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Price Relationships and Spillover Effects of Price Volatilities in Iran's Rice Market

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Abstract

Rice plays an especial role in Iranian households' nutrition basket. The volatilities of its price during recent years caused consumers' dissatisfaction. This paper investigates spillover effects of price volatilities (at the wholesale and retail levels) in the Guilan Province rice market. The Generalized Autoregressive Conditional Hetroscedasitic (GARCH) model was used for the monthly time period of 1999 to 2013. As the results of the unit root tests showed, the monthly time series of Sadri-Momtaz variety wholesale price and Sadri-Momtaz variety retail price have unit roots in zero frequency or they are I(1). Considering the amounts of trace and maximum eigen values statistics, there is a long-run relationship between Sadri-Momtaz variety wholesale and retail monthly price time series. Coefficients of normalized cointegration vector showed that, with one percent increase (decrease) in retail price, it would be likely that wholesale price could increase (decrease) by 0.99 percent. Results of GRACH model revealed that spillover effects exist from the retail price to the wholesale price and vice versa. In addition, price volatility in retail and wholesale levels had positive and significant effects on its own level price volatility. Accordingly, providing proper policy packages in both supply and demand sides were advised.

Keywords:
agricultural prices, cointegration, GARCH Model, Unit Root Test, volatility

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INTRODUCTION

The link between agricultural input prices, agricultural output prices, and retail food prices is of considerable economic interest. As agricultural inputs are transformed into raw food products and raw food products are processed, along with packaging and other services, into final food products, knowledge about the relationship between input, output, and retail food prices is important for contemporary policy and commodity market analyses. It provides useful information in relation to, for example, pricing efficiency, assimilation of market signals, as well as structural rigidities of prices. Numerous studies on price lineage in international agricultural commodity markets have emphasized the dynamic transmission of farm-level prices to final consumer prices (Goodwin & Holt, 1999). These studies have generally employed a time-series research design to examine the extent of price transmission through the production, processing, and marketing system. Another important issue of agricultural pricing relationships is the degree of price volatility of agricultural input, agricultural output, and retail food markets. Price volatility indicates the range in which prices might vary in the future (Natcher & Weaver, 1999).

It is generally known that the price fluctuations in agricultural commodities markets arise from supply and demand conditions which, in turn, depend on climate change, weather, market states, business cycles, as well as geopolitical situations (Lahiani et al., 2013). An increase in price volatility implies greater uncertainty about future prices, because the range in which prices might lie in the future becomes wider (Saha & Delgado, 1989). Nowadays, high volatility of prices makes a lot of concentrations in new economics literature and has been accepted as an important economic phenomenon (Alom et al., 2010). In this case, the matter of how to consider the effect of price in one's market from volatility of price in other markets is called the "spillover effect" and it has such significant importance (Apergis & Rezitis, 2003). Very little is known about the conditional correlations and volatility spillover effects across agricultural commodities. Investigation of spillover effects of price volatilities has not received much attention in Iran; however, various studies have been conducted in foreign countries: Below are the results of some studies that focus on spillover effect from foreign countries.

Bergmann et al. (2016) analyzed price and volatility transmission effects between EU and World butter prices, as well as between butter, palm oil and crude oil prices, before and after the Luxembourg agreement. Vector autoregression (VAR) models are applied to capture price transmission effects between these markets. These are combined with a multivariate GARCH model to account for potential volatility transmission. Results indicated that strong price and volatility transmission effects exist between EU and World butter prices. EU butter shocks further spillover to palm oil volatility. In addition, there is convincing evidence suggesting that oil prices spillover to World butter prices and World butter volatility.

Kavoosi-Kalashami et al. (2015) examined price transmission, threshold behavior, as well as asymmetric adjustment in poultry sector of three provinces in Iran using weekly price data for the period covering 1998-2012. A threshold cointegration model that permits asymmetric adjustment to positive and negative price shocks had been used. Findings revealed existence of asymmetry in price transmission for all markets. Also, the thresholds were estimated using TVECM and the same results were found.

Zhou et al. (2014) explored the volatility spillover effects between futures market and spot market in China, using both VAR model and TVP-VAR model. This study found strong bi-directional volatility spillovers between CSI futures and spot markets, and the change of futures' volatility decreased the change of spot market's volatility. Such results support the hypothesis that the risk management function of the futures market could calm the whole market when new shock comes. The empirical results showed that the influence of futures market on spot market enlarged as time passed, especially at the third quarter of 2011. Following that period, the relationship became stable.

