Symmetric Market Integration of Wheat in the World

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Abstract

This study determined market integration of wheat in the world using price time series (1966-2018) of major world producing countries. The data were sourced from FAO database and data analysis were performed using unit root tests, Engel-Granger and Johansen co-integration tests, Granger causality and impulse response tests, restricted vector auto-regression (VAR), and auto-regression integration moving average (ARIMA) models. The empirical evidence showed that the law of one price (LOP) or parity in prices failed to hold in these markets due to poor co- integration among these markets. Furthermore, the wheat prices of Indian, USA and China markets were efficient as they established long-run equilibrium. However, Australian, Canadian and France markets were observed to be autarkic markets as short-run disequilibrium adjustment processes will not lead to stable long-run prices. It was established that USA market prices is a relative follower and plays little or no role in the global wheat trade. Therefore, the study recommends that a network of wheat commodity network across the globe at almost equal distance from each other for the enhancement of *market integration and price transmission should be designed.*

Keywords: *Integration, Market, Wheat, World*

Dünyada Buğdayın Simetrik Piyasa Entegrasyonu

Öz

Bu çalışma dünyanın önde gelen üretici ülkelerinin fiyat zaman serilerini (1966-2018) kullanarak buğdayın dünyadaki piyasa entegrasyonunu belirlemiştir. Veriler FAO veri tabanından alınmış ve birim kök testleri, Engel-Granger ve Johansen eşbütünleşme testleri, Granger nedensellik ve dürtüsellik testleri ve kısıtlı vektör otoregresyon (VAR), otoregresif entegre hareketli ortalama (ARIMA) modelleri kullanılarak veri analizi yapılmıştır. Elde edilen bulgular, tek fiyat (LOP) kanununun veya paritenin, bu piyasalar arasındaki zayıf eşbütünleşme nedeniyle bu piyasalarda geçerli olmadığını göstermiştir. Ayrıca Hindistan, ABD ve Çin piyasalarının buğday fiyatları uzun dönemli dengeyi sağladıkları için etkindir. Ancak, Avustralya, Kanada ve Fransa piyasalarının, kısa vadeli dengesizlik ayarlama süreçleri istikrarlı uzun vadeli fiyatlara yol açmayacağı için otarşik piyasalar olduğu gözlemlenmiştir. ABD piyasa fiyatlarının göreli bir takipçisi olduğu ve küresel buğday ticaretinde çok az rol oynadığı veya hiç rol oynamadığı tespit edilmiştir. Bu nedenle, çalışma, piyasa entegrasyonunu ve fiyat aktarımını geliştirmek için dünya çapında birbirinden neredeyse eşit mesafede bir buğday emtia ağının tasarlanmasını önermektedir.

Anahtar Kelimeler: *Entegrasyon, Piyasa, Buğday, Dünya*

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INTRODUCTION

Food profiteering has been roundly condemned throughout history. Many involved in speculation, hoarding, exploitation or otherwise extracting money from sustenance have faced extreme rebuke, imprisonment or even execution (Berg, 2011). The once maligned food profiteer, in particular the commodity speculator, has been turned into a broadly positive and welcome force in the twenty-first century. The modern commodity speculator, far from causing damage or havoc, is often celebrated as the latest food cycle oracle, boldly wagering multi-million dollar bets on the course of prices on gigantic futures exchanges.

Although pouring unprecedented sums of cash into trading commodities, speculators argue that they are merely helping what futures markets are expected to do, at any moment in time finding the equilibrium price of products. They provide a societal good by providing "liquidity" and, citing numerous supporting economic studies, maintain that their trading activities have negligible effects on global benchmark prices or affect the food security policies of almost every country dependent on commodities. In short, they have managed to lift themselves to a respectable professional class, protected to some degree from ethical inquiry, unlike speculators of the past.

In the face of a future that is not yet understood, economic agents are continually forced to make decisions (Prakash and Stigler, 2011). Therefore, in evaluating current economic variables, expectations play an important role. The expectations that agents have at all times, on the other hand, are dictated by the knowledge they have on the economic system at that date, in particular on their current and former states. Therefore, observed economic processes are the product of a powerful and complex relationship between the expectations of the participating agents and the actual realization of economic variables (Grandmont, 1977; Godwin *et al*., 2008). Consequently, the price system's evolution and stability would rely on the rules and processes used by agents to build and revise expectations (Easy *et al*., 2008).

Wheat commerce outnumbers all other crops combined on a worldwide scale. The global wheat production volume in the marketing year 2019/2020 was around 765 million metric tons. In comparison to the previous marketing year, this represented an increase of over 30 million tons (Shahbandeh, 2021).

The sustained rise in food prices would have a direct effect on the rate of incidence of poverty. A number of studies indicate that the majority of the poor are net food consumers and are thus adversely affected by the increase in food prices (Poulton *et al*., 2006; Christiaensen and Demery, 2006). In assessing the impact on producers and consumers and understanding how they adapt to price shocks, price transmission between food markets is central (Rapsomanikis, 2011). Generally speaking, the lack of market convergence or the full transition of price increases from one market to another has significant repercussions for economic well-being. In general, weak transmission results in lower prices of information available to economic agents, leading to decisions that lead to less elastic demand and supply responses.

As a measure of overall market success in a number of nations, numerous researchers have used spatial price behavior in cereal markets. Integration of the spatial market is the smooth transmission of price signals and information across spatially isolated markets or the measure of the degree to which demand and supply are transmitted from one place to another. Given that variations in regional crop production patterns are often affected by ecological factors, policymakers may be interested in knowing the relationship between the price movements of staple foods in different regions.

Isolated markets can transmit inaccurate price information that could distort producer-marketing decisions and lead to inefficient movements of goods. Utilities of form, time and place regulate production, consumption and also help to make successful marketing decisions (Kohl and Uhl, 1998; Wani et al., 2015). These decisions are driven by price signals that decide the flow of marketing activities and provide guidance on how supplies are disposed of. An important feedback on the understanding of the market is provided by the inter-regional/continental markets located at distant locations from the place of production and the consequent price differences.

Producers and consumers have all been concerned about the uncertainty regarding future prices. The two significant roles performed by advance contracts were found to be price discovery and price risk management (Thomas, 2003; Ahuja, 2006; Wani *et al*., 2015). Therefore, it could be perceived that a reasonably good understanding of prices at a future date would encourage the reasonable market decisions of producers (particularly with regard to the choice of market(s) and the quantity of products to be dispatched) for the maximization of profit. Market convergence and price forecasting will help to stabilize markets against this backdrop by eliminating market imperfections such as monopolies and monopsonies and achieving market efficiency (Mushtaq *et al*., 2008; Wani *et al*., 2015).

The prerequisites for an effective marketing system are perfect market integration and full price transition (Praveen and Inbasekar, 2015). A marketing system of this standard will omit non-profit arbitrage and easily modify the price adjustments. A well-coordinated and successful marketing system will provide all the players in the marketing chain with full benefits. Spatial market integration knowledge can provide insights into competition, arbitration effectiveness, and pricing efficiency, thus helping to understand the overall success of the market. Market integration studies can dispense details of market performance needed for policy formulation and macroeconomic modelling. Price signals transmitted by non-integrated markets would also deceive the marketing decisions of producers and result in inefficient movement of products.

