agriculture

MDPI

Article

Volatility in Live Calf, Live Sheep, and Feed Wheat Return Markets: A Threat to Food Price Stability in Turkey

Faruk Urak [1], Abdulbaki Bilgic [2], Gürkan Bozma [3], Wojciech J. Florkowski [4,*] and Erkan Efekan [5]

1 The Turkish Radio and Television Corporation (TRT), Erzurum Directorate, Erzurum 25100, Turkey; farukurak.trt@gmail.com
2 Department of Management Information Systems, College of Economics and Administrative Sciences, Bilecik Şeyh Edebali University, Bilecik 11320, Turkey; abdulbaki.bilgic@bilecik.edu.tr
3 Department of Economics, College of Economics and Administrative Sciences, Iğdır University, Iğdır 76420, Turkey; gurkan.bozma@igdir.edu.tr
4 Department of Agricultural and Applied Economics, University of Georgia, 1109 Experiment Street, Griffin, GA 30223-1797, USA
5 Agriculture and Rural Development Support Institution (ARDSI), Erzurum Provincial Coordinatorship, Şükrüpaşa Neighborhood, T.M.O. Lodgings Street No:1, Yakutiye, Erzurum 25100, Turkey; erkan.efekan@tkdk.gov.tr
* Correspondence: wojciech@uga.edu

Abstract: The volatility of meat prices affects the accessibility and even food security of some consumers in Turkey. This study analyses the prices of selected livestock and a major feed component, wheat, as well as the exchange rate of the domestic currency in Turkey because imports augmented the domestic live calf and sheep supply. The analysis applies 470 price observations from January 2005 to October 2019 for each of the following price series: live calf, live sheep, feed wheat, and exchange rate of Turkish lira to US dollar. The series are analyzed by using the VAR-Asymmetric BEKK-GARCH technique. The results show that the elicited conditional variances of the return series were significantly affected by both short-term shocks and shocks across the return series. The uncertainties in the live calf, live sheep, and feed wheat markets were affected by both long-term volatilities and long-term swings in their own and the other markets, but their own market-induced effects were stronger. Similarly, the conditional variances of the returns of live calves, live sheep, and feed wheat were significantly affected by the rapid price ascent in the exchange rate and the periods of livestock imports as compared to the periods when imports were absent. The unfavorable news exerted particularly negative effects on persistent volatility in markets. Additionally, the live sheep market faced greater risks than the live calf or wheat markets and was greatly affected by the limited domestic sheep supply. Results provide knowledge useful in augmenting policy, assuring sustained accessibility to animal protein in Turkey and eliminating food insecurity.

Keywords: food security; live calf; live sheep; feed wheat; exchange rate; volatility; VAR-Asymmetric BEKK-GARCH; Turkey

check for updates

Citation: Urak, F.; Bilgic, A.; Bozma, G.; Florkowski, W.J.; Efekan, E. Volatility in Live Calf, Live Sheep, and Feed Wheat Return Markets: A Threat to Food Price Stability in Turkey. *Agriculture* **2022**, *12*, 566. https://doi.org/10.3390/agriculture12040566

Academic Editor: Francesco Caracciolo

Received: 11 March 2022
Accepted: 13 April 2022
Published: 16 April 2022

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

1. Introduction

The amount of meat consumption per capita is regarded as an important indicator in determining a country's development and welfare levels [1,2]. Animal products are the preferred data points as they are primary protein sources. Red meat rich in protein is still an important food source in developing countries [3,4]. The data of the World Health Organization (WHO) suggests that a healthy individual should consume 1 g of protein for each kilogram of body weight per day, and about 42% should be of animal origin. In 2017, annual per capita red meat consumption in Turkey was 12.5 kg (8.3 kg of beef, 4.1 kg of mutton, and 0.1 kg of pork), of which approximately 67% was beef, whereas the per capita consumption amounts in EU-28 countries and the United States in the same year were

45.4 kg (11 kg beef, 1.9 kg mutton and 32.5 kg pork) and 49.8 kg (25.8 kg of beef, 0.4 kg of mutton, and 23.6 kg of pork), respectively [5].

Surges in beef prices have an important effect on consumption, and red meat price fluctuations have occurred over time in Turkey. Whereas the average global beef price was $2.98, $3.35, and $4.98 in 2005, 2010, and 2016, respectively, the price in Turkey was $8.59, $16.04, and $12.72, in the same years [5]. The swings in red meat prices result from an input cost increase [2]. Feed costs comprise more than 60% of total livestock production costs [6]. Feed costs constitute 30% of the costs of cattle finishing in Turkey [7]. Therefore, an increase in the prices of grains increases livestock prices. Variations in feed prices in the cattle supply chain directly affect the costs and profitability of raising cattle [8,9].

Excessive price surges in agricultural products adversely influence food security, economic growth, and social stability, and disproportionately affect the poor [10–13]. The food crisis in 2008 and the resulting social unrest exemplify the consequences of such price fluctuations in emerging economies [14]. According to the United Nations Food and Agriculture Organization (FAO), the general food price index increased by 27% in 2007 and 25% in 2008, and the international prices of staple food products reached their highest level over the past three decades in June 2008 [15]. An estimated 115 million people have become chronically food insecure [15]. The volatility in global food prices contributed to the socio-political unrest in the Middle East in 2011 [16] because many countries in the region depend on food imports. The surges in food prices have been expected to continue [17]. For example, commodity prices increased in the latter part of 2016 [18]. Grain, red meat, and chicken prices increased in Iran by 17.5%, 12.7%, and 13.6%, respectively in 2017 [19]. In Turkey, beef, and lamb prices increased by 10.28% and 22.86%, respectively, during the 12 months from November 2017 to October 2018 [7]. Their price levels reached historical records of 33 Turkish Lira (₺) and ₺46 per kg, respectively, in July 2017. Easing import regulations caused meat prices to fall slightly. However, the effect was short-term because of feed price increases. Inadequate domestic forage crop production requires imported corn and soy causing higher animal feeding costs in Turkey than in other countries. As a result, Turkey’s animal product prices are vulnerable to fluctuation, compromising domestic food security and the nutritional needs of its population.

An understanding of the long-term integration of input markets with the livestock sector is needed for the development of food security policies in Turkey. In Turkey, 2.5% of the population has been reported as being food insecure, a level which has remained stable for several years [20]. Population segments vulnerable to food insecurity included landless rural residents, smallholder farmers, and women caring for families [21]. Affordability was the primary reason for food insecurity and nationwide nutrition surveys were deemed necessary to fully understand the scope of the problem [22]. Of particular concern has been the access and affordability of meat and its direct relation to household food security [23]. A recent study of a small sample of health center visitors, applying the Household Food Security Survey developed by USDA, reported a relatively high ratio of food-insecure families, while Bucak, et al. [24] suggested the persistence of the problem and called for a more complete study. Keskin and Demirbaş [25] argued for the use of a modified food security measurement method due to the multidimensionality of the problem specifically fitting the conditions in Turkey.

Instability (and even volatility) of food prices is one of the facets of food insecurity and has been a major concern for food security in Turkey [22,26]. Policy decisions supporting a stable supply of animal protein benefit from uncovering the presence and causality of short- and long-term uncertainty pass-through between livestock and feed markets. This study explores the causality between live cattle, live sheep, and feed wheat markets, as well as the effects of short-and long-term permanent fluctuations among their price series. Additionally, this study considers the effects of the exchange rate and import decisions and their influence on causality and transmission across the explored agricultural markets. Uncertainty and asymmetrical spillovers among agricultural products are highly likely to be penetrated in a developing country like Turkey, whose economic structure is constantly fragile due to climate change, water shortage pressure, high food inflation, bottlenecks in the food supply chain, depreciation of the local currency, income inequality, political instability, etc. It is, therefore, crucial for policymakers and industry stakeholders to embody such levels of risk by investigating the volatility pass-through between agricultural markets in a major developing country where food security depends on imported animal feed. Results, therefore, provide insights applicable to shaping domestic policies guiding livestock farmers, feedlot operators, and food marketers to secure the domestic food supply.

The remainder of this article is organized as follows. Earlier studies on the subject are presented in the literature review in Section 2. Section 3 provides detailed information on the materials and methods, including the data descriptions and preliminary statistics. While the model results are presented in the Results section, the extensive discussions on the subject follows in the Discussion section. Policy recommendations and limitations of the study are included in the Conclusion section.

2. Literature Review

The high volatility of agricultural product prices in the 2000s sparked a debate on the driving forces of food price instability. Studies demonstrated that the extreme volatility in agricultural product prices is dynamic and caused by many interrelated factors.

Turkey is a net importer of agricultural products and is directly affected by fluctuations in the US dollar exchange rate. The exchange rate variation causes food price volatility [19,27–29]. In recent years, the increase in corn- and soy-based biofuel production [30,31] affected feed prices, a basic input in animal husbandry [32]. The short-term depreciation of the Turkish lira has significantly affected wheat prices [33]. As noted by Salisu and Ayinde [34], the negative effects of continued volatility or uncertainty in exchange rates on the macroeconomic and domestic markets are inevitable and act as a barrier to an adequate food supply. This effect is even more pronounced in a developing country with a fragile economic structure. Abbott and Borot de Battisti [35] who investigated the silent drivers behind rising food prices in the world market, attributed this causality to factors such as insufficient investment in agriculture, increased international oil prices, and depreciation in the exchange rate, and Yan, et al. [36] listed distance and sales volume as price determinants. On the other hand, Birthal, et al. [37] found production shocks, seasonality in production and market entries, domestic trade, export policies, and market power of intermediaries as factors responsible for the volatility of onion prices in India. Mitchell [38] researched the effects of the exchange rate on food prices and estimated a 20% increase as a result of the rate depreciation. In contrast, Reboredo and Ugando [39] used copulas methods to examine the relationship between the US dollar exchange rate and the international prices of several agricultural commodities (corn, soybean, wheat, and rice) without their excessive market dependencies. A positive but weak dependence on the food exchange rate confirmed that the price spikes for those commodities were not due to excessive US dollar depreciation. Still, Mawejje and Nampewo [40] found that the large quantities and diversity of non-tradable staple foods in Uganda moderated the full transferability of global prices to domestic market prices, even though Ugandan local food prices adjusted to both exchange rate movements and international food prices. Similarly, in a study conducted in Nigeria, Akanni [41] found evidence that the directional interdependence between food prices and exchange rates is taken into account, based on the obtained diffusion indices. Moreover, after the collapse of the exchange rate, food prices tend to reflect the exchange rate returns and volatility. In an earlier study conducted in Turkey, it was emphasized that there was a causality relationship between the exchange rate of US dollars and goat meat price [42]. Urak, et al. [43] reported that long-term persistent uncertainties in wheat and exchange rate markets in Turkey create permanent uncertainty for all markets, including their own.

