that the low volatility regime (regime 1) dominated the years 1965–1966, 1978–1996 and 2007–2009. On the other hand, the high volatility regime (regime 2) dominated the years 1963–1964, 1967–1977, 1997–2006 and 2010. The low volatility of regime 1 can be related to the following changes in the institutional and agricultural policies taken by India, Pakistan and Bangladesh. Pakistan had set up an Agricultural Price Commission in 1981, while India established the National Bank for Agriculture and Rural Development (NABARD) in 1982, started economic reforms in 1991 and implemented the World Trade Organization Agreement on Agriculture in 1995. Finally, Bangladesh implemented its Seed Policy in 1993 for ensuring a balanced production in agriculture.

The following changes to institutional and agricultural policies might be linked with the high volatility of regime 2. The Indus river treaty between India and Pakistan in 1960 and implementation of the green revolution by India and Pakistan in 1966 might have increased the volatility of agricultural production. The implementation of land reforms in 1972 by India and Pakistan included a ceiling of land on individual holdings. The Government of Bangladesh implemented

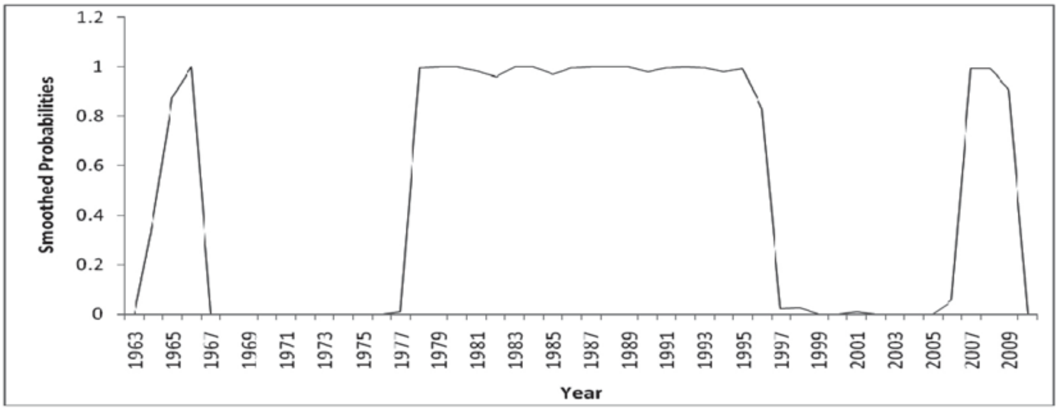

Figure 3. The smoothed probabilities of regime 1 for the MS(2)-VECM(1) model

its National Agriculture Policy in 1999 and actionable policy brief in 2004 to boost land, labour and water productivity, which might have caused the high volatility of regime 2. Moreover, some natural disasters might also have caused the high volatility of regime 2. In particular, a devastating cyclone struck Bangladesh and part of India in 1970. The drought of Pakistan happened between 1998 and 2002, which was the worst one in the past 50 years. The drought of India happened in 2002 and this was ranked as a hydrological drought. Finally, the war between Bangladesh and Pakistan in 1971 clearly shows the effects of high volatility on agricultural production in regime 2.

Causality Test

The results of the t-tests for short- and long-term causality are presented in Table 8. This study also performed Wald tests to examine the short- and long-term causality which are presented in Table 9. Note that the results of the t-tests and those of the Wald statistics support the same causal effects among the countries under consideration. More specifically, the test results of the low volatility regime (regime 1) have shown that India (*lpcapi)* is adjusting to the long-term deviation from the equilibrium generated from the relation between Pakistan and India (*Ect1*) since the coefficient of the error correction term (i.e. 0.846, from Table 8) is statistically significant at 1 per cent level of significance (i.e. the Wald test statistic is 21.705 with *p*-value 0.000, from Table 9) and it requires about 1.18 years to adjust. However, India (*lpcapi*) is not adjusting to the long-term deviation from the equilibrium generated from the relation between India and Bangladesh (*Ect2*) since the coefficient of the error correction term (i.e. 0.024, from Table 8) is not statistically significant at any conventional level of significance (i.e. the Wald test statistic is 0.198 with *p*-value 0.656).