Taking into account the importance of the information that emerges from market integration studies, an attempt is made to discern the status of market integration between the world's international wheat markets. Moreover, where markets are spatially distributed, the analysis of the existence and degree of market integration is more important. Recognizing the significance of pricing knowledge in different markets for producers and market functionaries to make profit-oriented marketing decisions, this study empirically determined the degree of integration among various major international wheat markets and forecast their future prices in order to help producers make successful market-oriented decisions.

The specific objectives were to determine the extent of market integration among the selected markets; to determine the degree of market integration among the selected markets; to examine the process of price formation in these markets; to determine the effect of bad news on each market prices; and, to predict the future prices of wheat in each of the selected market.

Hypothesis

H_{01}: long-run equilibrium does exist among the selected markets

H_{02}: The law of one price does not hold among the selected markets

RESEARCH METHODOLOGY

Annual time series data of 52 years (1966-2018) sourced from FAO databank and covered price series of six major wheat-producing countries *viz*. Australia, Canada, China, France, India and USA were used for the study. Objectives 1, 2, 3, 4 and 5 were analyzed using unit root tests, Engel-Granger and Johansen co-integration test models; restricted Vector autoregressive (VAR) model; Granger causality test; impulse response functions; and Autoregressive integrated moving average (ARIMA) model, respectively.

Model Selection Criteria

The information criteria are computed for the VAR models of the form:

$$Y_t = A_1 Y_{t-1} + \ldots\ldots + A_n Y_{t-n} + B_q X_{t-q} + CD_t + \varepsilon_t \quad (1)$$

Where Y_t is K-dimensional. The lag order of the exogenous variables X_t, q, and deterministic term D_t have to be pre-specified. For a range of lag orders n the model is estimated by OLS (Sadiq *et al*., 2016a; Sadiq *et al*., 2016b). The optimal lag is chosen by minimizing one of the following information criteria:

$$AIC(n) = log\ det\ \{\textstyle\sum_u(n)\} + \left(\frac{2}{T}\right) nK^2 \quad (2)$$

$$HQ(n) = log\ det\ \{\textstyle\sum_u(n)\} + \left(\frac{2log\ log\ T}{T}\right) nK^2 \quad (3)$$

$$SC(n) = log\ det\ \{\textstyle\sum_u(n)\} + \left(\frac{log\ T}{T}\right) nK^2 \quad (4)$$

$$FPE(n) = \left(\frac{T+n^*}{T-n^*}\right)^k det\ \{\textstyle\sum_u(n)\} \quad (5)$$

Where$\sum_u(n)$ is estimated by$T^{-1}\sum_{t=1}^{T} U_t U_t^1$, $n^*$is the total number of parameters in each equation of the model when n is the lag order of the endogenous variables, also counting the deterministic terms and exogenous variables. The sample length is the same for all different lag lengths and is determined by the maximum lag order (Sadiq *et al*., 2016a).

Augmented Dickey Fuller test

Following Sadiq *et al.* (2017a) the autoregressive formulation of the ADF test with a trend term is given below:

$$\Delta P_t = \alpha + P_{t-1} + \textstyle\sum_{j=2}^{it} \beta_i \Delta P_{it-j+t} + \varepsilon \quad (6)$$

Where, $P_{it}$is the price in market *i* at the time *t*, $\alpha$and$\Delta P_{it}(P_{it} - P_{t-1})$ is the intercept or trend term.

Engel and Granger Co-Integration Test

Following Engel and Granger (1987), the formulation tests on residual from the co-integration test is given below:

$$P_1 = \alpha + P_2 + \varepsilon \quad (7)$$

Where, P_1 and P_2 are two price series from different markets,α is constant, and ε is noise

The residuals from the above equation are considered to be temporary deviations from the long-run equilibrium. ADF unit root test is then conducted on the residual obtained from equation 7.

Johansen's Co-Integration Test

Following Johansen (1988); Sadiq et al.(2018) the multivariate formulation is specified below:

$$P_t = A_1 P_{t-1} + \varepsilon_t \quad (8)$$

So that

$$\Delta P_t = A_1 P_{t-1} - P_{t-1} + \varepsilon_t \quad (9)$$

$$P_t = (A_1 - 1)P_{t-1} + \varepsilon_t$$

$$\Delta P_t = \prod P_{t-1} + \varepsilon_t$$

Where, $P_t$and ε_t are $(n \times 1)$ vectors; A_t is an $(n \times n)$ matrix of parameters; I is an $(n \times n)$ identity matrix, and $\prod$ is the $(A_1 - 1)$matrix.

Using the estimates of the characteristic roots, the tests for the number of characteristic roots that are insignificantly different from unity were conducted using the following statistics:

$$\lambda_{trace} = -T \textstyle\sum_{i=r+1}^{n} ln\,(1 - \lambda_i) \quad (10)$$

$$\lambda_{max} = -T\ ln(1 - \lambda_i + 1) \quad (11)$$

Where, λ_i denotes the estimated values of the characteristic roots (Eigen-values) obtained from the estimated $\prod$ matrix, and T is the number of usable observations.

Granger Causality Test

Following Granger (1969); Sadiq *et al*.(2017) the model used to check whether market P_1 Granger causes market P_2or vice-versa is given below:

$$P_t = \alpha + \textstyle\sum_{i=1}^{n}(\emptyset P_{1t-i} + \delta_i P_{2t-i}) + \varepsilon_i \quad (12)$$

A simple test of the joint significance of $\delta_i$was used to check the Granger causality i.e.

$$H_0 := \delta_1 = \delta_2 = \ldots\ldots.. \delta_n = 0.$$

Vector Error Correction Model (VECM)

The VECM explains the difference in $y_t$and y_{t-1} (i.e.,Δy_t) and it is shown below (Sadiq *et al.*, 2016a; Sadiq *et al.*, 2016b; Sadiq *et al.*, 2020):

$$\Delta \gamma_t = \alpha + \mu(\gamma_{t-1} - \beta_{xt-1}) + \textstyle\sum_{i=0}^{i=t} \delta_i \Delta x_{t-1} + \textstyle\sum_{i=1}^{i=t} \gamma_i \Delta \gamma_{t-1} \quad (13)$$

It includes the lagged differences in both *x* and *y*, which have a more immediate impact on the value of$\Delta \gamma_t$.

Impulse Response Functions

The generalized impulse response function (GIRF) in the case of an arbitrary current shock

(δ) and history (ω_{t-1})is specified below (Rahman and Shahbaz, 2013; Beag and Singla, 2014) :

$$GIRF_Y(h, \delta, \omega_{t-1}) = E[Y_t + h \mid \delta, \omega_{t-1}] - E[Y_{t-1} \mid \omega_{t-1}] \quad (14)$$

Forecasting Accuracy

Mean absolute prediction error (MAPE), relative mean square prediction error (RMSPE), relative mean absolute prediction error (RMAPE), Theil's U statistic, and R^2 were determined using the following formulas to test accuracy in the fitted time series model:

$$MAPE = 1/T \sum_{i=1}^{5}(A_{t-1} - F_{t-1}) \quad (15)$$

$$RMPSE = 1/T \sum_{i=1}^{5} (A_{t-1} - F_{t-1})^2 / A_{t-1} \quad (16)$$

$$RMAPE = 1/T \sum_{i=1}^{5} (A_{t-1} - F_{t-1}) / A_{t-1} \times 100 \quad (17)$$

$$U = \sqrt{\frac{\sum_{t=1}^{n-1} \frac{(\hat{Y}_{t+1} - Y_{t+1})^2}{Y_t}}{\sum_{t=1}^{n-1} \frac{(Y_{t+1} - Y_t)^2}{Y_t}}} \quad (18)$$

$$R^2 = 1 - \frac{\sum_{i=1}^{n}(A_{ti} - F_{ti})}{\sum_{i=1}^{n}(A_{ti})} \quad (19)$$

Where, R^2= coefficient of multiple determination,A_t = Actual value; F_t = Future value, and T = time period

RESULTS AND DISCUSSION

Lag Selection Criteria

For a parsimonious result, two selection criteria *viz.* Akaike and Hannan-Quinn criteria against Bayesian criterion advised for the selection of lag six as the length of truncation as indicated by the 'asterisk' sign against their respective coefficient (Table 1). Thus, the unit root tests, multivariate co-integration test and vector auto-regression estimation were fitted with lag six proffered by Akaike and Hannan-Quinn criteria.