Price uncertainty especially influences beef because of the long biological production cycle. Price volatility is considered a major risk in production decisions and affects future prices [44]. Knowledge of price volatility can protect profitability by allowing risk management. Similarly, when information about price volatility spillover effects and implemented countermeasures is provided, policymakers can design solutions [45–47] and ensure food security.

Studies on fluctuations in livestock or meat prices are limited. Kesavan, et al. [48] stressed that in the United States, the volatility in beef and pork farm prices depends on the information obtained from previous periods. Piotr and Witold [49] have suggested, for example, that there are strong nonlinear relationships between live cattle and pork price returns and corn and wheat price returns. Luo and Liu [50] used various generalized autoregressive conditional heteroskedasticity (GARCH) models (i.e., such as the GARCH, MV-GARCH, T-ARCH, and E-GARCH techniques) in their study covering the period between January 2000 and December 2007 to demonstrate meat price volatility in China. The results concluded that beef is high-risk but low-return, and beef, sheep, and poultry prices show asymmetric price volatility, with volatility due to price decreases being lower than volatility due to price increases. Khiyavi, et al. [51] reported that the volatility in agricultural input and retail food prices showed significant and positive spillover effects on the volatility of agricultural output prices. It has also been reported that feeder cattle prices caused volatility in live cattle prices, but the volatility in live cattle prices did not affect feeder cattle prices [8,52]. A study of the substitute goods effect between red meat prices stated that the shock in one market created fluctuation in prices of another market [53]. In a study investigating the effect of the exchange rate on the volatility of meat-type prices, Miljkovic and Zhuang [54] investigated the spread of the exchange rate on Japanese meat import prices and found that there is a partial transmission of the exchange rate to meat and poultry import prices. However, among the rare studies examining short-run shock and volatility spillovers among the world's four major agricultural commodities, Lahiani, et al. [55] found the existence of both concurrent shock and long-term volatility spillover transmission among commodities by using the model of Ling and McAleer [56]. Interestingly, wholesale and retail meat prices were rising, whereas livestock prices were falling [57], increasing the farm-to-wholesale marketing margin, which is often casually defined as the difference between the farm-level price for livestock and wholesale meat prices. Meanwhile, Abdallah, et al. [58], in their study in Finland, found an interesting result wherein the vertical price pass-through for the pork market is reversed. In other words, the volatility was transmitted from consumer price spikes to producer price uncertainty in the pork market. Adeosun, et al. [59] emphasized that oil price shocks create upward pressure on food prices during periods of high inflation. Similarly, Tosun and Demirbas [60], in their study of 71 meat producers in Turkey, emphasized that the fluctuations in the prices of intermediate goods used in meat production negatively affected the prospective production plans of the producers. There are few studies on the supply chain of beef and dairy sectors in Turkey, but several of them are worth mentioning [61–63]. The literature review shows a lack of studies examining the uncertainty pass-through of returns between the red meat and feed (fodder) wheat markets in a large developing country like Turkey.

3. Materials and Methods

3.1. Data

Prices of live calves, live sheep, and feed wheat were retrieved from the Turkish Union of Chambers and Exchange Commodities (TUCEC) database. An insufficient supply of live cattle, live sheep, and feed wheat has required imports to secure an adequate domestic supply. Additionally, the effect of the "import" variable on the relevant markets was investigated by identifying the periods of livestock imports (i.e., the variable is defined as 1 when imported during the indicated period, 0 otherwise). In this context, the import variable series was obtained from the Turkish Statistical Institute (TSI) database. The real exchange rate series were retrieved from the Electronic Data Delivery System of the Central Bank of the Republic of Turkey (TCMB EVDS).

Live animal prices were obtained from the Edirne Commodity Exchange and the Livestock and Broom Wire Exchange and Social Facilities that became operational on

20 August 1991. It is the oldest institutionalized stock exchange for livestock in Turkey, although other livestock exchanges have been operating in recent years. The Edirne stock market has created a very important food channel to supply the population of Istanbul, the largest urban center in Turkey. The exchange generated data only if a specific commodity was traded on a given day. For example, on the day when live calves are traded, while commodities of interest are not traded, the observations are missing for other products. As a result, data losses were due to data matching, and the dataset includes observations only for days when all three commodities were traded. The applied dataset contains daily observations as the prices were recorded. A total of 470 observations between January 2005 and October 2019 were used to analyze the volatility across the series.

3.2. Econometric Approach

This study applies both conditional vector autoregression (VAR) to the return mean equations and Baba, Engle, Kraft, and Kroner (BEKK) multivariate GARCH (henceforth, BEKK-MGARCH) process [64] to the time-dependent conditional variance equations. Various information criteria such as Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC) options were used for the delay values in the VAR part and were determined as two. As for the lag values in the time-dependent BEKK-GARCH part, because it is almost impossible for the model to converge at the maximum point of the log-likelihood function with several parameters that have a non-linear form, only the first lag form of BEKK is considered in the current study. Therefore, the VAR (2)-Asymmetric BEKK-GARCH (1, 1) model meets the above notion and will be used as such for subsequent illustration. In addition, the relevant model assumes that positive and negative shocks are not of equal size. The model is superior to other models by adding asymmetric effects to the conditional variance equation [65,66]. The asymmetric effect of shocks in financial markets is often studied by using this type of model and that was the reason for choosing it to model the interdependencies between financial time series variables. This model also achieves the positive rank of conditional variance and covariance for all values of residuals through BEKK parameterization [65,66]. The conditional mean and variances of each return variable are given in Equations (1) and (2), respectively [56,65,66]. The return vector of the live calf, live sheep, and feed wheat markets, respectively, is $R_t = [R_{1,t}, R_{2,t}, R_{3,t}]'$, where each R_t is calculated as $R_t = 100 * \ln(P_t/P_{t-1})$. P_t represents the real price of the explored market, ln denotes the natural logarithm, and P_{t-1} represents the lag prices. The return equation in vector structure is as follows:

$$R_t = \mu + \sum_{i=1}^{p} \Gamma_i R_{t-i} + \Phi E + \omega I + \varepsilon_t, \quad (1)$$

where the lag length p is 2. E and I are the exchange rate closing level and the imported livestock dummy variable is equal to 1 if the import takes place and 0 otherwise. For each of the R_t equations, μ, Φ, and ω are predictors to be estimated, corresponding to the constant term, E, and I variables. Likewise, Γ parameters are predictors that correspond to the unitary effects of lagged agricultural market returns on current market returns, whereas ε_t indicates the vector of noises corresponding to each return market.

The higher-than-expected changes in the prices of live calves, live sheep, and fodder wheat are welcomed by the markets. However, a lower-than-expected change is generally greeted as unfavorable news. In this case, the residual of each return variable will be positive and will be shown as follows $\xi_{1,t} = \max\{\varepsilon_{1,t}, 0\}, \ldots, \xi_{m,t} = \max\{\varepsilon_{m,t}, 0\}$ [65], where m is 3. If the residuals are negative in the conditional variance, they will be encoded as 1, and 0 otherwise. Such an asymmetry in the system will act as a sensor or a receptor, serving as a process to segregate negative innovations from their positive counterparts.

We can express the conditional heteroscedasticity equation for the first order asymmetric BEKK-GARCH model as [67]:

$$H_t = \Upsilon\Upsilon' + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'H_{t-1}B + D'\xi_{t-1}\xi'_{t-1}D. \tag{2}$$

The matrix H consists of two parts. The first part includes the equation constants, including parameters from both E and I variables, which can be expressed as $\Upsilon = (C + \Psi E_t + \varphi I_t)$, where C, Ψ, and φ are 3×3 upper triangle matrices that measure the constant coefficients of time-varying conditional variance equations, pass-through of both exchange rate market, and import decisions on surges in the specific market, respectively. The second part consists of short-term shocks (ε_{t-1}), long-term volatilities (H_{t-1}), and asymmetric effects (ξ_{t-1}), which can be expressed as $A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'H_{t-1}B + D'\xi_{t-1}\xi'_{t-1}D$. The matrices A and B contain short-term shocks and long-term volatility parameters, respectively, and the matrix D includes parameters expressing the asymmetric effect. In addition, although the diagonal coefficients in the A, B, and D matrices are related only to their own shocks, volatility and asymmetry of the relevant market, the non-diagonal parameters in those matrices define the transmission from one market to another. The measurability of the BEKK model ensures that H_t is a positive definite for ε_t residuals, and allows different relative responses to positive–negative shocks through the conditional variance–covariance matrix (H_t) by smoothing the assumption of symmetry.

Just as uncertainty in a market (conditional variance) is affected by its short-term shocks and long-term uncertainty, it can also be captured by the short-term shocks and long-term surges of other commodity markets (cross markets). It is also affected by the asymmetry of short-term shocks or news about its own and cross markets, under the assumption that the negative innovations are larger and last longer than their positive counterparts. Long-term surges in the markets are also affected by the dollar exchange rate and livestock import variables in the country. It is of great importance to elicit the effects of the dollar exchange rate and imports in both the mean return equations and the long-term volatility equations of each agricultural market, where future policy tools can be solidly shaped based on such findings.