Lahiani et al. (2013) provided comprehensive evidence of return and volatility spillovers for the four major agricultural commodities including sugar, wheat, corn, and cotton over the period 2003-2010. Results from the VAR-GARCH model of Ling and McAleer (2003) that allows for simultaneous shock transmissions of conditional volatilities of returns across commodities showed the existence of substantial volatility spillover linkages between agricultural commodity returns and volatilities. Findings are also particularly insightful for optimal portfolio designs and risk management through the computation of optimal weights and hedge ratios.

Trujillo-Barrera et al. (2011) analyzed volatility spillovers from energy to agricultural markets in the U.S. which have increased due to strong crude oil price volatility and the large growth in ethanol production in the period 2006-2011. Results suggested that spillovers from crude oil to corn and ethanol market are similar in magnitude over time, and were particularly significant during periods of high turbulence in the crude oil market volatility spillovers between corn and ethanol also exist, but primary from the corn to ethanol market.

Kaltalioglu and Soytas (2011) found that movement in oil and food prices in the 2000s has attracted interest in the information transmission mechanism between the two markets. They investigated the volatility spillover between oil, food consumption item, and agricultural raw material price indices for the time period January 1980 to April 2008. The results showed that variation in oil prices did not cause the variance in food and agricultural raw material prices. Since there is no volatility spillover from oil markets to food and agricultural raw material markets, investors can benefit from risk diversification. However, there is bi-directional spillover between agricultural raw material and food markets.

Alom et al. (2010) investigated the mean and volatility spillover effects of World oil prices on food prices for selected Asia and Pacific countries including Australia, New Zealand, South Korea, Singapore, Hong Kong, Taiwan, India and Thailand. The research study employed Vector Auto Regression (VAR) and GARCH-family models using daily observations for the 2 January1995 to 30 April 2010 period, splitting the data into two subsamples 1995-2001 and 2002-2010. The major empirical findings of the study are as follows: World oil prices positively influence food prices of the selected countries both in mean and in volatility, though the magnitudes of effects differ from country to country for different time periods. The effects are found mostly in the short run but not in the long run. Stronger mean and volatility spillover effects are found for the more recent subsample period suggesting increasing interdependence between World oil and Asia Pacific food markets in recent times. In terms of mean spillover effects net food importer countries' food price show stronger effects to the shocks, whereas in terms of volatility spillover effects no distinction in absorbing the World oil shocks can be made between exporters and importers. The findings suggest that oil prices should be taken into consideration in policy preparation and forecasting purposes for food prices.

Shuang-Yinga and Dong (2010) mentioned that the concentration ratio was the important representation of industry structure changes. Through introduced the international oil price as the exogenous variables, and built the petrochemical industry concentration EGARCH models, it analyzed the impact of fluctuating oil prices on petrochemical industry concentration ratio, the leveraged effects and spillover effects. The conclusion was that china's petrochemical industry concentration ratio volatility had "high peaks and fat tails" and "volatility cluster" features. The spillover effects of international oil price ware prominent. When the oil price was changed by one unit, the industry concentration ratio would change by 0.0804.

Buguk et al. (2003) investigated price volatility spillovers in the U.S. catfish supply chain based on monthly price data from 1980 through 2000 for catfish feed, its ingredients, and farm-and wholesale-level catfish. The exponential generalized autoregressive conditional hetroscedasticity (EGARCH) model was used to test volatility spillovers for prices in the supply chain. Strong price volatility spillover from feeding material (corn, soybeans, and menhaden) to catfish feed and farm- and wholesale-level catfish prices was detected.

Rezitis (2003) investigated volatility spillover effects across consumer meat prices for lamb, beef, pork, and poultry. The empirical analysis used GARCH approach. The empirical results supported the presence of significant effects across the four meat categories under consideration.

Apergis and Rezitis (2003) investigated volatility spillover effects across agricultural input prices, agricultural output prices and retail food prices using the technique of GARCH models. The empirical findings showed that the volatility of both agricultural input and retail food prices exerts significant, positive spillover effects on the volatility of agricultural output prices. Moreover, the volatility of agricultural output prices has a significant, positive impact on its own volatility.

Engle et al. (1990)'s approach was followed for analyzing the volatility spillovers of rice price in Iran. The statistical procedure used to measure rice price volatility is Generalized Autoregressive Conditional Heteroscedastic (GARCH) which introduced by Bollerslev (1986). This method has been mainly used to study certain volatility features for price, stock and exchange rate time series.