Table 1. Lag selection criteria

Lag(s)	AIC	BIC	HQC
1	-5.661955	-4.008632*	-5.039798
2	-5.511542	-2.441085	-4.356109
3	-4.917518	-0.429926	-3.228807
4	-4.935159	0.969567	-2.713171
5	-5.903429	1.418432	-3.148163
6	-9.788817*	-1.049822	-6.500274*

*Note: * denote lag length selected by a criterion*

Unit Root Test

At level, the classical unit root test results *viz.* ADF and KPSS showed the residuals of all and almost all the price series respectively, to have white noise as evidenced by their respective test statistics which were not within the acceptable margin of 5% probability level (Table 2). However, the KPSS indicates that the China price series is stationary at level as evidenced by its tau-statistic value that is lower than t-critical value at 5% significance level. Thereafter, except KPSS tau-statistic for China, at first difference, the residuals of all the remaining prices were Gaussian white noise as indicated by their respective tau-statistics that were within the plausible margin of 5% significance level.

Due to the contradictory estimates which cast a doubt, ADF-GLS, a neo-classical unit root test was applied to establish the valid trend behavior of these price series. The possible reason is that classical unit root test especially ADF has restrictive assumptions on error term: is statistical independent and has constant variance residual which is not true in most cases when dealing with time series. Besides, it tends to lose its test of stationarity if the length of truncation is too long or there is presence of structural break.

The ADF-GLS test showed all the price series to have trend at level as indicated by their respective tau-statistics that were not different from zero at 5% degree of freedom. But after first difference, the residuals of all the price series didn't exhibit a random walk as evidenced by their respective tau-statistics which were different from zero at 5% degree of freedom. Generally, it can be inferred that at level and first difference, the price series were non-stationary and stationary respectively, thus integrated of order 1 i.e. [I(1)]. With the symmetric behavior of all the market prices i.e. integrated of the same order: [I(1)], co-integration test was performed to examine the extent of association of the selected markets in the long-run. Given that comparable grades/varieties of wheat were selected across the markets, price variability can be assumed not to be caused by differences in grades/varieties but by spatial effects.

Table 2. Unit root tests

Markets	Stage	ADF	KPSS	ADF-GLS
Australia	Level	-2.2248^{ns}	0.6601^{ns}	-2.9436^{ns}
	$1^{st}\Delta$	-6.1652st	0.1193st	-6.8400st
Canada	Level	-2.2374^{ns}	0.4618^{ns}	-2.4587^{ns}
	$1^{st}\Delta$	-5.3151st	0.0805st	-5.4184st
China	Level	-1.5635^{ns}	0.1700st	-1.3060^{ns}
	$1^{st}\Delta$	-5.5682st	-	-5.6375st
France	Level	-1.1607^{ns}	0.5482^{ns}	-1.7165^{ns}
	$1^{st}\Delta$	-7.1514st	0.1185st	-4.546st
India	Level	-1.4898^{ns}	0.6358^{ns}	-2.3232^{ns}
	$1^{st}\Delta$	-5.8257st	0.1114st	-3.0644st
USA	Level	-2.451^{ns}	0.6140^{ns}	-2.638^{ns}
	$1^{st}\Delta$	-6.7222st	0.0876st	-5.1551st

Note: ADF, ADF-GLS; and KPSS tau critical levels at 5% probability are -3.03 and 0.462 respectively.
**** ** * ns, st&Δ means significant at 1, 5, 10%, non-significant, non-stationary, stationary and first difference respectively*

Extent of Price Transmission among the Selected Markets

A perusal of Table 3 showed that there is neither unidirectional nor bidirectional co-integration but rather independent markets as evidenced by their respective ADF tau-statistics of the co-integrating regression residuals which were not different from zero at 5% probability level. Therefore, in pair-wise, all the selected markets are independents of each other, thus exogenous to the system- price influence is generated from outside the system. Thus, it can be inferred that in a pair there is no price linkage between two markets and this is caused by symmetric and asymmetric factors which owes to spatiality of the markets, thus affected the goal of market utilities. However, because of the inability of the Engel and Granger test to generate a co-integration between multiple markets – more than two markets, the Johansen multivariate co-integration test was performed to determine the number of co-integrating price series from the range of the six selected markets.

Table 3. Engel and Granger tests for co-integration

Markets	Australia	Canada	China	France	India	USA
Australia	-	-1.6608^{ns}	-2.6651^{ns}	-2.6394^{ns}	-2.3656^{ns}	-1.9581^{ns}
Canada	-1.4718^{ns}	-	-2.6779^{ns}	-1.9310^{ns}	-2.102^{ns}	-1.5027^{ns}
China	-1.3673^{ns}	-1.6577^{ns}	-	-1.5563^{ns}	-1.6436^{ns}	-1.4194^{ns}
France	-1.4364^{ns}	-1.2447^{ns}	-1.0512^{ns}	-	-1.4711^{ns}	-1.4376^{ns}
India	-0.7088^{ns}	-0.7830^{ns}	-1.7204^{ns}	-1.4961^{ns}	-	-0.4133^{ns}
USA	-2.9596^{ns}	-1.8523^{ns}	-2.5797^{ns}	-2.8032^{ns}	-2.6566^{ns}	-

*Note: ADF tau critical level at 5% probability is -3.03. * &^{ns} indicate significant at 5% and non-significant respectively.*

Multivariate co-integration

Both the trace and max tests showed two markets to be co-integrated out of the six selected markets as indicated by their respective co-integrating vectors at rank two that were within the plausibility margin of 5% probability level (Table 4). Therefore, it implies that at least two co-integrating vectors exist along with at best four common stochastic trends among the six selected wheat international markets in the world. Though, the market are horizontally integrated, it can be inferred that the law of one price (LOP) does not hold due to the presence of four common stochastic trends which implies absence of pair-wise co-integration of the market prices. The presence of four common stochastic trends revealed that four independent markets exist among the six selected markets. In other words, the results suggest that these six market prices are poorly co-integrated and are less likely to converge to long-run equilibrium in the sense that the international wheat market system is stationary in two directions and non-stationary in four directions. Thus, in the long-run there is poor price transmission among the selected market prices which owes to a weak horizontal integration of the selected markets as only two out of the six markets are co-integrated. This showed that spatiality affected the long-run price linkage among these markets, thus affected space utility goal of marketing. Given that the market prices move together in the long-run, then they are likely to establish a long-run equilibrium. Thus, restricted VAR was estimated to check whether these prices established long-run equilibrium.