The parameters of conditional mean and conditional variance–covariance equations of the BEKK model were maximized by using the log-likelihood function. The parameter was estimated by using the Student t-distribution recommended by [68]. The likelihood function of this distribution is:

$$L_t = \ln\left[\frac{\Gamma\left(\frac{v+n}{2}\right)v^{\frac{n}{2}}}{(vn)^{\frac{n}{2}}\Gamma\left(\frac{v}{2}\right)(v-n)^{\frac{n}{2}}}\right] - \frac{1}{2}\ln|H_t| - \frac{1}{2}(v+n)\ln\left(1 + \frac{\varepsilon'_t H_t^{-1}\varepsilon_t}{v-2}\right) \tag{3}$$

where n denotes the average number of equations, ε_t denotes the residuals of n vector mean equations, v denotes the degree of freedom (provided that v is greater than 2 or $v > 2$), and $\Gamma(\cdot)$ shows the gamma function.

The study tested null hypotheses of diagonal VAR, GARCH effects, diagonal GARCH effects, and asymmetry effect. Additional tests were also performed by calculating the Wald statistical value. Those tests checked if the effects in the exchange rate variable are not conveyed to long-term volatility in live calf, live sheep, and fodder wheat markets. Still another test verified whether the import policy implemented for livestock affects the market return and volatility of both livestock and feed wheat markets. After the model results were obtained, additional tests were also applied to determine whether the standardized model residuals ($z_{j,t} = \varepsilon_{j,t}/\sqrt{h_{j,t}},\ j = 1,2,3$) or residual squares still contain autocorrelation and whether there are time-varying variances remaining in the model. In addition, a t-test was used to demonstrate whether standardized residuals differ from zero on average and whether this residual variance is equal to one to support the abovementioned notions [65].

4. Results

4.1. Descriptive Statistics

The selected descriptive statistics, including correlation and autocorrelation relationships of price, return series, and squared return series are presented in Table 1. Live sheep prices have higher returns than live calf prices. Because the standard deviation is a measure of undirected volatility, the three agricultural commodity markets surveyed in Turkey, including the exchange rate, were exposed to uncertainty above the average return value, suggesting that all series are highly volatile. For example, the unconditional standard deviation obtained from the standard deviations of the live calf and live sheep price returns indicated higher volatility of live sheep prices than live calf prices. Such uncertainty is then followed by feed wheat and exchange rate markets. The degree of volatility in the live sheep market is almost double and triple that of the other two competing markets, followed by the degree of volatility in the live cattle market (Table 1). Contrary to the downturn in live calf prices, we expect that the increase in real prices of live sheep is most likely due to market dynamics in the explored period (Figure 1). These swings in the live sheep market are most likely due to market solid dynamics. For example, considering the supply side, the total number of sheep was around 34 million in Turkey in 1961 and declined to about 31 million by 2016 [69]. When eliciting the returns and standard deviations of the real exchange rate and wheat prices, the feed wheat prices provided lower returns with a relatively higher standard deviation compared to the exchange rate. Meanwhile, the pattern in feed wheat prices follows more closely the pattern seen in the live cattle market rather than that observed in the live sheep market. The difference in price patterns of the two livestock coincides with the feed wheat used in cattle feeding rather than sheep (Figure 1).

The explored market price relations are displayed in Figure 1. The almost one-to-one pattern relationship shows the ease with which the price spillovers transfer from one market to another, providing evidence of a highly correlated relationship between the two red meat markets. Just as such a template relationship stems from market dynamics (the degree of market competition, supply–demand connection, past prices, etc.), the policies the government has recently implemented to secure the red meat market overtime period should not be underestimated. For example, allowing for meat imports in 2009 and the expansion of livestock incentives including breeding-animal backing programs throughout the country might have been the driving forces behind the decline in the real prices of live calves in the 2010–2015 periods. While structuring incentives to target breeding and animal genetics for improving livestock quality is the primary goal, increasing quantity by improving quality is also a goal of the domestic breeding support programs. In Turkey, from 2009 to 2017, the support given to forage crops and livestock increased by 89% and 330%, respectively, in real prices, and hit a record of approximately 189 million and 4.3 billion ₺, respectively [70]. On the other hand, although the return levels in the three agricultural commodity markets were indistinguishable from zero, the exchange rate returns were different (Table 1). At the same time, the average return of live calves was below zero, whereas the other two agricultural markets, together with the exchange rate, provided average returns to their owners. In other words, although the live calf market made a loss, on average, in the analyzed period, the live sheep and feed wheat market resulted in an average gain.

Table 1. Descriptive Statistics and Unit Root Test Results.

Statistics	Returns			
	$R_{lc,t}$	$R_{ls,t}$	$R_{cw,t}$	$R_{e,t}$
Mean	−0.022	0.046	0.027	0.415 **
Std. dev.	8.284	16.391	5.822	3.762
Skewness	0.091 (0.422)	0.183 (0.106)	−0.291 *** (0.010)	2.756 *** (0.000)
Kurtosis	20.466 *** (0.000)	1.056 *** (0.000)	5.333 *** (0.000)	25.573 *** (0.000)
Jarque-Bera	8186.197 *** (0.000)	24.378 *** (0.000)	562.378 *** (0.000)	13373.451 *** (0.000)
Correlations between real price levels:				
$Pr_{lc,t}$		0.979	0.988	0.806
$Pr_{ls,t}$			0.969	0.815
$Pr_{cw,t}$				0.802
Correlations between return series including the exchange rate:				
$R_{lc,t}$		0.104	−0.029	0.014
$R_{ls,t}$			−0.068	0.080
$R_{cw,t}$				0.035
Correlations between squared return series including the exchange rate:				
$R^2{}_{lc,t}$		0.164	0.171	0.023
$R^2{}_{ls,t}$			0.113	0.149
$R^2{}_{cw,t}$				0.126
Testing serial correlation among return series of agricultural commodities:				
LB-Q(10)	134.404 *** (0.000)	74.900 *** (0.000)	91.167 ** (0.000)	
McLeod-Li(10)	127.078 *** (0.000)	80.780 *** (0.000)	71.915 *** (0.000)	
HM-Q(10)	363.801 *** (0.000)			
Testing ARCH effects among return series of agricultural commodities:				
ARCH-LM(10)	30.386 *** (0.000)	6.663 *** (0.000)	7.257 *** (0.000)	
MARCH-LM(10)	698.750 *** (0.000)			
HM-Q^2(10)	152.724 *** (0.000)			
Testing unit root among agricultural commodities:				
ADF	−22.597 *** (lags = 1)	−22.999 *** (lags = 1)	−22.158 *** (lags = 1)	
KPSS	0.011 (lags = 1)	0.006 (lags = 1)	0.015 (lags = 1)	

Note: The critical values vary with lags selected. In parentheses are associative *p*-values. *, **, and *** are statistically significant at 10%, 5%, and 1% respectively. $R_{lc,t}$, $R_{ls,t}$, and $R_{cw,t}$ indicate price returns of live calves, live sheep, and coarse wheat markets respectively.

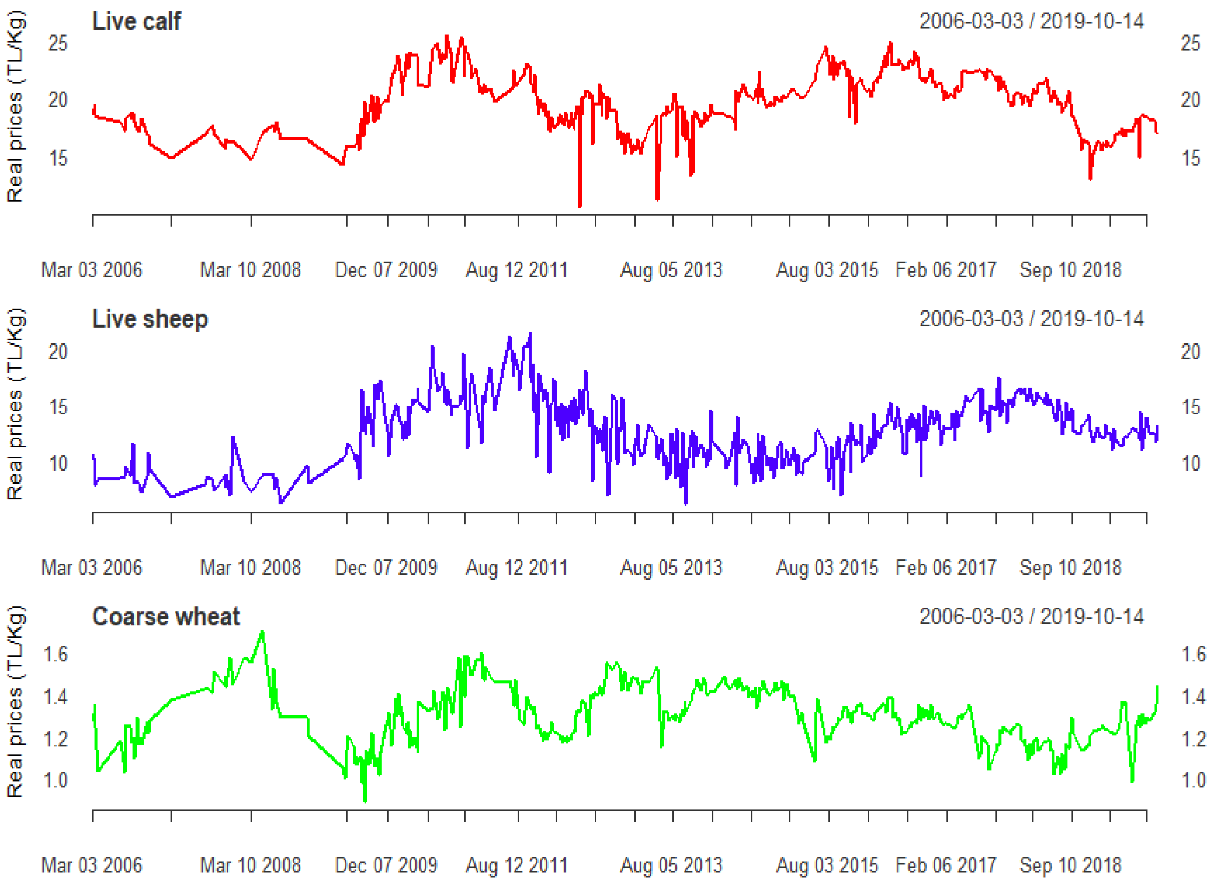

Figure 1. Daily real prices of live calves, live sheep, and coarse wheat.