Pakistan (*lpcapp)* is adjusting to the long-term deviation from the equilibrium generated from the both relations (i.e. *Ect1* and *Ect2*) since the coefficients of error correction terms (i.e. -0.557 and 0.098, from Table 8, respectively) are statistically significant at 1 per cent level of significance (i.e. the Wald test statistics are 19.097 and 7.177 with *p*-values 0.000 and 0.007, respectively). Pakistan (*lpcapp)* needs about 1.80 years and 10.20 years to adjust to the long-term deviation of *Ect1* and *Ect2*, respectively. On the contrary, Bangladesh (*lpcapb)* is not adjusting to the long-term deviation from the equilibrium of any relation (i.e. *Ect1* and *Ect2*) since its coefficients of error correction terms (i.e. 0.118 and 0.031, from Table 8, respectively) are not statistically significant at any conventional level of significance (i.e. the Wald test statistics are 0.462 and 0.388 with *p*-values 0.497 and 0.533, respectively). Thus *lpcapb* can be considered as an exogenous variable. In the short-term, *lpcapi* reacts to lagged changes in *lpcapp* (i.e. the Wald test statistic is 3.298 with *p*-value 0.069), while *lpcapp* reacts to lagged changes in *lpcapb* (i.e. the Wald test statistic is 5.259 with *p*-value 0.022). Finally, *lpcapb* responds to lagged changes in *lpcapi* (i.e. the Wald test statistic is 9.149 with *p*-value 0.002), indicating the existence of unidirectional causality which is directed from Pakistan to India, Bangladesh to Pakistan and India to Bangladesh.

On the other hand, for the high volatility regime (regime 2), India (*lpcapi*) is not adjusting to the long-term deviation from the equilibrium of any relation (i.e. *Ect1* and *Ect2*) since its coefficients of error correction terms (i.e. 0.263 and -0.023, from Table 8, respectively) are not statistically significant at any conventional level of significance (i.e. the Wald test statistics are 2.662 and 0.453 with *p*-values 0.103 and 0.501, respectively). Similarly, Pakistan (*lpcapp*) is not adjusting to the long-term deviation from the equilibrium of any relation (i.e. *Ect1* and *Ect2*) since its coefficients of error correction terms (i.e. -0.056 and -0.017, from Table 8, respectively) are not statistically significant at any conventional level of significance (i.e. the Wald test statistics are 0.218 and 0.390 with *p*-values 0.640 and 0.532, respectively). Thus, *lpcapi* and *lpcapp* can be considered as exogenous variables. Bangladesh (*lpcapb)* is not adjusting to the long-term deviation from the equilibrium generated from the relation between Pakistan and India (*Ect1*) since the coefficient of the error correction term (i.e. -0.061, from Table 8) is not statistically significant at any conventional level of significance (i.e. the Wald test statistic is 0.066 with *p*-value 0.798). However, Bangladesh (*lpcapb*) is adjusting to the long-term deviation from the equilibrium generated from the relation between India and Bangladesh (*Ect2*) since the coefficient of the error correction term (i.e. 0.112, from Table 8) is statistically significant at 5 per cent level of significance (i.e. the Wald test statistic is 4.404 with *p*-value 0.036) and it requires about 8.9 years to adjust. In the short-term, *lpcapb* responds to lagged changes in *lpcapi* and *lpcapp* (i.e. the Wald test statistics are 7.396 and 4.913 with *p*-values 0.007 and 0.027, respectively). Further, *lpcapi* reacts to lagged changes in *lpcapp*, *lpcapb* (i.e. the Wald test statistics are 3.234 and 3.116 with *p*-values 0.072 and 0.078, respectively) and lagged changes in its own agricultural production (i.e. the Wald test statistic is 18.906 with *p*-value 0.000), indicating bidirectional causality between *lpcapi* and *lpcapb*. However, *lpcapp* does not respond to the lagged changes of any variables, indicating that it is not dominated by any country when the volatility of agricultural production is high. Finally, the adjustments to the long-term deviation from the equilibrium of all countries are opposite their regimes (i.e. countries adjusting to one regime, do not adjust to the other regime).

Impulse Response Functions of MS-VECM

Figure 4 displays the impulse response functions of MS-VECM. The first graph of regime 1 in Figure 4 shows that responses to a shock in the per-capita agricultural production of India positively affects the per-capita agricultural production of Bangladesh, but negatively affects that of Pakistan (it requires about 10 years to come to the equilibrium level). The second graph of regime 1 shows that responses to a shock in the per-capita agricultural production of Pakistan positively affects the per capita agricultural production of Bangladesh, but negatively affects that of India (it requires about 7 years to come to the equilibrium level). The third graph of regime 1 shows that responses to a shock in the per-capita agricultural production of Bangladesh positively affects the per-capita agricultural production of India, but negatively affects that of Pakistan (it requires about 9 years to come to the equilibrium level).