Table 4. Multivariate horizontal-wise co-integration

Rank	Eigen value	Trace test	P-value	Lmax test	P-value
0	0.97974	293.26**	0.0000	179.37**	0.0000
1	0.65993	113.89**	0.0002	49.616**	0.0008
2	0.52837	64.275**	0.0441	34.571**	0.0208
3	0.30411	29.703	0.5255	16.678	0.4999
4	0.18636	13.025	0.7377	9.4870	0.6785
5	0.074031	3.5380	0.8016	3.5380	0.8033

*Note: **denotes rejection of the null hypothesis at 5 percent level of significance*

Degree of Market Integration

The diagnostic tests of the VECM model showed the residuals of all the market prices to be pure Gaussian white noise and have no Arch effect as indicated by their respective Ljung Box and Langrange multiplier test statistics respectively, which were not different from zero at 10 degree of freedom (Table 5). However, the residuals were not normally skewed as evidenced by the Doornik-Hansen test Chi^2 which is different from zero at 10% probability level. Non-fulfillment of normality assumption of the residual is not critical as it appears because data in their natural form are mostly not normally distributed (Sadiq *et al*., 2020). Although OLS does not require that the disturbances be normally distributed, we assumed that they were distributed for statistical inference purposes (Gujarati, 2004; Malinvaud, 1966). Therefore, with these aforementioned justifications, it can be inferred that the estimates of the restricted VAR are reliable for future prediction of the selected market prices with accuracy, certainty, consistency and efficiency.

The restricted VAR results showed three markets *viz*. Indian, USA and China to have established a long-run equilibrium as evidenced by their respective attractor coefficients which were different from zero at 10% degree of freedom. The significance of the attractor coefficients imply that a price shock that induces price deviation from the equilibrium will induce the traders to respond to the shock in a way that the prices will converge towards their equilibrium value. The attractor coefficients *viz*. Indian (-0.219), China (-0.335) and USA (-0.429) prices been negative, imply that if the respective average prices of these markets are high, they will quickly fall back towards the price levels of other markets.

Besides, in this present situation, the negative attractor coefficients indicate that the short-run disequilibrium adjustment process may lead to stable long-run prices in Indian, China and USA markets. The speed of adjustment at which Indian, China and USA markets will correct any short-run disequilibrium due to asymmetric price shock will be 21.9, 33.5 and 42.9% respectively. Thus, in a year, it will take Indian, China and USA market prices approximately 2.6, 4 and 5.2 months respectively to re-established equilibrium.

However, there is a delay in their respective long-run price transmissions as the coefficients of the lagged price differences were within the acceptable margin of 10% significance level. Therefore, it can be inferred that these three markets are efficient in the international wheat market as any discontinuity or shock generated by the short-run will be adequately absorbed, thus keeping the market stable.

Table 5. Degree of market integration

Variables	ΔAustralia	ΔCanada	ΔChina
Constant	2.4509(1.4769)[1.659]^{NS}	−4.3565(4.0523)[1.075]^{NS}	0.4668(2.7884)[0.167]^{NS}
$Australia_{t-1}$	−0.5257(0.2164)[2.429]**	−0.2646(0.5938)[0.445]^{NS}	0.4544(0.4086)[1.112]^{NS}
$Australia_{t-2}$	−0.6874(0.2883)[2.384]**	−0.0480(0.7911)[0.060]^{NS}	−0.7486(0.5443)[1.375]^{NS}
$Australia_{t-3}$	−0.3389(0.2749)[1.233]^{NS}	0.1077(0.7545)[0.142]^{NS}	−0.1366(0.5191)[0.263]^{NS}
$Australia_{t-4}$	−0.5081(0.2510)[2.024]*	0.2697(0.6889)[0.391]^{NS}	−0.6680(0.4740)[1.409]^{NS}
$Australia_{t-5}$	−0.3273(0.1392)[2.351]**	0.0561(0.3821)[0.147]^{NS}	−0.0744(0.2629)[0.283]^{NS}
$Canada_{t-1}$	−0.0945(0.3045)[0.310]^{NS}	−0.9316(0.8356)[1.115]^{NS}	−1.1272(0.5750)[1.960]*
$Canada_{t-2}$	−0.2747(0.2267)[1.212]^{NS}	−0.7558(0.6220)[1.215]^{NS}	−0.5792(0.4280)[1.353]^{NS}
$Canada_{t-3}$	0.0134(0.2059)[0.065]^{NS}	−0.4725(0.5649)[0.836]^{NS}	−0.4998(0.3887)[1.286]^{NS}
$Canada_{t-4}$	−0.2908(0.2001)[1.453]^{NS}	−0.2961(0.5490)[0.539]^{NS}	−0.4816(0.3778)[1.275]^{NS}
$Canada_{t-5}$	0.1157(0.2266)[0.510]^{NS}	−0.3733(0.6219)[0.600]^{NS}	−0.7168(0.4279)[1.675]^{NS}
$China_{t-1}$	0.0387(0.1568)[0.246]^{NS}	0.4786(0.4303)[1.112]^{NS}	0.6349(0.2961)[2.144]*
$China_{t-2}$	−0.0294(0.2144)[0.137]^{NS}	0.7042(0.5883)[1.197]^{NS}	0.5737(0.4048)[1.417]^{NS}
$China_{t-3}$	0.0949(0.2075)[0.457]^{NS}	0.8770(0.5694)[1.540]^{NS}	0.5463(0.3918)[1.394]^{NS}
$China_{t-4}$	0.0987(0.1924)[0.513]^{NS}	0.8122(0.5280)[1.538]^{NS}	0.5249(0.3633)[1.445]^{NS}
$China_{t-5}$	−0.0203(0.1562)[0.130]^{NS}	0.3516(0.4287)[0.820]^{NS}	0.0753(0.2949)[0.255]^{NS}
$France_{t-1}$	−0.0189(0.0934)[0.203]^{NS}	0.6165(0.2564)[2.404]**	0.0274(0.1764)[0.155]^{NS}
$France_{t-2}$	−0.1626(0.0890)[1.826]*	0.2720(0.2444)[1.113]^{NS}	0.1055(0.1681)[0.627]^{NS}
$France_{t-3}$	−0.0093(0.0838)[0.111]^{NS}	0.0745(0.2300)[0.323]^{NS}	−0.1521(0.1583)[0.961]^{NS}
$France_{t-4}$	−0.0987(0.0805)[1.227]^{NS}	−0.1237(0.2209)[0.560]^{NS}	−0.3167(0.1520)[2.084]*
$France_{t-5}$	0.0448(0.0769)[0.582]^{NS}	−0.1035(0.2110)[0.490]^{NS}	−0.0549(0.1452)[0.378]^{NS}
$India_{t-1}$	1.0760(0.4843)[2.221]**	−1.4183(1.3290)[1.067]^{NS}	−0.3503(0.9145)[0.383]^{NS}
$India_{t-2}$	0.0986(0.4226)[0.233]^{NS}	−1.7945(1.1597)[1.547]^{NS}	−0.5850(0.7980)[0.733]^{NS}
$India_{t-3}$	0.7381(0.4305)[1.714]^{NS}	−0.7922(1.1813)[0.670]^{NS}	0.6314(0.8129)[0.776]^{NS}
$India_{t-4}$	−0.1345(0.2345)[0.573]^{NS}	−0.7448(0.6435)[1.157]^{NS}	−0.6503(0.4428)[1.468]^{NS}
$India_{t-5}$	0.4362(0.2300)[1.897]*	−0.7490(0.6310)[1.187]^{NS}	0.1164(0.4342)[0.268]^{NS}
USA_{t-1}	0.9350(0.1770)[5.282]***	1.0413(0.4856)[2.144]*	0.7702(0.3342)[2.305]**
USA_{t-2}	0.1085(0.3127)[0.347]^{NS}	0.3494(0.8581)[0.407]^{NS}	−0.2243(0.5905)[0.379]^{NS}
USA_{t-3}	0.7275(0.2768)[2.627]**	0.1097(0.7597)[0.144]^{NS}	1.2051(0.5227)[2.305]**
USA_{t-4}	0.1920(0.2824)[0.679]^{NS}	−0.1547(0.7748)[0.199]^{NS}	−0.0021(0.5331)[0.004]^{NS}
USA_{t-5}	0.3754(0.3081)[1.219]^{NS}	−0.0092(0.8454)[0.010]^{NS}	1.5283(0.5817)[2.627]**
EC_{t-1}	−0.1163(0.0950)[1.225]^{NS}	−0.0438(0.2607)[0.168]^{NS}	−0.3347(0.1794)[1.866]*
EC_{t-2}	0.2171(0.3512)[0.618]^{NS}	0.6418(0.9637)[0.666]^{NS}	1.3096(0.6631)[1.975]*
R^2	0.9532	0.6917	0.7200
D-W stat	2.011	1.788	1.999
Autocorrelation (Chi^2)	0.022{0.88}	0.138{0.71}	0.0001{0.991}
Arch effect (LM test)	7.147{0.307}	2.764{0.837}	1.371{0.967}
Normality (Chi2)			