4.2. Preliminary Analysis

A series with a skewness close to zero and a kurtosis close to three is said to be normally distributed, whereas the higher value of kurtosis indicates that the data distribution of the series is leptokurtic which shows a heavier tail than the normal distribution. Except for the live calf market, the other series have extreme skewness. All series show extreme kurtosis features and skewness and kurtosis reflect the high-frequency data characteristics. A heavy tail is evident in the exchange rate series, followed by the live calf and feed wheat series. The leptokurtic distribution of the return series also shows that there might be an ARCH effect in the series. On the other hand, a kurtosis value less than three indicates that outliers are less likely in which such series are platykurtically distributed. The latter implies that the distributions of the return series are not normal, which is the case in the live sheep series. The two inconsistent cases in the series can be verified with the Jarque–Bera test statistic. The test statistics show that the agricultural commodity return series including the exchange rate did not follow a normal distribution (Table 1). General descriptive statistics show that the distributions of the explored agricultural commodity price return series, including the exchange rate closing values, are skewed, leptokurtic, and platykurtic. Such findings are consistent with the notion that the main feature of the data for many emerging markets is that they are generally non-normally distributed [71].

If price volatility is transmitted exactly and instantaneously between different layers of the same product, that is, along the supply chain or between different product markets, a close to one correlation is expected between price volatility at different market levels [47]. Among the three agricultural commodity prices examined, the strongest correlation was between live calf and feed wheat prices (0.988), followed by the correlation between live calf and live sheep prices (0.979) and between the live sheep and feed wheat prices (0.969) (Table 1). All these levels of correlation show almost one-to-one reflections on how easy it is to convey prices between the agricultural commodity markets in the country. On the other hand, the correlation levels of the three markets with the exchange rates are close to each other and vary between 0.802 and 0.815. Looking at the spillover transmission relationship between returns, there is a positive correlation (0.104) between live calf and live sheep commodity markets and negative correlation levels (i.e., −0.029 and −0.068) between other cross-correlation levels. The correlation levels between the returns of the agricultural commodity markets and the exchange rate returns were found to be positive but low. On the other hand, when the squares of return values, which are an indicator of unconditional variance, are analyzed, the highest level of relationship is between live calf and feed wheat (0.171), followed by live calf and live sheep (0.164), and between live sheep and forage wheat markets (0.113). The pass-through uncertainties between the three explored agricultural commodity markets are almost close to each other, indicating that they are highly likely affected by the same market dynamics. On the other hand, the correlation level between the square of the live sheep return series and the square of the exchange rate return series was found to be the highest (0.149), followed by the relationship between the exchange rate and the feed wheat market (0.126) and then the exchange rate with live calves (0.023). Such findings indicate that there will be a high level of spillover transmission from the exchange rate to the live sheep commodity.

Several statistical tests were applied to elicit the existence of serial correlation in return markets and the ARCH effect, which is an indicator of the presence of clustering in return serial squares (Table 1). First, Ljung–Box (LB-Q) and McLeod–Li, both individual tests, and then Hosking's Multivariate Q-statistics (hereafter HM-Q), a joint test, were applied to detect serial correlation in all return series of the explored agricultural markets. On the other hand, the ARCH–Lagrange multiplier (hereafter ARCH-LM) as an individual test and HM-Q^2 and multivariate ARCH-LM (hereafter MARCH-LM) as simultaneous tests to square returns to unravel time-varying conditional variances (ARCH effect) have been applied. The results of the LB-Q, McLeod–Li, and HM-Q statistics confirmed the presence of serial correlation in return commodities. Such a serial correlation on market returns is tempting to explain the correlation of increasing returns during hectic market periods as an increasing return follows an increasing return and a decreasing return follows a decreasing return, implying that the autoregressive (AR) process is inevitable in the return levels of the explored agricultural markets. Also, the high correlation relationship between the price levels of the agricultural commodities presented in Table 1 confirms the serial correlation. We can also easily deduce such a pattern in Figure 2. Especially during the 2008 world food crisis, the increased volatility in the three agricultural markets and the stagnating market returns afterward could be perceived as the evidence of serial correlation. Except for the marked surges in the live calf market return in some periods, when the unconditional returns of both live calf and live sheep markets overlap, the live sheep market return appears to be higher with increasing frequency, dwarfing the market return of live calves (Figure 2).

Included in Table 1 are the results of the tests applied to the serial return squares for the presence of the ARCH effect in the three competing agricultural markets. Concurrent tests (MARCH-LM and HM-Q^2) and individual ARCH tests at lag 10 indicate the presence of a clustered ARCH effect on market return squares. Thus, in some timeframes, clustered values imply that increasing returns often follow increasing returns and decreasing returns follow decreasing returns, and squared returns have a varying variance structure whose amplitude is independent of the defined time, suggesting that GARCH models are viable paths to analyze volatility transmission among agricultural commodities in question. Figure 3 confirms the results of these tests with the change in the unconditional volatility of the squared returns of the investigated markets. Moreover, in this graphical representation of squared returns, there is information about whether the higher-order serial correlation situation becomes more pronounced. Patterns in the figure show that short-term high volatility in each agricultural market indicates further consolidation of return squares, taken as a measure of unconditional volatility. As deduced from the figure, the volatility is more affected in certain short periods, such as the 2006–2009 world food and financial crisis, and during highly variable return periods in the explored agricultural markets. Again, as deduced from the pattern in the figure, from the beginning of 2010 to the end of 2015, the presence of unconditional volatility in agricultural markets was more severe than in other periods. We think that it is the result of subjective interventions in the country's economy with political instability over the course of the exchange rate in these periods (i.e., the repeated attempts to overthrow the government, including a coup attempt, stymied the economy). Finally, the augmented [72] (ADF) unit root test, used to determine the stationarity of the return series, revealed that the series is stationary at the I (0) level at the 1% significance level (Table 1). Results of the Kwiatkowski–Phillips-Schmidt-Shin (KPSS) test confirm those of the ADF unit root test, both results indicating that the prerequisite for volatility clustering via GARCH type analysis is met.

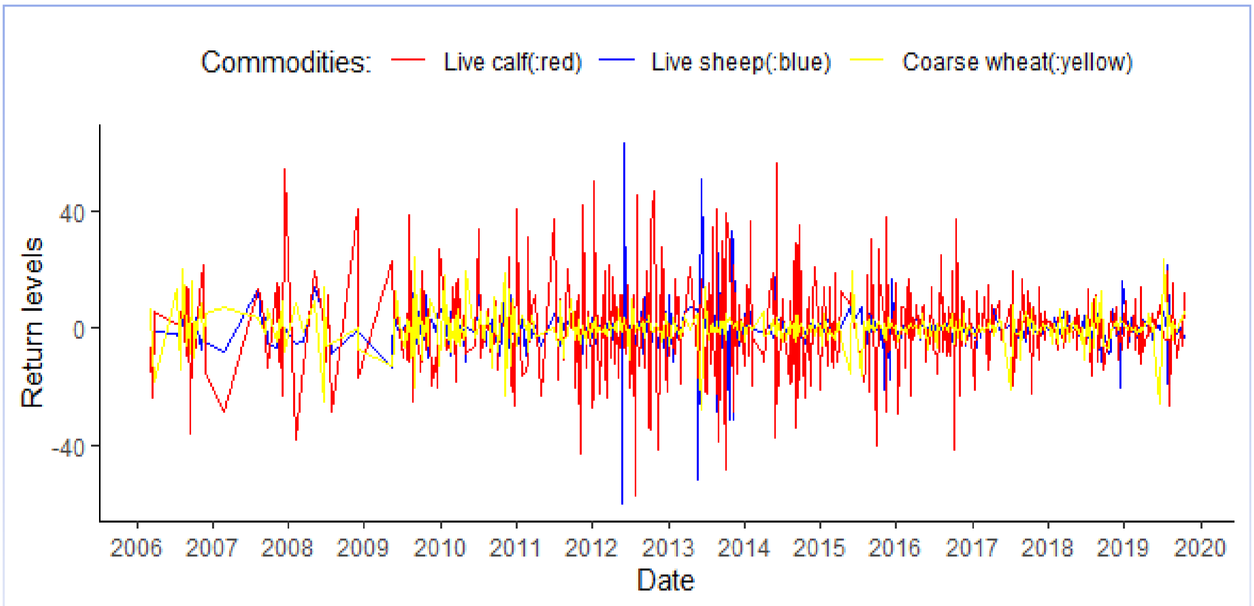

Figure 2. Time-varying return series of live calves, live sheep, and coarse wheat.

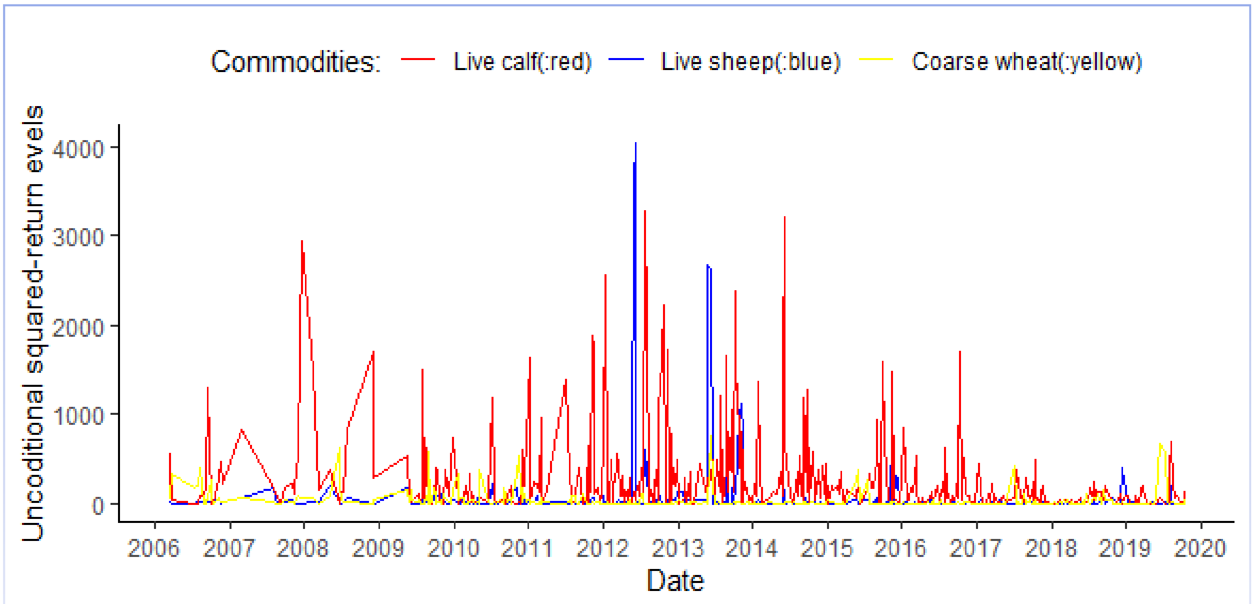

Figure 3. Squares of time-varying return series of live calves, live sheep, and coarse wheat.