The major goal of this study was investigating the spillover effects of rice price volatilities in Iran at two levels of wholesale and retail in specific market of Guilan Province, north of Iran. Hence, in addition of investigating the volatility of products' price in two levels of wholesaling and retailing, both scale and extreme effects of each informed prices in volatility will be analyzed and considered. It is strongly expected that the results of this investigation shall aim for better and much vivid prediction in price for rice markets.

MATERIALS AND METHODS

In this paper, Generalized Autoregressive Conditional Hetroscedasitic (GARCH) model was used to investigate the volatility spillover effects of price in Guilan's Province rice market. To this end, stationary tests for the two time series (index of wholesale and retail price), cointegartion test, estimating vector error correction model, and evaluating the effects of volatility spillover will be considered.

Stationary test of variables

Using the ordinary and classic methods of econometrics is not efficient and valid in time-series data when the variables are non-stationary and statistics of F and t tests are not valid as well. To solve this problem, the most important point regarding the time series design is how to investigate the unit root test of the variables. To deal with this problem, various tests have been suggested, and each of them has its own specific features and advantages (Gujarati, 2003). Tests that have been frequently used for this purpose are Augmented Dickey–Fuller (ADF), Phillips - Perron (PP) and Kwiatkowski, Phillips, Schmidt and Shin (KPSS). Since ADF and PP tests have been widely dealt with in economic studies, the KPSS test will be discussed below:

The Kwiatkpwski, Phillips, Schmidt, and the Shin (KPSS) test

Sometimes, it is convenient to have stationary as the null hypothesis. The KPSS test differs from the other unit root tests described here in that the series Y_t is assumed to be (trend-) stationary under the null. The KPSS statistic is based on the residuals from the OLS regression of Y_t on the exogenous variables X_t (Enders, 2004):

$$Y_t = X_t'\delta + U_t \tag{1}$$

KPSS LM test is defined as below (Kwiatkowski et al., 1992):

$$KPSS = LM = \sum_t S^2_{(t)} \Big/ (T^2 f_0) \tag{2}$$

Where, f_0 is an estimator of the estimated residual variance at frequency zero and S_t is a partial sum of residuals:

$$S_{(t)} = \sum_{s=1}^{t} \hat{e}_s \tag{3}$$

The researchers argue that the estimator of variance used in this calculation differs from the estimator used by GLS determining since it is based on a regression involving the original data and not on the quasi-differenced data. To specify the KPSS test, we must specify the set of exogenous regressors (X_t) and a method for estimating f_0.

Defining cointegration between variables and error correction models indication

The most important issue after evaluating the existence of stationary in each variable time series is investigating the existence of cointegration relationship among variables. Johansen and Juselius (1990) method is used for investigating the cointegration which is estimated by the help of the maximum likelihood estimator. In this method, variables integration order should be equal. The most important advantage of this method is its capability in identifying more than a cointegration vector among variables. This method is a highly efficient method and is used when more than one cointegration vector exist among variables. This method has two statistics, the maximum eigen value (λ_{max}) and the trace (λ_{trace}). We can determine the number of long run relationship by using these two statistics. Null and alternative hypothesis for maximum eigen value test is defined as below (Mensi et al., 2013):

$$\begin{Bmatrix} H_0 : r = 0 \\ H_1 : r = 1 \end{Bmatrix} \tag{4}$$

If the null hypothesis that indicates the absence of cointegration vector among variables of model is rejected, it means that r=1, or on other word, it can be contended that at least a cointegration vector exists among variables. It is obvious that these steps should continue until the null hypothesis become valid and acceptable. After determining necessary cointegration vectors, it is essential that optimum vector which is compatible throw theories and economical logics should be chosen from among the selected vectors.

After confirming the cointegration relation between variables, the short-term model is defined by using the error correction vector autoregressive mechanism. As such, the likelihood ratio test is assigned. The associated error correction vector autoregressive (ECVAR) mechanism is used to describe the short-run dynamics. ECVAR model is estimating the mean equation for generalized autoregressive conditional heteroscedasitic (GARCH) process. In addition, all the equations are estimated through econometric scales like nonexistence of serial correlations in residuals, nonexistence of functional misspecification, as well as nonexistence of heteroscedasiticy.