*Note: *** ** * means significant at 1%, 5% and 10% respectively*
Values in ( ); [ ] and { } are standard error, t-statistic and probability value

Table 5(Cont). Degree of market integration

Variables	ΔFrance	ΔIndia	ΔUSA
Constant	0.7282(6.0613)[0.120]^{NS}	2.9212(0.8610)[3.393]***	−4.8216(3.4387)[1.402]NS
$Australia_{t-1}$	−1.0214(0.8882)[1.150]^{NS}	−0.4734(0.1261)[3.752]***	−0.3884(0.5039)[0.770]NS
$Australia_{t-2}$	−1.1904(1.1833)[1.006]^{NS}	−0.4537(0.1681)[2.699]**	−0.1388(0.6713)[0.206]NS
$Australia_{t-3}$	−0.9674(1.1286)[0.857]^{NS}	−0.3375(0.1603)[2.106]*	0.1513(0.6402)[0.236]NS
$Australia_{t-4}$	0.0566(1.0305)[0.054]^{NS}	−0.2165(0.1463)[1.479]NS	0.6006(0.5846)[1.027]NS
$Australia_{t-5}$	−0.1135(0.5715)[0.198]^{NS}	−0.1549(0.0811)[1.909]*	0.0955(0.3242)[0.294]NS
$Canada_{t-1}$	−1.9823(1.2499)[1.586]^{NS}	−0.5170(0.1775)[2.912]**	−2.0370(0.7091)[2.873]**
$Canada_{t-2}$	−1.8045(0.9304)[1.939]*	−0.2334(0.1321)[1.766]NS	−1.6084(0.5278)[3.047]***
$Canada_{t-3}$	0.1445(0.8451)[0.171]^{NS}	−0.4673(0.1200)[3.893]***	−1.4032(0.4794)[2.927]**
$Canada_{t-4}$	−1.0802(0.8212)[1.315]^{NS}	−0.0855(0.1166)[0.733]NS	−0.3053(0.4659)[0.655]NS
$Canada_{t-5}$	−1.0977(0.9303)[1.180]^{NS}	−0.4789(0.1321)[3.624]***	−1.1477(0.5277)[2.175]**
$China_{t-1}$	1.1895(0.6437)[1.848]*	−0.0600(0.0914)[0.656]NS	0.9898(0.3652)[2.710]**
$China_{t-2}$	1.1818(0.8801)[1.343]^{NS}	0.2523(0.1250)[2.018]*	1.5065(0.4993)[3.017]***
$China_{t-3}$	0.6946(0.8518)[0.815]^{NS}	0.1521(0.1210)[1.257]NS	1.1304(0.4832)[2.339]**
$China_{t-4}$	0.7943(0.7897)[1.006]^{NS}	0.2418(0.1121)[2.156]*	1.2414(0.4480)[2.771]**
$China_{t-5}$	0.3267(0.6412)[0.509]^{NS}	0.1227(0.0910)[1.347]NS	1.0369(0.3637)[2.850]**
$France_{t-1}$	0.1753(0.3836)[0.457]^{NS}	−0.0051(0.0544)[0.095]NS	0.5245(0.2176)[2.410]**
$France_{t-2}$	0.2242(0.3656)[0.613]^{NS}	0.0141(0.0519)[0.271]NS	0.3570(0.2074)[1.721]NS
$France_{t-3}$	−0.2092(0.3441)[0.608]^{NS}	−0.1498(0.0488)[3.064]***	−0.0031(0.1952)[0.016]NS
$France_{t-4}$	−0.6382(0.3304)[1.931]*	−0.0484(0.0469)[1.032]NS	−0.1708(0.1874)[0.911]NS
$France_{t-5}$	−0.3764(0.3156)[1.192]^{NS}	−0.1027(0.0448)[2.290]**	−0.2664(0.1791)[1.487]NS
$India_{t-1}$	−0.1054(1.9879)[0.053]^{NS}	0.6693(0.2824)[2.370]**	−1.6473(1.1278)[1.461]NS
$India_{t-2}$	0.2648(1.7347)[0.152]^{NS}	0.3677(0.2464)[1.492]NS	−2.3439(0.9841)[2.382]**
$India_{t-3}$	1.3820(1.7670)[0.782]^{NS}	0.2536(0.2510)[1.010]NS	−1.6687(1.0025)[1.665]NS
$India_{t-4}$	0.0585(0.9626)[0.060]^{NS}	0.3369(0.1367)[2.464]**	−0.7266(0.5461)[1.331]NS
$India_{t-5}$	−0.2495(0.9439)[0.264]^{NS}	0.1550(0.1341)[1.156]NS	−1.0353(0.5355)[1.933]*
USA_{t-1}	1.1222(0.7264)[1.545]^{NS}	0.3193(0.1032)[3.094]***	1.3642(0.4121)[3.310]***
USA_{t-2}	2.0923(1.2836)[1.630]^{NS}	0.5685(0.1823)[3.118]***	1.0663(0.7282)[1.464]NS
USA_{t-3}	−0.1215(1.1363)[0.106]^{NS}	0.4288(0.1614)[2.656]**	0.5998(0.6446)[0.930]NS
USA_{t-4}	0.9877(1.1589)[0.852]^{NS}	0.3056(0.1646)[1.857]*	−0.2323(0.6575)[0.353]NS
USA_{t-5}	0.9297(1.2645)[0.735]^{NS}	0.4662(0.1796)[2.595]**	0.0618(0.7174)[0.086]NS
EC_{t-1}	−0.6507(0.3900)[1.668]^{NS}	−0.2198(0.0554)[3.967]***	−0.4294(0.2212)[1.941]*
EC_{t-2}	2.5585(1.4415)[1.775]*	0.5894(0.2047)[2.879]**	2.2559(0.8178)[2.758]**
R^2	0.6437	0.9051	0.7380
D-W stat	1.9699	1.8853	1.7966
Autocorrelation (Chi^2)	0.005{0.943}	0.072{0.788}	0.125{0.723}
Arch effect (LM test)	1.649{0.948}	3.538{0.738}	4.484{0.611}
Normality (Chi2)	52.69{0.000}***	52.69{0.000}***	