Table 9. Wald test results

	Δlpcapi_1	*Δlpcapp_1*	*Δlpcab_1*	*Ect1*	*Ect2*
			Regime 1		
Δlpcapi	2.58599 (0.108)	3.29776 (0.069)	0.60148 (0.438)	21.70486 (0.000)	0.19849 (0.656)
Δlpcapp	1.05806 (0.304)	1.91450 (0.166)	5.25879 (0.022)	19.09746 (0.000)	7.17709 (0.007)
Δlpcapb	9.14908 (0.002)	2.44042 (0.118)	0.11639 (0. 733)	0.46190 (0.497)	0.38829 (0.533)
			Regime 2		
Δlpcapi	18.90559 (0.000)	3.23378 (0.072)	3.11558 (0.078)	2.66216 (0.103)	0.45318 (0.501)
Δlpcapp	1.94012 (0.164)	1.52656 (0.217)	1.41170 (0.235)	0.21814 (0.640)	0.39037 (0.532)
Δlpcapb	7.39609 (0.007)	4.91298 (0.027)	0. 43912 (0. 508)	0.06566 (0.798)	4.40415 (0.036)

Note: The values within the parentheses correspond to the *p*-value. *Δlpcapi*, *Δlpcapp* and *Δlpcapb* are the first differences of the per-capita agricultural production of India (*lpcapi*), Pakistan (*lpcapp*) and Bangladesh (*lpcapb*) in logs, *Δlpcapi_1*, *Δlpcapp_1* and *Δlpcapb_1* are the variables of lag one