5. Discussion

In the current study, after converting the series to real prices, a return series was created for each agricultural commodity for the analysis. Table 2 shows the results of both the mean return equations and conditional variances of the return series of the VAR (2)-Asymmetric BEKK-GARCH (1, 1) model. Live calves and live sheep returns are statistically significantly affected by both imports and one- and two-period lags. Past values have negatively affected the current cattle and sheep market returns, and similarly, the import decision for the livestock market has reduced these returns. First of all, the aim of import decisions by the government is to curb price inflation, especially in red meat, and thus coincides with Central Bank monetary policies, which aim to keep the food components of inflation low by protecting consumer purchase power through agricultural imports. The customs tax applied to live calves was reduced from 135% to 26% in accordance with the Council of Ministers Decision 217/10440, one of the agricultural market short-term foreign trade measures that followed the decision taken by the Food and Agricultural Product Markets Monitoring and Evaluation Committee in 2017 [73]). Obtaining such an empirical finding is extremely important, and indeed in line with expectations, because live animals imported from abroad are cheaper than domestic counterparts, which can drive breeders out of the industry. To prevent such negativities, multi-faceted incentive programs for livestock breeders are being implemented in the country, especially in the livestock sector since 2009. On the other hand, current forage wheat returns were statistically significantly affected by both historical two-period market returns and other opposing two-period market returns, but the effect of the live calf return on the fodder wheat was positive. Thus, the positive atmosphere in the live calf market has made it attractive for investors in the feed wheat commodity market in the country, as the live calf market is the primary market area of the feed wheat market. On the other hand, when examining the exchange rate, it is obvious that the lagged exchange rate positively statistically affects the current mean return of the feed wheat market. Although the dollar, which is appreciated against the Turkish lira, creates high energy costs for the investors in the country, it also increases the value of the feed wheat in terms of the Turkish lira (TL), especially from its exports to neighboring countries.

Table 2. Parameter estimates for both mean returns and conditional variances.

Parameters	Returns		
	$R_{lc,t}$	$R_{ls,t}$	$R_{cw,t}$
Mean return estimates			
Constant	0.879 *** (0.331)	3.379 *** (0.601)	0.162 (0.133)
$R_{lc,t-1}$	−0.315 *** (0.027)	−0.022 (0.058)	0.061 *** (0.019)
$R_{lc,t-2}$	−0.050 * (0.026)	−0.024 (0.059)	0.050 *** (0.014)
$R_{ls,t-1}$	0.016 (0.019)	−0.522 *** (0.038)	0.011 (0.008)
$R_{ls,t-2}$	−0.006 (0.013)	−0.256 *** (0.039)	−0.022 *** (0.007)
$R_{cw,t-1}$	−0.055 (0.035)	0.038 (0.090)	−0.377 *** (0.043)
$R_{cw,t-2}$	−0.026 (0.031)	0.049 (0.082)	−0.106 *** (0.035)
$R_{\text{exchange rate},t-1}$	−0.025 (0.070)	−0.142 (0.180)	0.186 *** (0.069)
R_{import}	−0.899 *** (0.346)	−3.366 *** (0.715)	−0.582 *** (0.132)

Table 2. *Cont.*

Parameters	**Returns**		
	$\mathbf{R_{lc,t}}$	$\mathbf{R_{ls,t}}$	$\mathbf{R_{cw,t}}$
Conditional variance estimates			
c_{1i}	6.872 *** (1.217)	-	-
c_{2i}	1.144 (0.806)	3.813 ** (1.750)	-
c_{3i}	3.545 ** (0.533)	−4.841 *** (0.663)	3.803 (0.550)
a_{1i}	0.479 *** (0.128)	−0.126*** (0.057)	0.006 *** (0.030)
a_{2i}	0.099 *** (0.036)	0.172 ** (0.071)	−0.019 * (0.011)
a_{3i}	0.356 *** (0.084)	0.658 *** (0.120)	0.228 * (0.124)
b_{1i}	0.264 * (0.142)	0.052 (0.134)	−0.015 (0.024)
b_{2i}	−0.035 ** (0.016)	0.867 *** (0.019)	−0.004 (0.007)
b_{3i}	−0.293 *** (0.073)	−0.192 *** (0.072)	0.736 *** (0.058)
d_{1i}	0.451 *** (0.119)	0.114 (0.106)	0.122 *** (0.039)
d_{2i}	−0.069 (0.049)	−0.613 *** (0.109)	−0.036 (0.023)
d_{3i}	0.165 ** (0.081)	0.247 (0.244)	0.567 *** (0.093)
Exchange Rate_{1i}	−0.366 *** (0.081)	-	-
Exchange Rate $_{2i}$	1.182 *** (0.216)	−0.099 (0.381)	-
Exchange Rate $_{3i}$	−0.073 (0.084)	0.753 *** (0.221)	−0.408 ** (0.162)
Import_{1i}	−2.340 ** (1.102)	-	-
Import_{2i}	4.771 *** (1.468)	−2.640 (2.022)	-
Import_{3i}	−2.569 *** (0.531)	3.135 *** (0.539)	−1.516 *** (0.190)

Note: *, **, and *** are statistically significant at 10%, 5%, and 1% respectively and standard errors are in parenthesis.

Considering the time-dependent conditional variance predictors in Table 2; a_{1i}, a_{2i}, and a_{3i} show shock propagation from each market to its market and other agricultural markets considered in this study. For example, short-term shocks in the live cattle market increase long-term market volatility in its own market (a_{11} = 0.479) and the feed wheat market (a_{12} = 0.006), whereas those shocks reduce long-term surges in the live sheep market (a_{12} = −0.126). Therefore, the short-term shocks arising from the market were positively conveyed to its own market and the feed wheat market, whereas their propagation to the live sheep market was negative. We can suggest that the conditional volatility in the transmitted market will be adversely affected when the sign of shocks in the transmitting market encounters the same sign of shocks in the transmitted market.

However, just as the magnitude of the shock in the donor market is important, so is the magnitude of the shock in the receiving market. Meanwhile, the successive price rises/decreases in the market create unpredictable uncertainties in its market, and trigger unpredictability by transmitting it to the opposite markets. Considering that feed wheat and live sheep are complementary and substitutes for the live calf market, respectively, these results are in line with expectations. Compared to the other two opposing markets, market shocks were transmitted more strongly to the persistent risk in its market, whereas there was a milder transmission to the long-term conditional volatility of the feed wheat market. Kesavan, Aradhyula, and Johnson [48] emphasized that the fluctuations in prices of two close substitutes, beef and pork, resulted from their short-term shocks, whereas Zhen, Rude, and Qiu [52] reported that there was no shock spillover transmission from the barley market to the fed cattle market or vice versa, but that each lagged spread of market fluctuations affected its own market's conditional volatility in Canada. However, focusing on the long-term spillovers of this market to the conditional volatilities of other counter-markets, including its market, the long-term surges in the market left a strong and lasting trace, providing only a spillover transmission to the long-term conditional volatility of its market (b_{11} = 0.264).

We found it interesting that although the transaction volume and market value were the largest among the explored agricultural markets, the risks from the market were limited only to their market, which would only be successful if the intervention by the government or precautions by investors should be limited to the market. This finding coincides with results reported by Fakari, Aliabadi, Mahmoudi, and Kojori [53] who indicated that the price swings in the red meat market create persistent volatility. In the case of long-term surges in the counterparty markets, live calf investors are likely to take action by putting the existing animals up for sale [52]. Many international studies of agricultural commodities have reported that most agricultural markets are affected by oscillations in long-term persistent conditional volatility [74–79]. On the other hand, looking at the spillover transmission from asymmetry information (e.g., past negative innovations) from the live calf market, the long-term conditional volatility both in its market (d_{11} = 0.451) and in the feed wheat market (d_{13} = 0.122) is positively affected, where negative news from the market deepens the risks in these two markets, which is most likely due to consecutive price increases in the live calf market. However, the risk in its market is more severe than the risk level in the competing fodder wheat market. In addition, such an indirect volatility spillover effect will be very severe in the feed wheat market when raising prices are experienced in both markets. Supporting this notion, Ozertan, Saghaian, and Tekgüç [63] found by using a vector error correction (VEC) model that price transmission for beef along the supply chain is asymmetrical for Turkey. They also found that wholesale prices adjusted faster than retail prices, eliciting relative price stickiness at the retail level as price margins widen. They finally concluded that although the presence of asymmetric price transmission along the supply chain may be a sign of imperfect competition and oligopolistic market behavior, supermarkets in the country may have a price adjustment role by creating marketing power through persistent retail imperfect competition. Moreover, Rezitis and Stavropoulos [80] and Luo and Liu [50] found asymmetric effects by examining pork, beef, mutton, and chicken price volatility.