*Note: *** ** * means significant at 1%, 5% and 10% respectively*
Values in ( ); [ ] and { } are standard error, t-statistic and probability value

The none plausibility of the attractor coefficients of Australia, Canada and France markets at 10% probability level imply that these markets did not establish long-run equilibrium, thus are autarkic markets. The possible reason for the autarkic situation may be attributed to an asymmetric price that undermine the degree of integration and generates discontinuity in the price response to exogenous shocks. The presence of entry barriers, information failure, risk aversion, inadequate infrastructure may be the causal factors that created a friction in the arbitrage process due to characteristics of agricultural production, consumption pattern and commercialization. Besides, the existence of menu costs, understood as costs arising from the re-pricing and information process faced by producers in the presence of exogenous variations, contributes to discontinuous or asymmetric price responses. If the agents perceive fluctuations in the cost of the commodity as temporary, the cost of the menu can be a motivation not to alter prices, even if there is a shift in the cost of the product. Also, a leverage effect due to inventory accumulation by traders of Australian, Canadian and France markets may be a source of discontinuity in the adjustment of their prices in the face of the global market. The variations in the prices of wheat serve as a barometer that induced inventory holders to either reduce or accumulate stocks. The anticipated rise in the price of the dominant market over the next period is an incentive for traders to increase their inventory holdings, thus purchasing significant quantities of the commodity at present. The rise in market stocks, however, is driving prices down, so the real rise is not as high as originally anticipated. On the contrary, if it were to be predicted that the dominant market prices would decline, this would be an incentive for traders to reduce their inventory stocks, a reaction that would moderate the severity of the subsequent fall in prices. In view of this inventory keeping system, autarkic market prices will not be able to completely respond to shifts in the prevailing market prices.

Price Formation

Granger causality was calculated between the selected market pairs after establishing co-integration between the various wheat markets. The causality of the granger indicates the direction of price formation between two markets and related spatial arbitrage, i.e. the physical movement of the product to change the difference in prices (Ghafoor et al., 2009).

Based on the Granger causality test, the market pairs viz. Australia-Canada, France-Australia, China-Australia, India-Canada, USA-Canada and France-China had a unidirectional causality as indicated by the respective F-statistics of the former in each pair which were within the acceptable margin of 5% probability level (Table 6).

Table 6. Horizontal pair-wise Granger causality test

Null hypothesis	F-stat	P< 0.05	Granger cause	Direction
$AUST \leftrightarrow CAN$	3.492	0.045*	Yes	Unidirectional
	0.767	0.613	No	
$AUST \leftrightarrow CHINA$	2.257	0.131	No	None
	1.782	0.209	No	
$AUST \leftrightarrow FRANCE$	2.888	0.074	No	Unidirectional
	3.532	0.044*	Yes	
$AUST \leftrightarrow INDIA$	8.167	0.003*	Yes	Bidirectional
	12.05	0.0007*	Yes	
$AUST \leftrightarrow USA$	29.23	0.000*	Yes	Bidirectional
	3.384	0.049*	Yes	
$CAN \leftrightarrow CHINA$	2.012	0.166	No	None
	1.881	0.189	No	
$CAN \leftrightarrow FRANCE$	4.221	0.026*	Yes	Bidirectional
	7.990	0.003*	Yes	
$CAN \leftrightarrow INDIA$	2.769	0.082	No	Unidirectional
	12.17	0.0007*	Yes	
$CAN \leftrightarrow USA$	1.525	0.272	No	Unidirectional
	5.207	0.014*	Yes	
$CHINA \leftrightarrow FRANCE$	2.655	0.091	No	Unidirectional
	3.436	0.047*	Yes	
$CHINA \leftrightarrow INDIA$	4.819	0.018*	Yes	Bidirectional
	8.959	0.002*	Yes	
$CHINA \leftrightarrow USA$	4.897	0.017*	Yes	Bidirectional
	5.376	0.012*	Yes	
$FRANCE \leftrightarrow INDIA$	3.736	0.037*	Yes	Bidirectional
	11.16	0.001*	Yes	
$FRANCE \leftrightarrow USA$	5.550	0.011*	Yes	Bidirectional
	4.617	0.020*	Yes	
$INDIA \leftrightarrow USA$	7.875	0.003*	Yes	Bidirectional
	7.145	0.005*	Yes	
$AUST \rightarrow ALL$	28	0.000*	Yes	Multidirectional
$CAN \rightarrow ALL$	2.700	0.059	No	None
$CHINA \rightarrow ALL$	3.5548	0.025*	Yes	Multidirectional
$FRANCE \rightarrow ALL$	4.193	0.014*	Yes	Multidirectional
$INDIA \rightarrow ALL$	11.20	0.0003*	Yes	Multidirectional
$USA \rightarrow ALL$	3.1623	0.036*	Yes	Multidirectional

*Note: * denotes rejection of the* H_0 *at 5% level of significance; NS: Non-significant*

$\rightarrow \leftarrow$ *means forward and backward directions respectively*

Thus, it implies that in each pair, a change in the price of the former is transmitted to the price of the latter while a change in the price of the latter is not transmitted to the price of the former. Therefore, it can be inferred that there exists a weak endogeneity between these market pairs as the price of the former is exogenous and is determined outside the system. Furthermore, it was observed that bidirectional causality holds between these market pairs: Australia-India, Australia-USA, Canada-France, France-India, France-USA, India-USA and India-China as evidenced by the plausibility of their respective F-statistics at 5% probability level. This implies that in each of the market pair, both markets contain information that predicts the future of the other. In other words, it implies that in each market pair, there is a feed-forward and a feed-backward price causal effect between the markets. Thus, it can be inferred that there is strong endogeneity in the prices of these market pairs as their respective prices were determined by the internal system. However, there was no price causality between the market pairs viz. Australia-China, Canada-China The implication is that these markets are independent, as in each market pair; neither the former nor the latter market contain useful information to predict the future of each other. Therefore, it can be inferred that strong exogeneity exists between these market pairs and their prices are determined outside the system. Out of the thirty pair-wise price relationships, only ten relationships were exogenous to the system. Generally, it can be inferred that wheat prices adjust in the markets according to supply and demand in the world.

Effect of Shocks on Market Prices

Whereas impulse response functions (IRFs) die out over time from a stationary VAR, IRFs do not always die out from a co-integrating VECM. The effect of a shock on each of these variables must die out so that the variable can return to its mean, since each variable in a stationary VAR has a time invariant mean and finite, time-invariant variance. The I(1) variables modelled in a co-integrating VECM, on the other hand, are not mean reverting, and the unit moduli in the matrix of the companion suggest that any shocks will not die out over time. The IRFs show how and to what degree, over a span of twelve years, a standard deviation shock in one of the wheat markets influences current as well as future prices in all interconnected markets. A perusal of the graphs showed that unexpected shocks that are local to Australian market will have a transitory effect on China market price and a permanent effect on the prices of the remaining markets: inclusive its own market. An orthogonalized shock on the market price of Canada will not die-out over time in all the markets, inclusive its own market. In the same vein, an unexpected shock that is local to the market price of France will have permanent effect on the average prices of all the remaining markets, inclusive its market. An unexpected bad news that is local to Indian market will not die-out overtime in all the selected markets-inclusive its market. An unexpected innovation that is local to USA market will die-out over time in all the markets, inclusive itself; except China market where it will not die-out overtime. Furthermore, an orthogonalized shock on the market price of China will have a permanent effect on all the markets, inclusive its own market (Figure 1).

