Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 23, Issue 1, 2023
PRINT ISSN 2284-7995, E-ISSN 2285-3952

ESTIMATING VOLATILITY SPREADS BETWEEN MELON, WATERMELON, AND GRAPE MARKETS WITH THE DIAGONAL BEKK-GARCH (1.1) EQUATION MODEL

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Abstract

This investigation has been conducted to determine the fluctuations in the real prices of melon, watermelon, and grapes cause volatility in their own and other markets in Turkey. Diagonal-Bekk Garch (1,1) model was used under the Full-rank constraint with 101 monthly data for the period 2010M01-2022M08. The results of the research have put out that the shock or uncertainty experienced in the melon and watermelon market has increased the uncertainty both in its own market and in the watermelon and grape markets. Shocks in the grape market have only increased the uncertainties in its own market. In addition, it has been determined that the shocks in the melon and watermelon markets are permanent in these markets in the short and long term, but the shocks in the grape market do not have a permanent effect in the short and long term. As a result, it may be necessary to reduce the negative effects of this situation on consumers and to regulate and renew policies that will minimize the risk for producers and consumers in the face of high price volatility.

Key words**:** *market volatility, Diagonal-Bekk Garch (1.1) model, melon, watermelon, grape*

INTRODUCTION

Agricultural price fluctuations create risks and uncertainty in the markets. In the last decade, food prices experienced two significant increases in 2007-2008 and 2010-2011, and also, in the last two years, the effect of the pandemic has been influential on price fluctuations. In addition to the causes of price fluctuations, issues such as the loss of welfare and social unrest caused by price volatility in society have been examined by different researchers, and the relationships between price policies applied by governments and price variables have been evaluated [4, 6, 10, 12, 14]. As a matter of fact, it has been reported that while stocks are formed during periods of high agricultural production, due to supply and demand mismatch, serious price fluctuations occur during periods of excess demand [3].

Melon, watermelon, and grape markets have an important place in agricultural activities in Turkey, and although these products change over the years, they are also subject to foreign trade.

Turkey has 3% of the world's watermelon planted areas and is the most produced vegetable after tomato. Watermelon is a product that is generally subject to domestic consumption [18].

Turkey ranks second in the world in melon production and annual production is 1.5-2 million tons. While 3,670,000 tons of fresh grapes are produced in Turkey, it ranks first in the world for raisins [19].

For this reason, it is extremely important to determine the price volatility of the melon, watermelon, and grape markets, and to ensure price stability in the markets of these products, which have a significant share in the Turkish economy.

And also, Turkey has an international competitive power in these products as well as in tomatoes and walnuts [1, 2].

ARCH, GARCH, and EGARCH models are generally used to determine price volatility. There are also many studies on the price

volatility of agricultural products. For example, [7] determined the relationship between crude oil and agricultural commodity prices. Similarly, [3] determined whether it affects the price flow from the wheat market to the flour market with the balance price relationship between wheat and flour prices. In addition, the price and volatility risk arising from the links between the energy and agricultural commodity markets was determined by the GARCH model [5]. Similarly, the volatility of sugar prices in Turkey was determined using ARCH, GARCH, and EGARCH analyses [16]. Research on price volatility in the markets is still up-to-date and examples can be multiplied on this subject [11, 15, 16, 21].

Melon, watermelon, and grape prices and markets, which have an important place in agricultural production in Turkey, fluctuate throughout the production season.

Consumers are adversely affected by these fluctuations.

These three products are both loved and consumed abundantly, not only in the world but also in Turkey. For this reason, it should be revealed how the macro variables of the said markets are affected by the uncertainty in their variances against the negative or positive variables that occur. It should be determined how the melon, watermelon, and grape markets affect both their own short and long-term uncertainties and the uncertainties of the competitor's market. Modeling how the melon, watermelon, and fresh grape markets, which are important for Turkey, affect each other, and how the changes in one market affect its own market and the other two markets are very important to understand the causes of price fluctuations.

The periods when these three products are offered to the market the most coincide with each other and the price of the products usually determines the consumer's preferences.

On the other hand, in the face of negative or positive shocks that will mobilize the markets such as rising input costs, it is necessary to produce policies on how can protect producers and consumers from price fluctuations that will occur in the future. Therefore, this research has been conducted to determine the fluctuations in the real prices of melon, watermelon, and fresh grapes cause volatility in their own and other markets in Turkey by using the Diagonal BEKK GARCH (1,1) model, under the Full Rank constraint.