Conditional Volatility Estimates: Spillover Effects of Sadri-Momtaz Rice in two levels (wholesale and retail)

MVGARCH models, developed by Bollerslev (1986), are considered as a parsimonious special case of an ARMA process applied to the squared stochastic error term (Tsay, 1987):

$$\Delta P_t^W = a_1 + \sum_i f_{1i} \Delta p_{t-i}^W + \sum_i f_{2i} \Delta p_{t-i}^r + \phi_1 ec_{t-1} + e_t^W \tag{5}$$

$$\Delta P_t^R = a_2 + \sum_i f_{3i} \Delta p_{t-i}^W + \sum_i f_{4i} \Delta p_{t-i}^R + \phi_2 ec_{t-1} + e_t^R \tag{6}$$

$$h_t^W = b_1 + b_2 {e_{t-1}^W}^2 + b_3 h_{t-1}^W + b_4 {e_{t-1}^R}^2 + b_5 h_t^R \tag{7}$$

$$h_t^r = b_6 + b_7 {e_{t-1}^r}^2 + b_8 h_{t-1}^r + b_9 {e_{t-1}^w}^2 + b_{10} h_t^w \tag{8}$$

Where, ΔP^W and ΔP^R are the first differences of wholesale and retail price logarithms, respectively. ec_{t-1} is the lagged value of the error correction term derived from the long-run cointegrating vector, e^w and e^R are stochastic disturbance terms of the mean process for wholesale and retail prices. Finally, h^w and h^R are the conditional variances of wholesale and retail prices, respectively (Engle and Boller-Slev, 1982).

RESULTS AND DISCUSSION

This research explored the volatility spillover effects across wholesale and retail levels in Guilan's province Sadri-Momtaz rice market using the Generalized Autoregressive Conditional Heteroscedasitic (GARCH) models. Monthly data on wholesale and retail prices of rice were

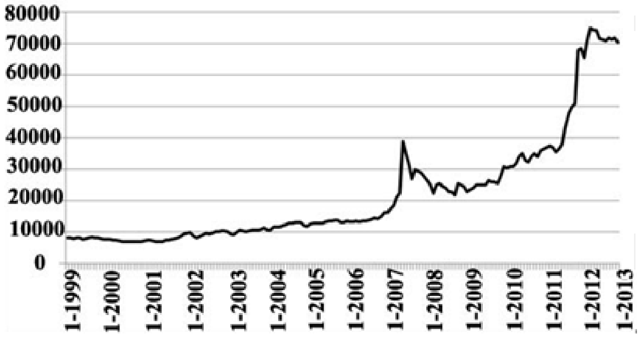

Figure 1. Sadri-Momtaz Rice wholesale level monthly prices (Rials) (P^W) between 1999 and 2013.

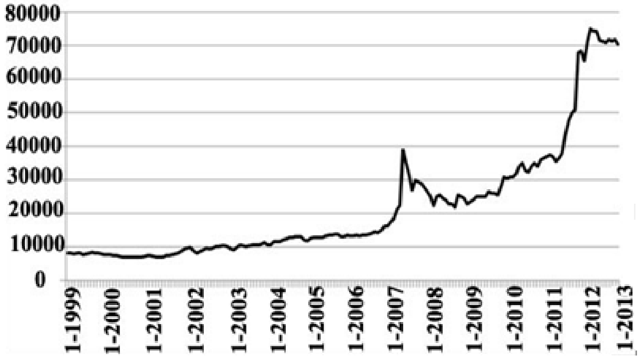

Figure 2. Sadri-Momtaz Rice retail level monthly prices (Rials) (PR) between 1999 and 2013.

obtained between 1999 and 2013. Capitalizing on a time series research design, the study illustrated the upcoming procedure with shocks in the mentioned time period. Figure 1 and 2 show the changes in rice prices in wholesale and retail levels between 1999 and 2013.

The upcoming procedure of this time series is observable during the period and the volatilities of time series among this period is caused by seasonal shocks and also market shocks.

Like monthly time series for wholesale price, the upcoming procedure of retail price time series was observed during the period and the volatilities of time series among this period caused by seasonal shocks and also market shocks in retail level.

The researchers first tested non-stationary of wholesale and retail price of rice in logarithm form (LPW and LPR) by using unit root tests such as Augmented Dickey–Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski, as well as Phillips, Schmidt and Shin (KPSS). The results are summarized in Table 1.