The shocks that originate from Canadian, France, Indian and China markets are more transmitted to other markets while the shock that emanate from Australian market is more or less transmitted to other markets. However, the shock that originates from USA market is less transmitted to other markets. Therefore, it can be inferred that Canadian, France, Indian, China and Australian wheat markets have dominance effect in price determination of other markets in the world. However, the dominance effect of USA market in price determination on other markets is weak and this may owe to high marketable surplus and likely influences of neighboring countries that engaged in exportation of the product. The strong dominance effect of Australian, Canadian and France markets may be attributed to leverage effect while that of Indian and China market owes largely to a low marketable surplus. Thus, it can be inferred that USA market is a relatively market follower, thus do not play a significant role in the global wheat market

Figure 1. Impulse response of market prices

Wheat Price Forecasts

Through the one-step-ahead forecast, the validity of the predictive power of the best fit VECM was checked and how closely they could follow the direction of the actual observations (Table 7).

In addition, as indicated by Theil's coefficient of inequality (U) and the relative mean absolute prediction error (RMAPE), respectively within the range of 1 and 5 per cent (Table 8), the VECM was found to be accurate for prediction. The VECM can therefore be used with high forecast validity and accuracy for *ex-ante* forecast, as the predictive error associated with the projected equation is negligible and low in monitoring the actual data (*ex-post* prediction)..

Table 7. One step ahead forecast of prices

Year	Australia market		Canada market		China market	
	Actual	Predict	Actual	Predict	Actual	Predict
2014	284.80	292.11	192.3	227.61	377	357.54
2015	225.40	228.91	181.4	178.41	377	317.14
2016	205.90	216.25	174.4	165.23	385.1	355.33
2017	177	182.70	180.7	192.94	385.1	400.46
2018	203.20	215.28	190.1	248.19	385.1	379.34
	France market		India market		USA market	
	Actual	Predict	Actual	Predict	Actual	Predict
2014	216.2	204.02	269.5	273.66	220	259.12
2015	172.9	137.18	273.1	269.54	180	192.12
2016	159.9	137.16	276.7	253.11	143	143.27
2017	157.7	138.70	280.3	283.49	169	183.05
2018	195	216.65	283.9	287.07	169	211.91

Table 8. Validation of models

Market	R^2	MAPE	RMSPE	RMAPE (%)	RMSE	Theil's U
Australia	0.994276	-0.03078	0.000263	-0.58086	0.037369	0.262312
Canada	0.989964	-0.05232	0.002999	-0.99546	0.125371	0.997092
China	0.992286	0.045862	0.001284	0.772415	0.087319	0.184103
France	0.984271	0.081592	0.004078	1.611037	0.14468	1.004
India	0.997161	0.015964	0.000298	0.284288	0.14468	0.516131
USA	0.985544	-0.07462	0.002408	-1.45178	0.111184	0.719363

Table 9. Out of sample price forecast of the selected markets ($ per ton)

	Australia market			Canada market			China market		
	Forecast	LCL	UCL	Forecast	UCL	LCL	Forecast	LCL	UCL
2019	198.8449	181.1001	218.3283	227.5571	176.0787	294.0859	385.859	323.434	460.3329
2020	285.0293	218.0582	372.5689	302.7523	203.8532	449.6327	342.6577	256.6391	457.5078
2021	244.2111	176.4825	337.9321	226.9054	141.7677	363.1714	242.8857	162.6505	362.7007
2022	151.5883	104.6527	219.5737	151.1738	87.3783	261.5467	189.8095	113.1433	318.425
2023	145.7949	94.18067	225.6958	146.8957	75.68455	285.1091	198.72	103.7758	380.5285
2024	161.8562	95.02946	275.6765	158.6404	73.92884	340.4189	220.7752	104.0243	468.5599
2025	232.2371	128.8284	418.6503	222.2429	96.16515	513.6155	287.8663	124.7533	664.247
2026	290.7096	154.031	548.6688	278.9295	114.3815	680.194	339.2621	138.0431	833.7887
2027	296.2083	150.1577	584.3155	268.3451	103.5325	695.5222	328.2833	125.8976	856.0117
2028	294.2677	141.2402	613.0938	242.0574	88.06939	665.2913	328.3762	119.6154	901.4801
2029	235.0152	106.8636	516.8465	216.8739	74.40588	632.1312	323.9629	110.9849	945.6419
2030	222.029	96.24067	512.225	226.1148	73.40727	696.4974	310.2973	100.4822	958.2225
	France market			India market			USA market		
	Forecast	LCL	UCL	Forecast	UCL	LCL	Forecast	LCL	UCL
2019	298.0478	203.0859	437.4131	328.5319	311.107	346.9324	206.5604	166.1605	256.7832
2020	225.5559	132.9347	382.7102	353.5051	317.6592	393.3957	242.2034	170.2546	344.5575
2021	156.282	78.62974	310.6211	298.5105	254.1869	350.5628	164.8855	105.7265	257.1468
2022	122.2455	47.03321	317.7319	278.5465	230.3074	336.8898	116.1319	69.68478	193.5374
2023	104.4674	33.41961	326.5575	263.2215	206.3581	335.7541	134.8855	73.01785	249.1729
2024	134.5071	36.83104	491.2209	270.3147	201.4677	362.6887	197.7877	98.57227	396.8657
2025	197.8423	47.08338	831.3243	287.6585	207.7493	398.3042	243.2428	114.7805	515.4797
2026	209.6663	43.4206	1012.422	302.1229	210.8924	432.8192	261.0135	117.6432	579.1074
2027	156.3522	28.12593	869.1615	353.1963	239.1854	521.552	258.3486	109.0616	611.9851
2028	151.0515	23.74562	960.8747	366.1793	239.1818	560.6081	221.7146	87.67063	560.705
2029	139.7005	19.72106	989.615	360.5527	227.5675	571.2512	201.3307	75.01612	540.3375
2030	135.6588	17.34056	1061.286	349.7305	215.146	568.5044	213.4296	74.93395	607.8979