MATERIALS AND METHODS

Data set

Average kilogram prices of melons, watermelons, and grapes were taken from the reports of the Istanbul Vegetable-Fruit Market Directorate, and the data set of the research was created with 101 monthly data for the period 2010M01-2022M08 [13].

In addition, the raw data of the three markets for the analyzed period were converted to real values for analysis.

In addition, the raw data of the three markets for the analyzed period were converted to real values for analysis.

The returns of the series were determined by the equation (P_t: the current real prices of the relevant markets, P_{t-1}: the prices of the previous period):

$$R_{i,t} = \Delta \log(P_t) = 100 * \log(\frac{P_t}{P_{t-1}}), i = 1,2,3 \quad .....(1)$$

Econometric Method

Since the possible price volatility difference is evaluated with the diagonal BEKK approach in various market evaluations [8, 9], the Diagonal BEKK GARCH (1,1) method was preferred under the Full Rank constraint to evaluate the price volatility in the melon, watermelon and grape markets.

The diagonal BEKK-GARCH equation is presented below:

$$H_t = C''C + B'H_{t-1}B + A'\varepsilon_{t-1}\varepsilon'_{t-1}A \quad ... \quad (2)$$

In this equation, C: the constant matrix coefficients, A, B: the effect of short and long term shocks in the markets.

The matrix expansion in the BEKK approach is presented below [8, 9]:

Assuming Ω is equal to an 3x3 matrix, C ′C,

$$= \begin{bmatrix} c_{11} & 0 & 0 \\ c_{12} & c_{22} & 0 \\ c_{13} & c_{23} & c_{33} \end{bmatrix} \begin{bmatrix} c_{11} & c_{12} & c_{13} \\ 0 & c_{22} & c_{23} \\ 0 & 0 & c_{33} \end{bmatrix}$$

$$\begin{bmatrix} c^2 & c_{11}c_{12} & c_{11}c_{13} \\ c_{11}c_{12} & c_{12}^2 c_{22}^2 & c_{12}c_{13} + c_{22}c_{23} \\ c_{11}c_{13} & c_{12}c_{13} + c_{22}c_{23} & c_{13}^2 c_{23}^2 c_{33} \end{bmatrix} \quad \text{.... (3)}$$

The Ht matrix is represented by the following formula:

$$H_t = \begin{bmatrix} h_{11,t} & h_{12,t} & h_{13,t} \\ h_{21,t} & h_{22,t} & h_{23,t} \\ h_{31,t} & h_{32,t} & h_{33,t} \end{bmatrix} \quad \text{..... (4)}$$

The final state of the equation is as follows:

$$H_t = \begin{bmatrix} h_{11,t} & h_{12,t} & h_{13,t} \\ h_{21,t} & h_{22,t} & h_{23,t} \\ h_{31,t} & h_{32,t} & h_{33,t} \end{bmatrix} = \begin{bmatrix} \Omega_{11,t} & \Omega_{12,t} & \Omega_{13,t} \\ \Omega_{21,t} & \Omega_{22,t} & \Omega_{23,t} \\ \Omega_{31,t} & \Omega_{32,t} & \Omega_{33,t} \end{bmatrix}$$

$$+ \begin{bmatrix} a_{11} & 0 & 0 \\ 0 & a_{22} & 0 \\ 0 & 0 & a_{33} \end{bmatrix}' \left(\begin{bmatrix} u_{1,t-1} \\ u_{2,t-1} \\ u_{3,t-1} \end{bmatrix} \begin{bmatrix} u_{1,t-1} \\ u_{2,t-1} \\ u_{3,t-1} \end{bmatrix}' \right) \begin{bmatrix} a_{11} & 0 & 0 \\ 0 & a_{22} & 0 \\ 0 & 0 & a_{33} \end{bmatrix}$$

$$+ \begin{bmatrix} b_{11} & 0 & 0 \\ 0 & b_{22} & 0 \\ 0 & 0 & b_{33} \end{bmatrix}' \begin{bmatrix} h_{11,t-1} & h_{12,t-1} & h_{13,t-1} \\ h_{21,t-1} & h_{22,t-1} & h_{23,t-1} \\ h_{31,t-1} & h_{32,t-1} & h_{33,t-1} \end{bmatrix} \begin{bmatrix} b_{11} & 0 & 0 \\ 0 & b_{22} & 0 \\ 0 & 0 & b_{33} \end{bmatrix}$$

..... (5)