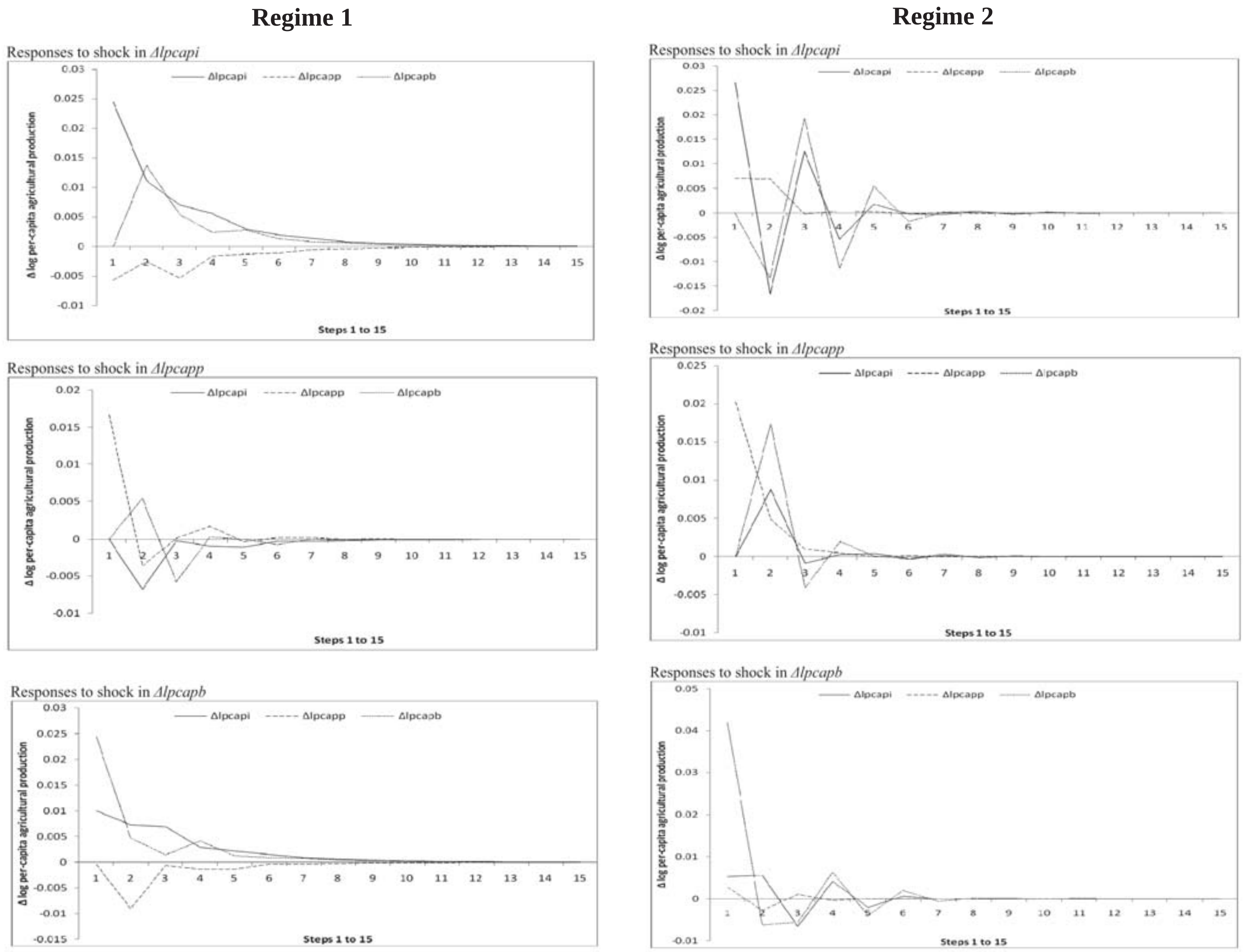

Figure 4. Impulse response functions of MS-VECM, *Δlpcapi*, *Δlpcapp* and *Δlpcapb* are the first differences of the per-capita agricultural production of India, Pakistan and Bangladesh in logs, respectively.

By contrast, the first graph of regime 2 shows that responses to a shock in the per-capita agricultural production of India negatively affects that of Bangladesh but positively affects Pakistan's agricultural production (it needs about 7 years to come to the equilibrium level). The second graph of regime 2 shows that responses to a shock in the per-capita agricultural production of Pakistan positively affects that of India and Bangladesh and that it requires about 5 years to come to the equilibrium level. The third graph of regime 2 shows that responses to a shock in the per-capita agricultural production of Bangladesh positively affects that of India but negatively affects that of Pakistan (it requires about 8 years to come to the equilibrium level). A cursory look at Figure 4 shows that the agricultural production adjustments in regime 1 are smoother than those in regime 2, while the adjustments are faster in the case of a shock to agricultural production in Pakistan than to the agricultural production of either Bangladesh or India in both regimes.

Conclusions

The paper has investigated the relationships and effects of the impulse responses of the per-capita agricultural production of three SAARC countries, namely Bangladesh, India and Pakistan, for the period 1961–2010. These three countries have been selected since they convey very strong agricultural economic importance to the region. The models, VECM and MS-VECM, have been used to investigate the relationships between the per-capita agricultural production of Bangladesh, India and Pakistan. The impulse response functions of VECM and MS-VECM have also been employed to investigate the responses of shocks to the per-capita agricultural production of these countries. The findings of this paper also support using these econometric applications since the models are fitted well.

The study has supported the presence of two long-term cointegrating relations between per-capita agricultural production: (i) Pakistan–India, and (ii) India–Bangladesh. The restricted model has been justified by the LR test. From the long-term relation between Pakistan and India, it is observed that an increase in the per-capita agricultural production of India would increase the per-capita agricultural production of Pakistan. Furthermore, the cointegrating relation between India and Bangladesh has shown that an increase in the per-capita agricultural production of Bangladesh would increase the per-capita agricultural production of India. The VECM has provided results on the impulse response functions, which indicate that transitory impacts are very low (almost null), while permanent impacts are high and quite similar for the three countries under examination.

Moreover, the MS-VECM findings have shown two volatile regimes: a low volatile regime (regime 1) and a high volatile regime (regime 2). The average duration of the low volatile regime has been found about 6.757 years and that of the high volatile regime about 8.333 years. The smoothed probabilities of the model have indicated that the high volatile regime has a stronger probability of staying in the same regime than that of the low volatile regime. Regime 2 clearly holds the reasons that might play an important role behind the high volatility of the regime such as war, natural disasters, the implementation of green revolution, land reforms and the various agricultural policies taken by Bangladesh, India and Pakistan.

The MS-VECM has provided the results on the use of impulse response functions for the low volatility regime (regime 1) and the high volatility regime (regime 2). In particular, it has found that the agricultural production adjustments in regime 1 are smoother than those in regime 2 and that in the case of a shock to the agricultural production, the adjustments are faster in Pakistan than in either Bangladesh or India in both regimes.

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References

Assadzadeh, A. and Nasab, M.H.N. (2012) Investigating the relationship between tourism industry and GDP in the Islamic Republic of Iran. *International Review of Business Research Papers,* **8**(2): 85–95.

Ben-Kaabia, M., Gil, J.M. and Chebbi, H. (2002) The effect of long-run identification on impulse-response functions: An application to the relationship between macroeconomics and agriculture in Tunisia. *Agricultural Economic Review*, **3**(2): 36–48.