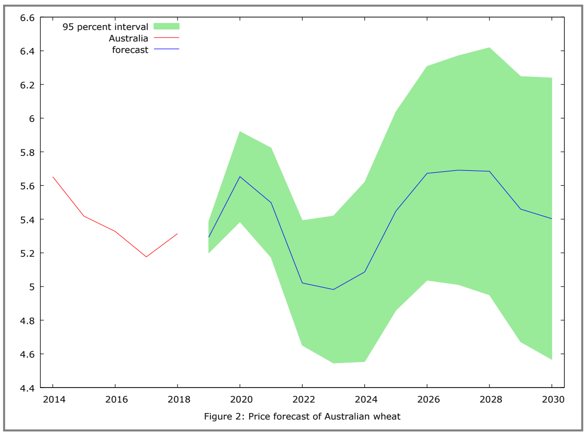

Figure 2. Price forecast of Australian wheat

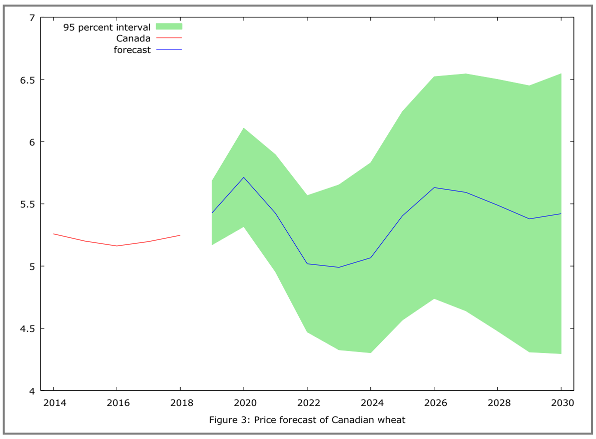

Figure 3. Price forecast of Canadian wheat

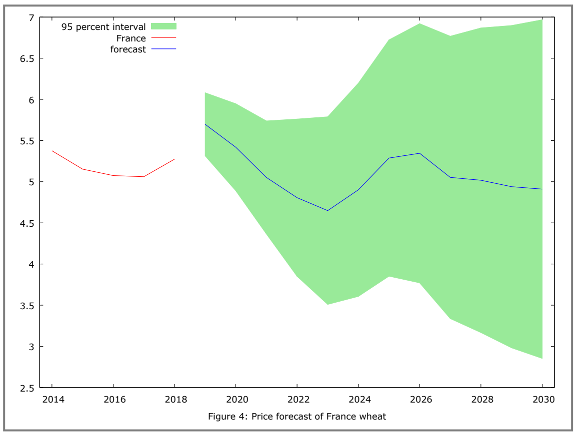

Figure 4. Price forecast of France wheat

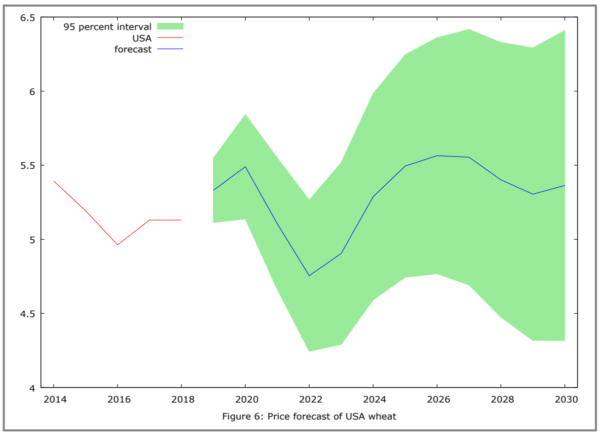

Figure 6. Price forecast of USA wheat

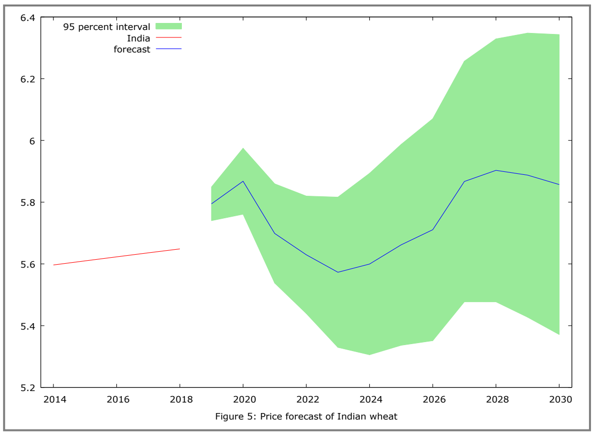

Figure 5. Price forecast of Indian wheat

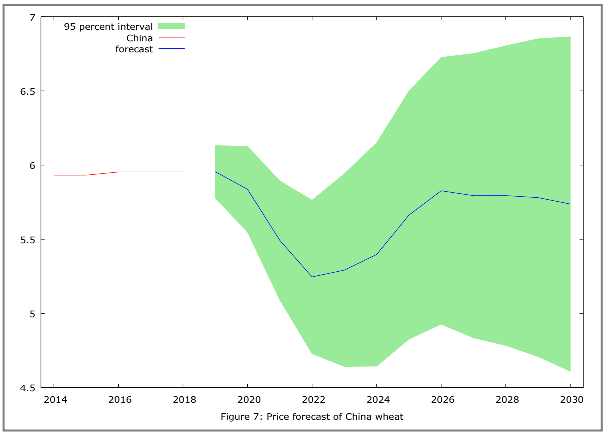

Figure 7. Price forecast of Chine wheat

In Figure 2-7 and Table 9 are the one-step-ahead-out of the sample forecast of producer wheat prices for the all-selected markets for the period 2018 to 2030. The price of Australian market will be marked by a steep cyclical trend that steeply inclined from 2018 and peak at 2020, thereafter steeply plummeted till 2023. Afterward, the price will revive from the ebb (2023), pass through the recovery phase (2024-2025); prosperity phase (2026); and, then peak in the year 2027. Subsequently, the price will recess till the end of the forecasted period (Figure 2). The price of Canadian market will observe a gentle cyclical trend with peak points in 2020 and 2026; and trough points in 2023 and 2029 (Figure 3). However, the boom and ebb points of the first complete cycle will be steeper than that of the second complete cycle. In France market, the future prices will undergo recession (2020-2021), depression (2022), and, then trough in the year 2023. Afterward, in the year 2024, the price will initiate a recovery, transits prosperity and boom in the year 2026. Subsequently, a slight decline that passes recession and terminates at depression phase will characterized the price trend (Figure 4). The price trend of Indian market will witness two peak points (2020 and 2028) and one ebb point (2023). In the complete cycle, the price will undergo recession and depression in the year 2021 and 2022 respectively. Between 2024 and 2027, the price trend will pass through a recovery and prosperity phases. After the boom year (2028), the price will be marked by a slight plummeting recession which will persist till the end of the forecasted period (Figure 5). The USA price market will peak in the 2020; then steeply declined and ebbed in the year 2022. Thereafter, the price trend will witness a steep recovery, goes into prosperity phase and then will boom in the year 2026. Afterward, the price will go into recession, depression, ebb and initiate a recovery at the end of the forecasted period (Figure 6). For China market, the price will exhibit a steep decline from 2019 and trough in 2023. Then, a steep recovery trend will set in and will peak in the year 2026. Thereafter, the price will plummet slightly i.e. recess and will subsist till the end of the forecasted period (Figure 7). Generally, Australian and USA market prices will witness two complete trade/price cycles while the remaining markets will pass through one complete trade/price cycle. Therefore, it can be inferred that none of the market will have their price in a comfortable zone as the future prices of wheat in the international market will be determined largely by inflation which may owe to currency devaluation, WTO trade policies, internal market structure and production quantum.

CONCLUSION AND RECOMMENDATIONS

Despite the wheat prices of the selected markets have long-run price association, it can be inferred that the LOP did not hold among these markets. Furthermore, it can be inferred that Indian, USA and China markets were efficient as any short-run disequilibrium adjustment process would lead to stable long-run prices in these markets. However, Australian, Canadian and France markets were inefficient as their prices didn’t establish long-run equilibrium, thus autarkic markets. Except USA market prices, all the remaining markets play a significant role in the global wheat trade as bad news/innovation is transmitted to the contemporary markets. Little or non-transmission of bad news makes USA market to be a relatively market follower and do not play a significant role in the international wheat market. It was observed that the future wheat prices of the selected markets will be affected by inflation, leverage effects, internal trade policies and structural production. Generally, global trade of wheat is not competitive and to achieve the goal of integration, WTO should promote information and communication, and enhance infrastructural facilities within the markets.

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