Finally, each conditional variance and covariance equation is represented by the following equations:

$$h_{11,t} = \Omega_{11} + a_{11}^2 u_{1,t-1}^2 + b_{11}^2 h_{11,t-1} \quad (6)$$

$$h_{12,t} = \Omega_{12} + a_{11}a_{12}u_{1,t-1}u_{1,t-1} + b_{11}b_{22}h_{12,t-1} \quad (7)$$

$$h_{13,t} = \Omega_{13} + a_{11}a_{33}u_{1,t-1}u_{3,t-1} + b_{11}b_{33}h_{13,t-1} \quad (8)$$

$$h_{22,t} = \Omega_{22} + a_{22}^2 u_{2,t-1}^2 + b_{22}^2 h_{22,t-1} \quad (9)$$

$$h_{23,t} = \Omega_{23} + a_{22}a_{33}u_{2,t-1}u_{3,t-1} + b_{22}b_{33}h_{23,t-1}$$

$$h_{33,t} = \Omega_{33} + a_{33}^2 u_{3,t-1}^2 + b_{33}^2 h_{33,t-1} \quad (10)$$

$$h_{33,t} = \Omega_{33} + a_{33}^2 u_{3,t-1}^2 + b_{33}^2 h_{33,t-1} \quad (11)$$

RESULTS AND DISCUSSIONS

Before starting the calculations to detect price volatility, 101 monthly data sets for the period 2010M01-2022M08 were generated. A number of analyses were made to determine the effect of price volatility between markets after the current prices were converted to real. When Table 1 is examined, descriptive statistics will be seen. When the average price values are examined, the highest prices of the three markets were determined for grapes, melons, and watermelons, respectively. According to the maximum and minimum values, the highest kilogram price of melon was 46,044₺, watermelon was 33,106₺, and grape was 76,331₺.

The results of kurtosis, skewness, and Jarque-Bera (whether the series are normally distributed or not) showed that all series have asymmetric distribution.

Table 1. Descriptive statistics table of prices (TL/kg) of melon, watermelon, grape*

	r_melon	**r_watermelon**	**r_grape**
Mean	13.891	9.381	20.189
Median	12.082	7.921	18.828
Maximum	46.044	33.106	76.331
Minimum	4.450	2.496	8.505
St. Dev.	7.094	5.356	10.302
Distortion	1.650	1.960	2.224
Kurtosis	6.681	7.829	11.107
Jarque-Bera	102.916	162.849	359.904

Source: [13] *Calculated by authors.

Figures 1, 2 and 3 show price volatility graphs of real prices over time. Compared to the melon market, more price volatility is observed in the watermelon and grape market. The highest price volatility occurred in the watermelon market. 2010-01 serious increase in the price of watermelon and melon come to the fore.

Towards the end of the same year, there is an increase in prices in the grape market.

The most serious increase in the watermelon market was in 2014.

After 2016, it is observed that the prices in the other three markets are more stable.

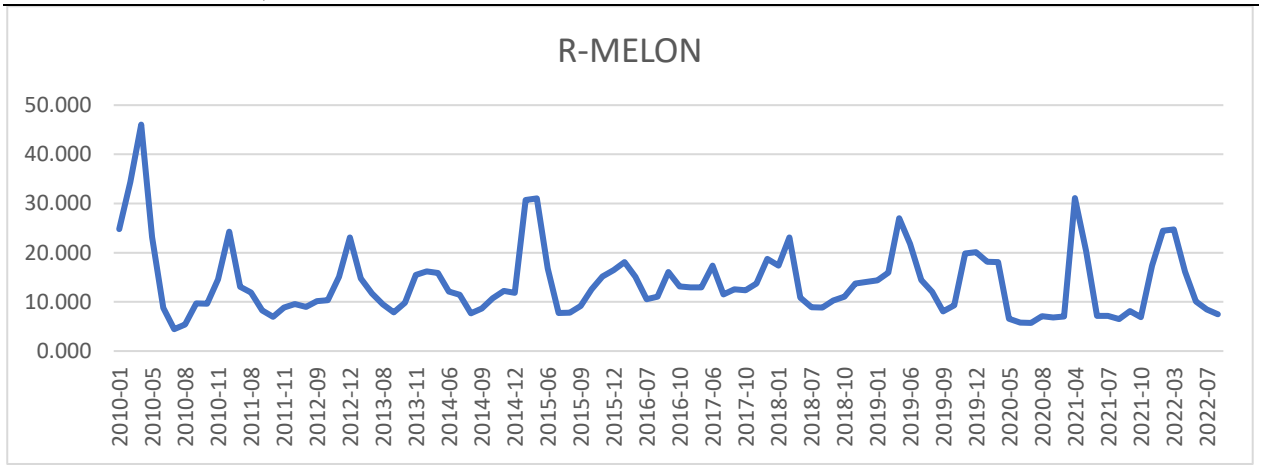

Fig. 1. Price volatility graph of real melon prices over time (TL/kg)
Source: [13].