Considering short-term shocks, long-term persistent spillovers, and short-term asymmetric spreads from the live sheep market, there is a transmission of short-term risks originating from the live sheep market to the conditional volatility level of both itself and the other two competing markets. Although the risk transmission to its own market (a_{22} = 0.172) and the live calf market (a_{21} = 0.099) is positive, it is negatively conveyed to the feed wheat market (a_{23} = −0.019), but the effect is stronger in its market. Fakari, Aliabadi, Mahmoudi, and Kojori [53] focused on the substitution relationship between red meat prices and stated that a shock in one market would cause fluctuations in the prices of another market. Focusing on the long-term risk transmission of this market, past long-term uncertainties from this market exacerbate its long-term volatility (b_{22} = 0.867), whereas easing conditional volatility in the competitive live calf market (b_{21} = −0.035) in the country. This intramarket swing has a greater impact on its long-term uncertainty (b_{22} = 0.867) than the other two rival markets have on themselves (b_{11} = 0.264 for live calves and b_{33} = 0.736). These findings are in line with our descriptive findings, implying that the live sheep market has a more fragile and easily transferable market structure in terms of lasting risk. In this context, long-term risks in the live sheep market will make the risks in their markets more pronounced and perhaps cause investors or small-scale enterprises to stop sheep farming. In particular, if the scope of the support given to cattle breeding is further expanded and adapted to small cattle breeding, the possible high-risk level can be mitigated to some extent. Also, asymmetric risks originating from the market are only limited to its market (d_{22} = −0.613), whereas there is an insignificant risk of spillover transmission to other markets. Interestingly, historically asymmetrical risks help sustain persistent uncertainty in that market when live sheep prices fall.

Considering the effects on the feed wheat market, these intramarket short-term shocks are conveyed to the persistent conditional volatilities of the other two rival agricultural commodity markets, including its market (a_{31} = 0.356, a_{32} = 0.658, and a_{33} = 0.228). Interestingly, the persistent risk of surges in all three markets is increasing, but live sheep are most affected, followed by live calves, and then its market, which is probably due to consecutive price raises in the feed wheat market. Because the relevant market is mostly an energy-intensive production type, rising energy costs hit the market first, and then the risk may move to long-term volatility in other markets, to the extent of the importance of risk and intermarket connections. These intramarket shocks may primarily worry calf and sheep breeders, but their long-term volatility faces increased exposure as immediate disposal of livestock is not instantaneous. Considering the effects of the past long-term uncertainties from the market on the permanent volatility of both itself and the other two competing markets, the spillover transmission on the other two markets was negative (b_{31} = −0.293 and b_{32} = −0.192), except for the effect on its own market (b_{33} = 0.736). Such findings indicate that as successive price increases or decreases occur in the feed wheat market, same-directional price movements dominate the other two competing markets. But its lasting impact on its market has been more severe than on the other two markets. As Zhen, Rude, and Qiu [52] noted, it could be argued that cattle price volatility may be more sensitive to price increases than to price decreases in feed grain markets (possibly as a result of inventory effects). The literature also states that all anticipated volatility expansions along the supply chain are unidirectional (e.g., from fodder wheat or barley to fed livestock), where such expansions originate from the market channel to the input–output markets [8,44,52,81]. Moreover, Urak, Bozma and Bilgic [43] emphasized previously that the uncertainty in agricultural commodity prices such as wheat and barley is largely due to the long-term volatility. In addition, uncertainties originating from the energy market will further increase the risk level in the market to the extent that this market is transferred. In the literature, the existence of linear [82] and non-linear [49] relationships between the inputs used in red meat production determines the uncertainty in the markets. Interestingly, contrary to the short period in this market, as the level of risk in this market increased, it may have greatly worried the animal breeders again, but this time, the breeders may have taken advantage of the long-term period mitigating the risks of feed wheat in their market by either sending their animals to slaughter or selling them. In general, farmers and agribusinesses face a high degree of risk due to some new pehnomena such as increasing price volatility of inputs and outputs, climate change, international trade restrictions, new and stricter food safety standards, and public concerns [83,84]. Turkish farmers are a very diversified group in terms of the scale of production; large-scale farmers may have some options to manage such risk, but small producers lack the knowledge or resources to manage risks. Farmers or livestock breeders are more likely protected against the risk of volatile prices by immediately disposing of their goods with a possible small loss [61]. Alternatively, they may want to reduce losses with secondary products, such as milk and calves, without taking any precautions against price risk; or, they try to protect themselves from low price risks with the production support they will receive from the state based on production including subsidies. On the other hand, the asymmetry of outgoing short-term shocks worsens the long-term risk level both in its market (d_{33} = 0.567) and in the live calf market (d_{31} = 0.167), but the impact in its market is greater. The starting point of such risks is most likely due to cascading price increases in the feed wheat market, which summarizes Turkey's fragile economic structure. Regardless of its nature, including speculative behavior, the search for removal of negative news in the market should be developed, or at least its effects should be mitigated by creating solid information sources and by preparing production cost-weighted business plans.

Changes in the local currency affect the production costs through imports (feed wheat) and the trade of agricultural commodities, in Turkey because of its dependency on imports. The rising exchange rate may, therefore, reduce the long-term conditional volatilities in the live calf, live sheep, and feed wheat markets. In this study, the exchange rate increase limited the conditional time-varying variances of the live calves, live sheep, and feed wheat price returns. Imported live calf and sheep became more expensive on the domestic market, causing an increase in the domestic animal supply, thus eventually slowing the price. Burakov [85] confirmed the Granger causality between agricultural commodity prices and exchange rates in the long term. The uncertainty in the exchange rate market has been reported to mitigate the long-term volatility of the feed market [86]. With the increase in live calf and feed wheat supply in periods of importing livestock as compared to periods when imports are not taking place, it is expected that the volatility of returns in those markets will decrease in the long run. The results of this study support such conjecture. Such a varied empirical finding is extremely important and provides policymakers with insight into mitigating food inflation, which is a large share of national inflation, at least in the short term. Red meat imports curb the conditional volatility in three agricultural commodities and the current study findings coincide with the results of Chadwick and Baştan's [62] univariate model for red meat only in Turkey in 2017, using consumer and producer beef inflation series. However, our findings differ significantly from Chadwick and Baştan [62] in some respects. For example, although they emphasized that, unlike consumer price inflation, meat import decisions have no role in the uncertainty of producer price inflation, the current study results reject such an inference showing that red meat import decisions play a significant role in alleviating the volatility in the livestock market in the long run. Such significant divergence between the two studies is most likely attributable to the difference in the length of time intervals and the choice of models and variables used in the two studies. At the same time, the current study finds that import decisions for red meat cause a reduction in average levels of market returns, including the feed grain market. Chadwick and Baştan [62] did not consider the feed grain market. The imports are consistent with the Central Bank of the Republic of Turkey's (CBRT) inflation reduction targets as food prices play an important role in inflation, and may encourage governments to resort to such explicit measures to prevent food inflation (i.e., due to the inflation targeting regime implemented by the CRBT, the findings of research to eliminate undue concerns about the effect of such a price policy are worth considering [62]). However, in the live sheep market, such an outcome is not anticipated and is likely explained by the very low live sheep imports in Turkey. According to [87], roughly 1.5 million cattle and 425,000 small calves were imported in 2018. About 43% of imported calves were breeding stock.

Figure 4 shows the movements of the conditional variance of commodity returns. The conditional variances of the live calves, live sheep, and feed wheat returns were 6.073, 16.340, and 4.946, respectively. The conditional variance of the live sheep return was higher than the conditional variances of the other two markets' returns, which is in line with the finding in the conditional variance model discussed above. The high uncertainty may be due to the supply–demand dynamics of the sheep market in Turkey (such as the bottleneck in the sheep supply) and the economic crisis that dominated the world markets in the specified period. Figure 2 also shows that the conditional variance of live sheep has been fluctuating from year to year. As deduced from Figure 4, the volatility decreased slightly after 2010 when the import of live sheep started, but it increased in the following years. The conditional variance of live calf returns remained lower than that of sheep. The conditional variance of live calf returns has generally decreased between 2010 and 2019. From 2010, when the import of cattle started, the domestic supply increased during the period of live calf imports. A sudden surge in the conditional variance of live calf returns took place in the period April–May 2012 (Figure 4). The surge coincided with the published decision of the Turkish government about importing 2700 head of cattle from the United States, Hungary, Austria, and Slovakia. Moreover, the examination of the conditional variance of feed wheat shows a decrease over time but seasonal variation remained. Again, from 2010 through 2018, the feed wheat market volatility was less than the volatility observed in the live calf market, and the movements appear to be synchronized. The observed pattern is likely due to the heavy use of fodder grain in cattle production.

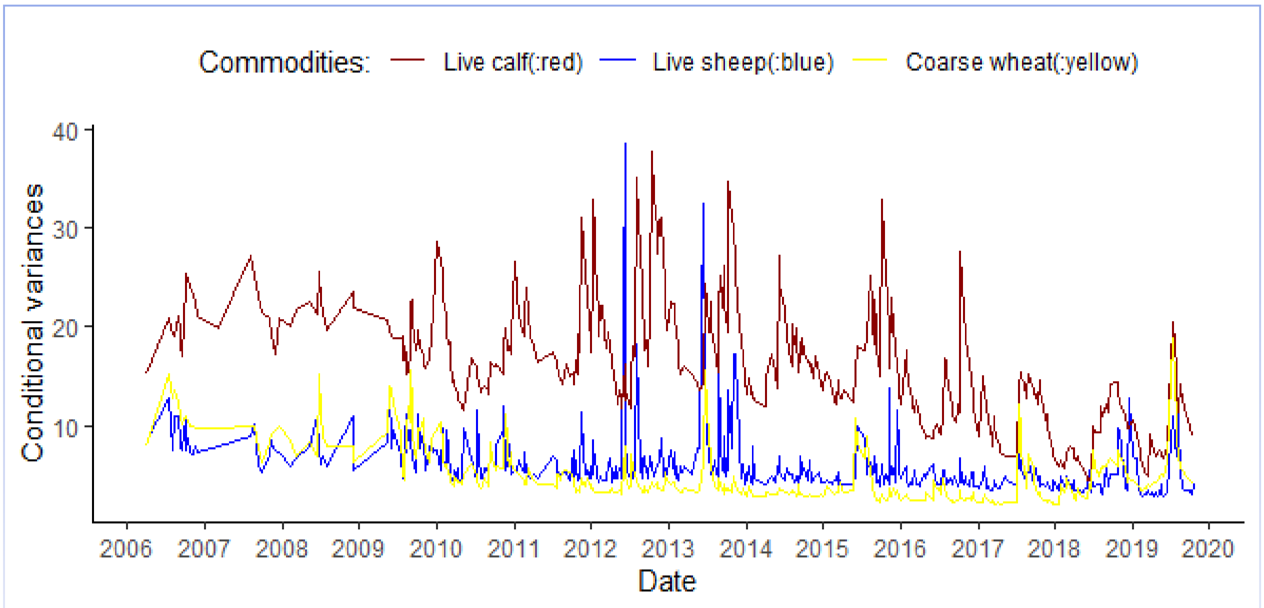

Figure 4. Time-varying conditional variances of live calves, live sheep, and coarse wheat.