The results of ADF and PP tests for LPW showed the acceptance of null hypothesis in data level and the acceptance of alternative hypothesis in first difference level of data. In addition, KPSS results for this time series showed the rejection of null hypothesis in data level and acceptance of null hypothesis in first difference level of data. Hence, it can be concluded that the LPW has a unit root in zero frequency or it is I(1).

The results of ADF and PP for LPR showed the acceptance of null hypothesis at the data level and the acceptance of alternative hypothesis

Table 1
The Results of Unit Root Tests

Variable	ADF		PP		KPSS	
	levels	First differences	levels	First differences	levels	First differences
LPW	-0.56	-12.36***	-0.54	-12.34***	1.6***	0.18
LPR	-0.58	-12.67***	-0.62	-12.66***	1.63***	0.19

***p<0.01

Table 2
The Results of Cointegration Tests.

The maximum eigen value			trace statistic		
Hypothesis	λ_{trace} value	Critical values	Hypothesis	λ_{max} value	Critical values
Nonexistence of long-run relationship	70.57**	15.49	Nonexistence of long-run relationship	70.48**	14.26
Existence of one long-run relationship	0.09	3.84	Existence of one long-run relationship	0.09	3.84

**p<0.05

at the first difference level of data. In addition, KPSS results for this time series showed the rejection of null hypothesis at the data level and acceptance of mentioned hypothesis at the first difference level of data. Accordingly, it can be contended that the LPR has a unit root in zero frequency or it is I(1).

The next step is to define long-run relation existence between these two time series by using proper tests.

Results of long-run relationship tests

Cointegration test of Johansen's model is used for determining the existence of long-run relationship between two time series of LPW and LPR. By using this model, we have two statistics that include the maximum Eigen value and the trace. Table 2 illustrates the results of this test.

In first hypothesis test for trace statistics, the null hypothesis refers to the nonexistence of long-run relationship and alternative hypothesis suggests the presence of one long-run relationship between two time series variables LPW and LPR. The calculated statistic of this hypothesis test is 70.57; comparing this amount to critical value statistics, the alternative hypothesis is accepted. In the second hypothesis test for trace approach, the null hypothesis shows the existence of one long-run relationship, versus the alternative hypothesis shows the presence of more than one long-run relationship. In the second hypothesis test, comparing the calculated statistics (0.09) with critical value suggests the acceptance of the null hypothesis which shows the presence of just one long-run relationship between LPW and LPR. Therefore, according to trace test, the existence of one long-run relationship between these two time series is endorsed.

In the first hypothesis test for the maximum eigen value statistic, the null hypothesis refers to the nonexistence of long-run relationship and alternative hypothesis suggests the presence of one long-run relationship between two time series variables LP^W and LP^R. The calculated statistics of this hypothesis is 70.48; this demonstrates the acceptance of alternative hypothesis (comparing with critical value, calculated statistic is more than critical value). In follow-up hypothesis testing, the null hypothesis suggests the presence of one long-run relationship, although alternative hypothesis suggests the presence of more than one long-run relationship. In the second hypothesis testing, comparing the calculated statistic with its critical value demonstrates the acceptance of null hypothesis which suggesting the existence of just one long-run relationship between LP^W and LP^R. Therefore, like trace test, the existence of just one long-run relationship between these two time series is validated according to the maximum eigen value statistics.

Results of vector error correction

For defining the long-run and short-run effects of price variables on each other, VECM is used. The use of VECM is possible when we have long-run relationship among price levels and I(1) time series variables. Normalizing with respect to the coefficients, the co-integrating vector takes the following form. The numbers in parentheses denote Z statistics.

$$LP^W = 0.995\ LP^R$$
$$(1511.5)^{***}$$

***Significant at the 1 percent level

The estimated coefficient indicates elasticity

Table 3
The Results of VECM.

Coefficients	ΔLP^{W}_{t}	ΔLP^{R}_{t}
ΔLP^{W}_{t-1}	0.43	0.84**
ΔLP^{W}_{t-2}	0.16	0.38
ΔLP^{W}_{t-3}	-0.11	-0.01
ΔLP^{R}_{t-1}	-0.36	-0.75*
ΔLP^{R}_{t-2}	-0.17	-0.37
ΔLP^{R}_{t-3}	0.02	-0.07
ec_{t-1}	-0.46*	-0.43*

**p<0.05,*p<0.1

among the price levels. Thus, a percent increase (decrease) in retail prices is expected to lead to 0.99 percent increase (decrease) in wholesale price. Results of VECM are shown in table (3). In this model, Sims' (1980), likelihood ratio (LR) tests, were corrected for the degrees of freedom. In addition, the estimated equations satisfy certain econometric criteria, namely known as absence of serial correlation in residuals (LM).