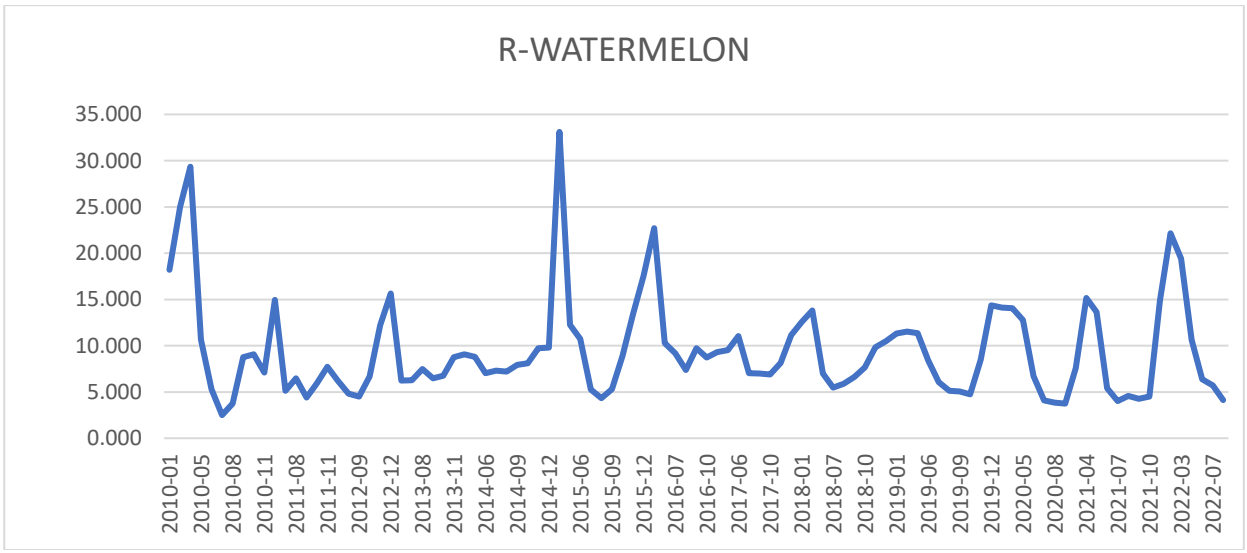

Fig. 2. Price volatility graph of real watermelon prices over time (TL/kg)
Source: [13].

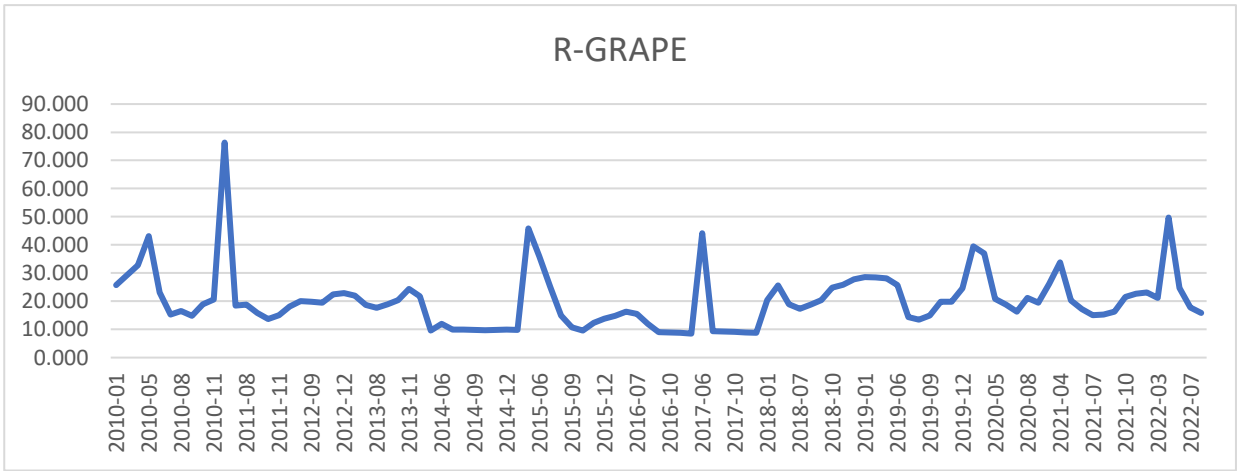

Fig. 3. Price volatility graph of real grape prices over time (TL/kg)
Source: [13].