Figure 5 shows the time-varying movement of the conditional correlation between live calves, live sheep, and fodder wheat returns. Such conditional correlation between live calf and live sheep series averaged 0.184 during the period under consideration and indicates that the two markets trigger each other's volatility. The correlation between the conditional variance of the live calf and live sheep series is approximately twice the conditional correlation between live calves and fodder wheat and about thirteen times the conditional correlation between live sheep and fodder wheat series. The relationship between live calf and live sheep prices is likely due to the high substitutability and the transmission of volatility between the live calf market and the live sheep market is high. The correlation between the markets provides insights regarding the affordability of feed and lamb and the effect on food security in terms of animal protein favored by consumers. The very high amplitude of correlation relationships may be due to the particular inefficiency of production and input costs [61], the supply–demand relationship in the market, volatility in energy costs, climate and weather events, a fragile economic structure, and political instability prevailing in Turkey. The inefficiency of such production processes seems to be the prominent problem in the production phase, due to the presence of low-yielding breeds, the small scale of the enterprises, and the increasing dependence on imported animal feed as a result of insufficient forage availability in the country [61].

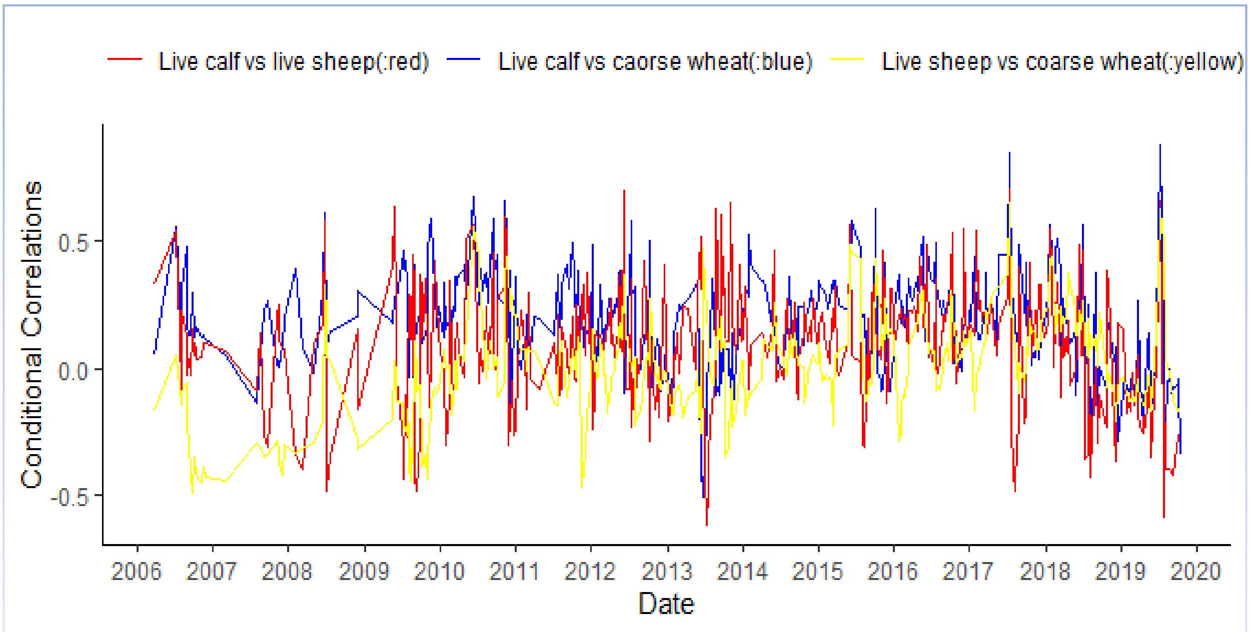

Figure 5. Time-varying conditional correlation between live calves, live sheep, and coarse wheat.

Table 3 shows the results of residual diagnostic tests (Panel A) and model specification (Panel B) tests. Individual tests (LB-Q and McLeod–Li) and a multivariate test (HM-Q) detect whether the remaining standardized errors are serially correlated at lags 20. Among the individual tests (Panel B of Table 3), the LB-Q test shows no serial correlation in the residuals of the series except live sheep, whereas the McLeod–Li test shows that all series are not correlated. On the other hand, when testing all serial correlations together, the multivariate HM-Q test is significant at 5.5% (i.e., below the 0.05 threshold), confirming the abovementioned findings. The individual ARCH-LM and MARCH-LM tests established the absence of the ARCH effect in the error terms obtained from the volatility of live calf, live sheep, and feed wheat returns. Additionally, the equality of zero mean and unit variance of the error terms ($E(z) = 0$ ve $E(z^2 = 1)$) was tested and confirmed [65] (the test results can be provided to the interested readers upon request). All tests established evidence of white noise residuals indicating the fit of the chosen model.

A series of causality tests (Panel B of Table 3) are applied to the mean return equations. For example, although the null hypothesis that the market returns of live sheep, feed wheat, exchange rate, and the import decision do not affect the returns of live calves was insignificant (Wald statistic = 10.204, $p > 0.10$), the null hypothesis that the market returns of live calves, feed wheat, exchange rate, and the import decision do not affect the return of live sheep was rejected (Wald statistic = 45.156, $p < 0.000$). Therefore, there is a simultaneous causality relationship between the live sheep market returns and the other markets under consideration including exchange rate and import decision variables. A similar causality relationship was obtained for the variables included in the market return of the feed wheat equation and the conditional market return of the feed wheat (Wald statistic = 57.159, $p < 0.000$). Those results show that both the live sheep and feed wheat markets are affected by a change in other markets, including the variables of exchange rate and meat import decisions.

Table 3. Parameter estimates for conditional variances in VAR-Asymmetric BEKK GARCH.

		$\mathbf{R_{lc,t}}$	$\mathbf{R_{ls,t}}$	$\mathbf{R_{cw,t}}$
Panel A: Residual Diagnostic Tests				
H_0: No serial correlation				
Ljung-Box Q(20)		30.566 * (0.061)	45.724 *** (0.001)	21.788 (0.352)
McLeod-Li(20)		3.627 (1.000)	6.460 (0.988)	5.432 (0.999)
HM-Q(20)			211.414 * (0.055)	
H_0: No ARCH effect				
ARCH-LM(20)		0.170 (0.999)	0.305 (0.998)	0.251 (0.999)
MARCH-LM(20)			378.370 (0.243)	
HM-Q^2(20)			82.528 (1.000)	
AIC			19.970	
SBC			20.618	
HQC			20.225	
Log-likelihood value			−8233.452	
Panel B: Model Specification Tests				
Granger Causality Tests				
H_0: Live sheep, feed wheat, exchange rate, and import do not Granger cause live calves				10.204 (0.116)
H_0: Live calves, feed wheat, exchange rate, and import do not Granger cause live sheep				45.156 *** (0.000)
H_0: Live calves, live sheep, exchange rate, and import do not Granger cause feed wheat				57.159 *** (0.000)
No GARCH	$H_0: \ a_{ij} = b_{ij} = d_{ij} = 0$ for all i, j = 1,2,3			30023.122 *** (0.000)
Diagonal GARCH	H_0: All off-diagonal elements of A, B, and are jointly zero			233.323 *** (0.000)
No Asymmetry	$H_0 : d_{ij} = 0$ for all i, j = 1,2,3			102.993 *** (0.000)
H_0: Off-diagonal exchange rates in the conditional variance equations are jointly zero				55.048 *** (0.000)
H_0: Off-diagonal of import in the conditional variance equations are jointly zero				36.513 *** (0.000)

Note: *, **, and *** indicate the significance at 10%, 5%, and 1%, respectively; *p*-values in parentheses.

The hypothesis that there is no GARCH relationship showing that all parameters of the live calf, live sheep, and forage wheat market returns in the conditional variance equation are simultaneously zero was rejected (Wald statistic = 30023.122, $p < 0.000$). Such a result indicates that the scattering of uncertainty risks in the conditional variances of market returns is persistently conveyed both inside and outside the market in question. Thus, uncertainty scattering is highly likely to emerge in an environment where agricultural commodity price movements exhibit almost a one-to-one pattern in a vulnerable economy like Turkey. For the diagonal GARCH test of the model, the computed Wald statistic was 233.323 ($p < 0.000$), rejecting the hypothesis that all non-diagonal elements in matrices A, B, and D are zero. Based on this test result, the transmission of short-term shocks, long-term uncertainties, and information asymmetry among markets is valid, where the conditional variance of the receiving markets is significantly affected by uncertainty risk spillovers in neighboring markets. Furthermore, the calculated Wald test statistic shows that the persistence of negative news varies in its effect from positive news. Therefore, different perceptions in the markets will, unfortunately, lead to a different trace of the persistence of volatility (Wald statistic = 102.993, $p < 0.000$). Considering that the distorting effect of negative news on the market is higher than the corrective effect of positive news, food security can be guaranteed by establishing particularly robust price mechanisms in the country.

The null hypothesis that the exchange rate does not cause volatility in the three markets was rejected, showing that the foreign exchange rate contributed to market disturbance (Wald statistic = 55.048, $p < 0.000$). When the Turkish lira depreciates, exporters of agricultural products gain compared to importers leaving less in the country causing prices to increase risking food insecurity. On the other hand, the import decision is one of the most important factors of volatility in the transfer between markets (Wald statistic = 36.513, $p < 0.000$). While reducing the permanent risk in a market, it contributes to the continuity of the risks in other competing markets by providing the pass-through of its impact.