LM statistics in the third lag is 4.39, which, due to the probability level of 36 percent, suggests the acceptance of null hypothesis that refers to the non-existence of serial autoregression. The Eigenvalue test was used to define the stability of model. Calculated value and also the equality value (0.36) of Modulus statistics with Eigenvalue shows the stability of estimated VECM. Calculated values of information criteria include AIC, HQIC and SBIC from this model were -11.54, -11.41 and -11.22, respectively.

Conditional volatilities estimation (spillover effects of wholesaler and retail prices)

For investigating the spillover effects of wholesale (LP^{W}) and retail (LP^{R}) prices of Sadri-Momtaz rice, the Generalized Autoregressive

Table 4
The Results of GARCH

Conditional mean equations		
Coefficients	ΔLP^{W}_{t}	ΔLP^{R}_{t}
ΔLP^{W}_{t-1}	0.94***	0.48***
ΔLP^{W}_{t-2}	-0.26***	-0.37**
ΔLP^{W}_{t-3}	0.27***	-0.13
ΔLP^{R}_{t-1}	0.14***	0.45
ΔLP^{R}_{t-2}	-10**	0.21***
ΔLP^{R}_{t-3}	-0.13**	0.34***
Conditional mean equations		
Coefficients	h^{w}	h^{r}
C	0.0004***	0.0003***
$e^{w\,2}_{t-1}$	0.0924***	0.0006**
h^{w}_{t-1}	0.0168***	0.309**
$e^{r\,2}_{t-1}$	0.0250**	0.06441***
h^{r}_{t-1}	0.680**	0.4716***

**p < 0.05, *** p < 0.01

Conditional Hetroscedasitic (GARCH) model is used. We should estimate the two following models:

$$h_t^w = b_1 + b_2 {e_{t-1}^w}^2 + b_3 h_{t-1}^w + b_4 {e_{t-1}^r}^2 + b_5 h_t^r \quad (13)$$

$$h_t^r = b_6 + b_7 {e_{t-1}^r}^2 + b_8 h_{t-1}^r + b_9 {e_{t-1}^w}^2 + b_{10} h_t^w \quad (14)$$

Results are shown in the following table.

The empirical results of the GARCH model are reported in Table 4. A Box–Jenkins selection procedure indicated that a GARCH (1, 1) model for relative Sadri-Momtaz variety rice prices exhibited the best fit.

Results show that in the h^W and h^R equations the volatility spillover coefficients, i.e. b2, b4, b7 and b9 are positive and statistically significant. However, the magnitude of these coefficients is small, which indicates weak volatility spillovers from retail level to wholesale level and vice versa. In addition, price volatilities of Sadri-Momtaz rice in retail and wholesale levels have positive and significant effects on their volatilities. The statistical significance of b_3 and b8 coefficients implies that in the wholesale and retail levels, price volatility clustering also mattered. The sum of $b_2 + b_3 + b_4 + b_5 + b_6 + b_7$ suggests the stability and permanency. If this definitely is less than unity, it can be argued that the GARCH model is stationary for both wholesale and retail prices. In other words, shocks on wholesale or retail prices do not condition the future variance for a long period.

CONCLUSION

According to the results of unit root tests, monthly time series of Sadri-Momtaz rice wholesale price and Sadri-Momtaz rice retail price have unit roots in zero frequency or they are I(1). Considering the trace and maximum eigenvalue statistics, it can be contended that there is a long run relationship between these two monthly time series. Coefficients of normalized cointegration vector showed that by one percent increase (decrease) in retail price, it is expected that the wholesale price increases (decreases) by 0.99 percent. Results of GRACH model revealed that spillover effects exist from retail price to wholesale price and vice versa. In addition, price volatility in retail and wholesale levels had positive and significant effects on its own level price volatility. Overall, the results reveal that Sadri-Momtaz rice price has different degrees of sensitivity to past own shocks and volatility. Moreover, there is evidence of significant return and volatility transmission across rice wholesale and retail market levels and the conditional volatility has explanatory power on both mentioned market levels. Accordingly, providing proper policy packages in both supply and demand sides is advised. The impact of the volatility is important, because it can render rice prices more volatile, augmenting market uncertainty and risk for market levels.

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