The results of the ADF unit root test applied for the series are given in Table 2. Fixed and trend-free, only constant and trend-containing unit root tests were applied to the series, respectively. In this context, it has been

determined that the series are stationary only in constant and constant-trend.

Diagonal Bekk Garch (1,1) model results under full-rank constraint are given in Table 3. Substituted coefficients show the long-term averages of the markets. The long-term averages of all the coefficients [C(1), C(2), C3), C(5) 1%, C(4) and C(6) 5%] were found to be statistically positive and significant. Although there is no variance and covariance pass-through in these coefficients, shocks or uncertainties in the markets cause price fluctuations of 7.5% in the melon market, 5.9% in the watermelon market and 16.1% in the grape market.

Table 2. Results of the Stationarity Test of the Series*

Dickey-Fuller (ADF) Test Statistic				
	Extrinsic Variable: Constant		Exogenous Variable: Constant and Trend	
	t-statistic	Possibility	t-statistic	possibility
r.melon	-7.382	0.000	-7.330	0.000
r.watermelon	-8.516	0.000	-8.504	0.000
r.grape	-7.044	0.000	-7.013	0.000

(1) The lag length for all series was chosen as 1 according to the Schwarz information criterion.
Source: *Calculated by authors.

The coefficients of the variance equations are presented in the second part of Table 3 and C(7-18) represents the ARCH and GARCH coefficients. While coefficients of C(7), C(8), C(10), C(12), C(13), and C(14) were found to be statistically positive and significant at 1%, coefficients of C(9) and C(10) are also positive and significant at 5%. The fact that the coefficients giving the GARCH effect are statistically significant and at the same time, the sum of the coefficients giving the ARCH and GARCH effect is greater than one indicates that shocks have a permanent effect in the short term and long term.

In the last part of Table 3, the transformed coefficients of variance are presented. M shows the transition effect of coefficient variables in covariance matrices. M coefficients are statistically positive and significant. A shock that will occur in the melon market [M (1,1)] increases the uncertainty in its own market by 23.2%, the uncertainty in the watermelon market [M(1.2)] by 14.6%, the uncertainty in the grape market [M (1.3)] by 24.8% and it is statistically significant by 1% and 5%, respectively. Level is important. A shock in the watermelon market increased the uncertainty in its own market [M (2.2)] by 10.5%, while the uncertainty in the grape market [M (2.3)] increased by 15.7%. The coefficient of covariance matrices [M (3.3)] indicates that shocks in the grape market increase the uncertainty in its market by 81.4%. The A1 and B1 coefficients of the relevant markets show the effects of ARCH and GARCH in the markets. As a matter of fact, the A1 coefficient represents the permanence of the short-term shocks of the markets, and the B1 coefficient represents the permanence of the long-term shocks. The fact that the A1+B1 coefficients are greater than one means that the short and long-term shocks in the markets are permanent. Therefore, the fact that the ARCH and GARCH coefficients of the melon and watermelon markets are greater than one [A1(1,1) + B1(1,1) =1,036], [A1(2,2) + B1(2,2) = 1,164] proves the permanence of the short and long-term shocks that will occur in these two markets. Contrary to the other two markets, the fact that the sum of ARCH and GARCH coefficients of the grape market [A1(3,3) + B1(3,3) = 0,707] is less than one indicates that the shocks are not permanent for this market. Similar results have been obtained in studies investigating whether short- and long-term shocks have a permanent effect on the markets. For instance, it has been found that the conditional variances of grains and oil and the real exchange rate returns are affected by the long-term volatility of both own and other markets. In addition, it has been determined that this effect can be both direct and indirect [20]. Similarly, the effects of volatility in sugar prices in Turkey were determined using

ARCH, GARCH and EGARCH analyses and it was emphasized that the sugar market was affected by short and long term shocks [17].