Chowdhury, M.B. (2011) Remittances flow and financial development in Bangladesh. *Economic Modelling,* **28**(6): 2600–2608.

Chowdhury, M.B. (2012) Foreign aid and trade competitiveness in SAARC. *Indian Journal of Asian Affairs*: **25**: 21– 41.

Dennis, J.G. (2006) *Cats in Rats: Cointegration Analysis of Time Series*. Estima, Illinois, USA.

Dickey, D.A. and Fuller, W.A. (1981) Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica*, **49**(4): 1057–1072.

Elliott, G., Rothenberg, T.J. and Stock, J.H. (1996) Efficient tests for an autoregressive unit root. *Econometrica*, **64**(4): 813–836.

Frey, G. and Manera, M. (2007) Econometric models of asymmetric price transmission. *Journal of Economic Surveys*, **21**(2): 349–367.

Giese, J.V. (2005) Level, slope, curvature: characterising the yield curve's derivatives in a cointegrated VAR model. *A Paper Presented at International Conference in Finance*. 2–4 September, University of Copenhagen, Denmark.

Granger, C.W.J. (1969) Investigating causal relations by econometric models and cross spectral methods. *Econometrica*, **37**: 424–438.

Gunes, S. (2007) Functional income distribution in Turkey: A cointegration and VECM analysis. *Journal of Economic and Social Research*, **9**(2): 23–36.

Hannan, E. J., and Quinn, B. G. (1979) The determination of the order of an autoregression. *Journal of the Royal Statistical Society. Series B (Methodological)*, **41**: 190–195.

Hsiao, C. (1981) Autoregressive modeling and money–income causality detection. *Journal of Monetary Economics,* **7**(1): 85–106.

Johansen, S. (1996) *Likelihood-based Inference in Cointegrated Vector Autoregressive Models.* 2nd edn. Oxford University Press, Oxford.

Johansen, S. and Juselius, K. (1990) Maximum likelihood estimation and inference on cointegration with applications to the demand for money. *Oxford Bulletin of Economics and Statistics,* **52**: 169–210.

Joshi, A. (2013) Long-term causality of GDP-led export (GLE) using VECM model with reference to India. *Sanchayan,* **2**(1): 14–25.

Juselius, K. (2006) *The Cointegrated VAR Model Methodology and Applications.* Oxford University Press, New York.

Khan, M.A. and Sajid, M.Z. (2007) Integration of financial markets in SAARC countries: Evidence based on uncovered interest rate parity hypothesis. *Kashmir Economic* Review, **XVI**(1): 1–16.

Krolzig, H.M. (1996) *Statistical Analysis of Cointegrated VAR Processes with Markovian Regime Shifts.* SFB 373 Discussion Paper 25/1996, Humboldt-Universitätzu, Berlin.

Krolzig, H.M., Marcellino, M. and Mizon, G.E. (2002) A Markov-switching vector equilibrium correction model of the UK labour market. *Empirical Economics,* **27**: 233–254.

Kwiatkowski, D., Phillips, P.C.B, Schmidt, P. and Shin,Y. (1992) Testing the null hypothesis of stationarity against the alternative of a unit root. *Journal of Econometrics,* **54**: 159–178.

Newey, W.K. and West, K.D. (1994) Automatic lag selection in covariance matrix estimation. *Review of Economic Studies,* **61**: 631–653.

Phillips, P.C.B. and Perron, P. (1988) Testing for a unit root in time series analysis. *Biometrica,* **75**(2): 335–346.

Pradhan, R.P. and Bagchi, T.P. (2012) The expenditure-GDP nexus: Evidence from a panel of SAARC 7-countries. *International Journal of Public Policy,* **8**(4/5/6): 295–307.

Rahbek, A. and Shephard, N. (2002) *Autoregressive Conditional Root Model.* Nuffield College, Economics Working Paper, 2002.

Rashid, F., Ullah, S. and Bedi-uz-Zaman (2012) Effects of exports instability on economic growth in SAARC region countries. *Pakistan Journal of Commerce & Social Sciences,* **6**(1): 97–120.

Rezitis, A.N., Mentesidi, F. and Stavropoulos, K.S. (2009) Price transmission and Markov switching regime shifts: An application to the Greek lamb market. *Research Topics in Agricultural and Applied Economics,* **1**: 1–22.

Rezitis, A.N., and Pachis, D.N. (2013) Investigating the price transmission mechanism of the Greek fresh tomato market with a Markov-switching vector error correction model. *Agricultural Economics Review,* **14**(2): 29–45.

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