Table 3. Diagonal BEKK-GARCH (1,1) Analysis Results*

System:SYS04				
Prediction Method: ARCH Maximum Likelihood (Marquardt)				
Covariance Type: Diagonal BEKK				
Substituted Coefficients	Coefficient	Standard error	z-statistic	Probability
C (1)	7.584***	0.873	8.681	0.000
C (2)	0.498***	0.085	5.826	0.000
C (3)	5.951***	0.550	10.813	0.000
C (4)	0.103**	0.044	2.343	0.019
C (5)	16.167***	2.602	6.121	0.000
C (6)	0.586**	0.199	2.940	0.033
Coefficient of Variance Equation				
C (7)	4.816***	0.527	9.132	0.000
C (8)	3.042***	0.439	6.927	0.000
C (9)	5.156**	0.527	9.132	0.010
C (10)	1.127***	0.307	3.671	0.000
C (11)	0.023	3.869	0.006	0.995
C (12)	7.404***	0.754	9.807	0.000
C (13)	0.791***	0.183	4.305	0.000
C (14)	1.089***	0.189	5.762	0.000
C (15)	0.661**	0.282	2.345	0.019
C (16)	0.245	0.192	1.320	0.186
C (17)	0.075	0.202	0.373	0.708
C (18)	0.046	1.059	0.043	0.965
Log likelihood	-899.1156			
Akaike info criterion	18.34231			
Hannan-Quinn criter	18.81124			
Schwarz criterion	18.53210			
Covariance Type: Diagonal BEKK				
GARCH = M + A1*RESID(-1)*RESID(-1)'*A1 + B1*GARCH(-1)*B1				
M = full rank matrix, A1= diagonal matrix, B1= diagonal matrix				
Converted Coefficients of Variance				
	Coefficient	Standard error	z-statistic	Probability
M (1,1)	23.203***	5.081	4.566	0.000
M (1,2)	14.656***	3.407	4.301	0.000
M (1,3)	24.838**	11.880	2.090	0.030
M (2,2)	10.529***	2.394	4.397	0.000
M (2,3)	15.715**	7.299	2.153	0.030
M (3,3)	81.413***	16.163	5.036	0.000
A1(1,1)	0.791***	0.183	4.305	0.000
A1 (2,2)	1.089***	0.189	5.762	0.000
A1 (3,3)	0.661**	0.282	2.345	0.010
B1(1,1)	0.245*	0.192	1.320	0.186
B1 (2,2)	0.075	0.202	0.373	0.708
B1 (3,3)	0.046	1.059	0.043	0.965

*, ** and *** indicate the significance level at 10%, 5% and 1%, respectively.
Source: *Calculated by authors.

The combined price volatility graph of the simultaneous returns of the markets over time is given in Figure 4.

In all of the analyzed markets, price increases are observed in 2011 and 2015. Moreover, more price fluctuations were detected in grape prices compared to the melon and watermelon markets in 2017.

As a matter of fact, when Figure 4 is examined, price fluctuations can be clearly seen in the melon market in 2021 and in the watermelon market in the first months of 2022.

Variance and conditional variance and conditional correlation graphs are presented in Figures 5 and 6. It is seen that the markets exhibited high price volatility in 2010, 2015, and 2020.

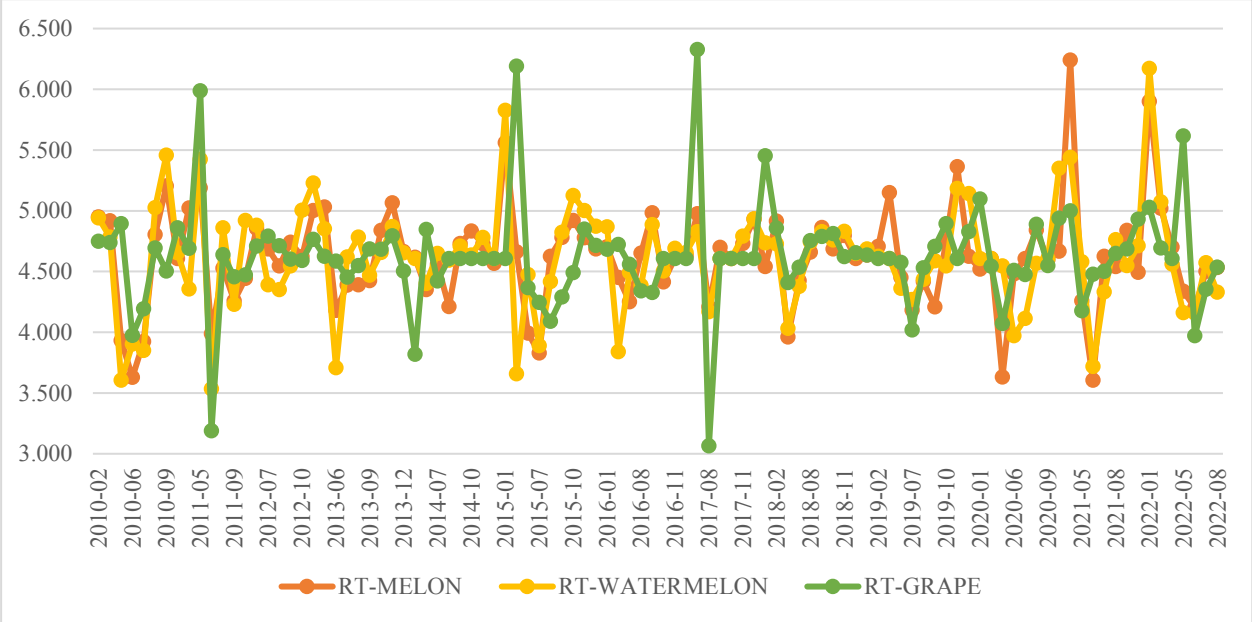

Fig. 4. The combined price volatility graph of the simultaneous returns of the markets over time (TL/kg)*
Source: *Calculated by authors.

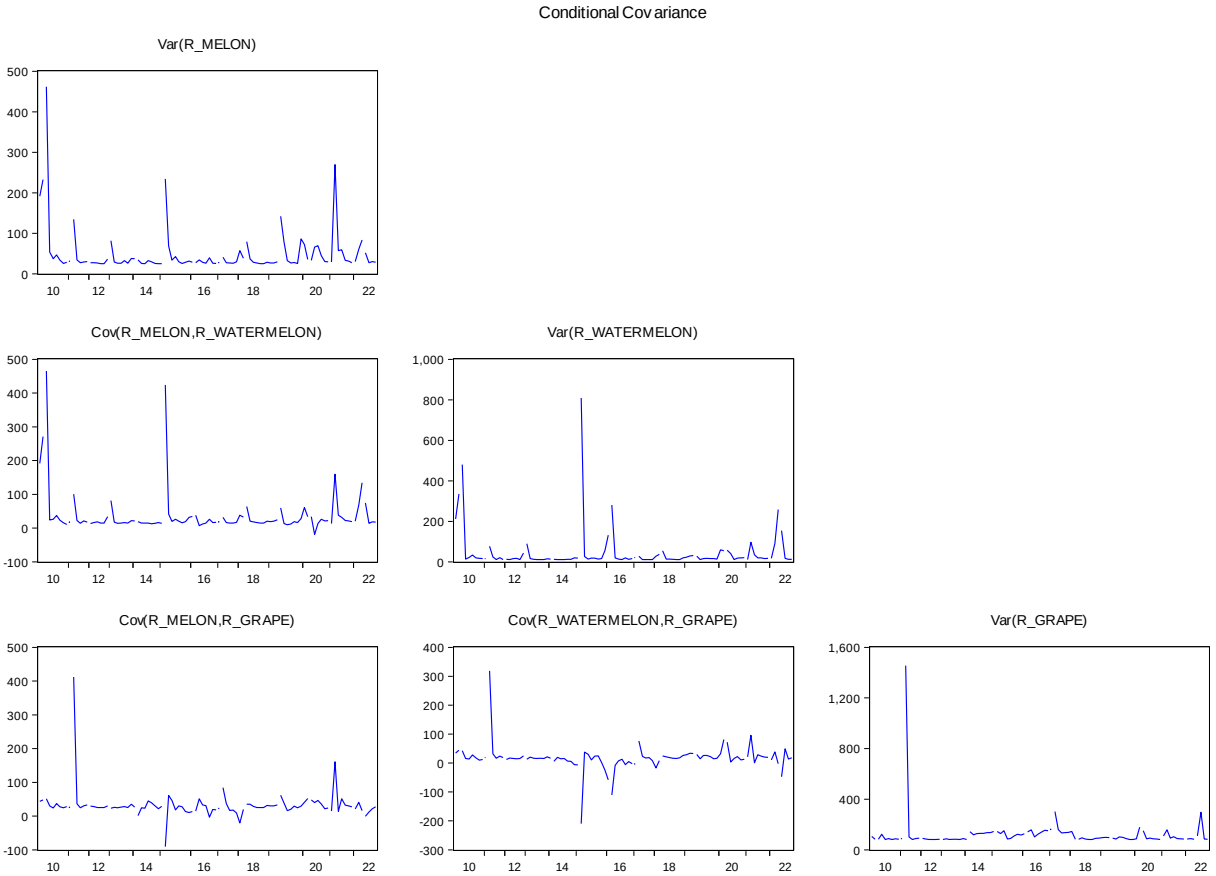

Fig. 5. Variance and conditional covariance graphs of data series*
Source: *Calculated by authors.

This may be due to the reflection of Turkey's political, economic, and social crises on the markets in the mentioned years. In addition, the world food crisis in 2010, the political crises experienced accordingly, and finally the Covid-19 pandemic, which started in 2019 and whose effects are still continuing, have affected the markets. On the other hand, the climate change experienced in recent years and the increase in input costs negatively

affect the markets and cause serious price volatility in the markets.

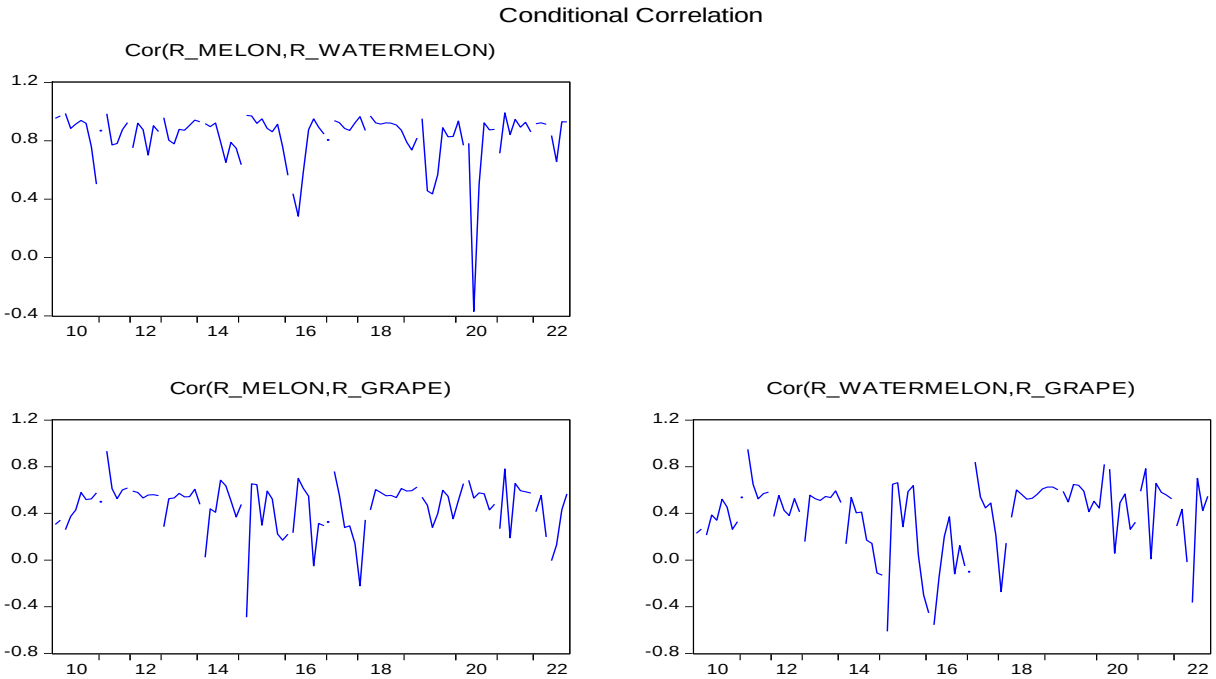

Fig. 6. Conditional correlation graphs of data series*
Source: *Calculated by authors.

CONCLUSIONS

Diagonal-Bekk Garch (1,1) model was used under the Full-rank constraint to analyse the price volatility in the melon, watermelon and grape markets. According to the results obtained from the Diagonal-Bekk Garch (1,1) model, the shock or uncertainty in the melon market has increased the uncertainty both in its own market and in the watermelon and grape market. Similarly, a shock in the watermelon market increased the uncertainty both in its own market and in the grape market. Shocks in the grape market, on the other hand, increase the uncertainties in its own market. Moreover, it has been determined that the shocks in the melon and watermelon markets are permanent in these markets in the short and long term, but the shocks in the grape market do not have a permanent effect in the short and long term. There is a spread of instability among the markets, and the effects of spillover from one sector to another sector vary depending on the market volumes of the sectors.

Problems in product supply, increases in oil prices, increases in production input costs, as well as the fact that agriculture is a risky and uncertain sector, cause price fluctuations in the markets. As the price fluctuations in the markets continue to be high in the medium and long term, the income level that will experience real income loss is an important issue for the low-income segment. It is essential to reduce the negative effects of this situation on consumers and to regulate and renew policies that will minimize the risk to producers and consumers in the face of high price volatility. It is also necessary to partially control the market uncertainties in the agricultural sector by focusing on the domestic production of the majority of the inputs in the relevant markets, especially by the important actors that have an impact on the economy.

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