6. Conclusions

Although the Turkish government tried to control beef prices in the short term with foreign trade measures and various financial incentives for livestock support programs throughout the country, such measures could not prevent the volatility in beef and lamb prices in the long term. With the contribution of the government's successful incentive packages and live animal imports, cattle stock increased by 57 percent in 2018 compared to 2008. However, meat and milk prices are more volatile compared to the consumer price index (CPI) due to production inefficiency, whereas high input costs can be attributed to the failure of the government market regulation. Although such a process is attributed to the existence of many intermediaries in the food chain, the lack of an effective price control mechanism can be viewed as the main reason.

Studies on price uncertainty transfers for the agricultural sector in Turkey are almost non-existent. Eliciting the extent and effects of the transmission of uncertainty in the markets provides crucial information for stakeholders and policymakers in identifying future investments, planning a new strategy for the sector, and assuring accessible food and food security for consumers. To this extent, the current study examined the transmission of volatility within and across price series of the live calf, live sheep, and wheat markets in the context of exchange rate and decisions to import livestock in periods of insufficient domestic livestock and feed supply because of the importance of those major agricultural commodities for Turkey's food security.

Conditional variances in the return series were significantly affected by both their volatility and the volatile interaction with other return series. The live calf, live sheep, and feed wheat markets were especially affected by negative news. This study confirmed that the uncertainties in the live calf, live sheep, and feed wheat markets were due to both their long-term uncertainties and long-term uncertainties in other markets. But the long-term effects have great persistence in their respective markets. In this context, all shocks such as market dynamics, asymmetric news, speculations, and long-term risks will first deepen the volatility in the relevant market and then reflect on other competing markets. Competent bodies and policymakers should focus on the relevant market to ensure possible food security in the country before mitigating the effects in competing markets. This will only be successful in mitigating possible risks by ensuring that price information is perfectly communicated to all stakeholders along the supply chain, with the existence of a price mechanism established in markets in the country. This study also explored how exchange rate volatility and livestock import decisions had a lasting effect on the returns of the three major commodities. The conditional variances of the live calf, live sheep, and feed wheat returns were significantly affected by the increases in the exchange rate and during the periods of importing livestock. If volatility affected retail prices, then consumers, especially those from low-income households, could become food insecure.

The majority of the livestock market participants in the country consists of small-scale subsistence enterprises, and these are associated with complex price mechanism flows. The decision-makers should, therefore, focus on the key markets to ensure price stability and their stabilizing effect on other markets, because of the key market influence on the level of food security. In addition, severe market volatility is devastating for the well-being of producers and consumers. Because domestic price shocks have a significant impact on future price volatility, product price-fixing programs such as producer subsidies, buffer stock programs, and price supports that can be implemented in response to price volatility may have to be considered as tools to reduce price fluctuations. In this regard, a number of suggestions follow directly, or indirectly, from our findings. First, stringent measures such as investment in improving agricultural productivity can be a part of regionally based rural development and government programs. For example, the licensed warehousing and contract farming of agricultural commodities can foster contracting between large-scale meat traders or the state's Meat and Dairy Institution and cattle farmers, helping to manage risk. Creation of such a value chain directly connects producers to retailers without the intermediaries managing both the sector growth and price uncertainty contributing to the livestock producers' well-being. Likewise, widespread price volatility can be prevented by connecting producers and buyers over futures exchanges by facilitating such opportunities throughout the country to allow price risk management and shorten the supply chain, improving profitability. Moreover, the consolidation and market dominance of supermarkets or large-scale chain stores along the beef supply chain in the country should be encouraged to apply transparent pricing which would reduce speculative behavior.

Second, the production of finished grain cattle can be promoted through incentives and subsidies which would facilitate access to reasonably priced and adequate feed. For example, the organizing small-scale subsistence enterprises which produce their own feed at minimal cost through a digital network might ensure price stability and prevent price distortion. Third, stabilizing the exchange rate will improve stability in relationships between the live calf, live sheep, and feed wheat markets, as in the whole economy. Additionally, foreign trade policy can advance the goal of sustained and secured live calf and live sheep supply through breeding cattle imports, complementing programs supporting domestic animal productivity improvement. Lastly, the fact that the import regressor has mitigated the long-term uncertainties of the three agricultural enterprises suggests allowing sometimes imports to alleviate the effect of inflationary pressure in the food sector, particularly on end-users. For example, to stabilize the spikes in meat prices, the government may facilitate imports through the zero tariffs offering a short-term solution for market intervention).

The current study has some limitations. First, the effect of the volatility in energy prices was not reflected in the considered markets because the absence of an oil exchange market did not provide data reflecting the daily price volatility. Second, Turkey lacks efficient livestock futures exchange markets. Daily data from livestock and futures exchange markets can increase the data frequencies, resulting in more robust results. Additionally, possible strategies and plans can be drawn by considering the impact of Covid-19 on the considered markets in future studies.

Author Contributions: Writing—review and editing, F.U., A.B., and W.J.F.; write-up of original draft and preparation F.U., G.B., and E.E.; conceptualization, A.B., and W.J.F.; methodology, F.U., and A.B.; software, A.B.; formal analysis, F.U., A.B., and W.J.F.; resources, F.U., G.B., and E.E.; supervision, A.B., and W.J.F. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Morrison, J.; Balcombe, K.; Bailey, A.; Klonaris, S.; Rapsomanikis, G. Expenditure on different categories of meat in Greece: The influence of changing tastes. *Agric. Econ.* **2003**, *28*, 139–150. [CrossRef]
2. Rask, K.J.; Rask, N. Economic development and food production–consumption balance: A growing global challenge. *Food Policy* **2011**, *36*, 186–196. [CrossRef]
3. McAfee, A.J.; McSorley, E.M.; Cuskelly, G.J.; Moss, B.W.; Wallace, J.M.; Bonham, M.P.; Fearon, A.M. Red meat consumption: An overview of the risks and benefits. *Meat Sci.* **2010**, *84*, 1–13. [CrossRef] [PubMed]
4. Speedy, A.W. Global production and consumption of animal source foods. *J. Nutr.* **2003**, *133*, 4048–4053. [CrossRef] [PubMed]
5. Ayyıldız, M.; Çiçek, A. Analysis of red meat prices with Garch method: The case of Turkey. *Turk. J. Agric. -Food Sci. Technol.* **2018**, *6*, 1775–1780.
6. Lawrence, J.D.; Mintert, J.R.; Anderson, J.D.; Anderson, D.P. Feed grains and livestock: Impacts on meat supplies and prices. *Choices* **2008**, *23*, 11–15.
7. UKON. *Yaşar 2018 Sustainability Report*; National Red Meat Council: Ankara, Turkey, 2018.
8. Pozo, V.F.; Schroeder, T.C. Price and Volatility Spillover between Livestock and Related Commodity Markets. In Proceedings of the 2012 Annual Meeting, Seattle, WA, USA, 12–14 August 2012.
9. Tejeda, H.A.; Goodwin, B.K. Dynamic Price Relationships in the Grain and Cattle Markets, Pre and Post-Ethanol Mandate. In Proceedings of the 2011 Annual Meeting, Pittsburgh, PA, USA, 24–26 July 2011.
10. Ceballos, F.; Hernandez, M.A.; Minot, N.; Robles, M. Grain price and volatility transmission from international to domestic markets in developing countries. *World Dev.* **2017**, *94*, 305–320. [CrossRef]
11. Olayungbo, D.; Hassan, W. Effects of oil price on food prices in developing oil exporting countries: A panel autoregressive distributed lag analysis. *OPEC Energy Rev.* **2016**, *40*, 397–411. [CrossRef]
12. Rezitis, A.N.; Stavropoulos, K.S. Greek meat supply response and price volatility in a rational expectations framework: A multivariate GARCH approach. *Eur. Rev. Agric. Econ.* **2012**, *39*, 309–333. [CrossRef]
13. Taghizadeh-Hesary, F.; Rasoulinezhad, E.; Yoshino, N. Energy and food security: Linkages through price volatility. *Energy Policy* **2019**, *128*, 796–806. [CrossRef]
14. Lucotte, Y. Co-movements between crude oil and food prices: A post-commodity boom perspective. *Econ. Lett.* **2016**, *147*, 142–147. [CrossRef]
15. FAO. *The State of Agricultural Commodity Markets, High Food Prices and Food Crisis-Experiences and Lessons Learned*; FAO: Rome, Italy, 2009.
16. Ianchovichina, E.I.; Loening, J.L.; Wood, C.A. How vulnerable are Arab countries to global food price shocks? *J. Dev. Stud.* **2014**, *50*, 1302–1319. [CrossRef]
17. Headey, D.; Fan, S. *Reflections on the Global Food Crisis: How Did It Happen? How Has It Hurt? And how Can We Prevent the Next One?* International Food Policy Research Institute (IFPRI): Washington, DC, USA, 2010; Volume 165.
18. World Bank. *Commodity Markets Outlook*; World Bank: Washington, DC, USA, 2017.
19. Radmehr, R.; Henneberry, S.R. The Impact of Prices of Oil, Currency, and Capital on Food Prices: An Empirical Evidence from the Panel VAR Analysis. In Proceedings of the 2019 Annual Meeting, Birmingham, Alabama, 2–5 February 2019.
20. World Bank. *Prevalence of Undernourishment*; World Bank: Washington, DC, USA, 2022.
21. MARA. *Strategies for National Agricultural Development*; Republic of Turkey Ministry of Agriculture and Rural Affairs: Ankara, Turkey, 2020.
22. FAO. *Nutrition Country Profile—TURKEY*; FAO: Rome, Italy, 2001.
23. Niyaz, Ö. Evaluation of food security about some of the main food products in Turkey. In Proceedings of the 25th Scientific-Experts Congress on Agriculture and Food Industry, Izmir, Turkey, 25–27 September 2014; pp. 77–80.
24. Bucak, H.I.; Tumgor, G.; Temiz, F.; Afat, E.; Yasemen Canöz, P.; Turgut, M. Food insecurity: Experience in a tertiary health center in Turkey. *Minerva Pediatr.* **2015**, *67*, 117–121.
25. Keskin, B.; Demirbaş, N. Is there a perfect way for food security measurement? Evaluation for Turkey. *Prog. Nutr.* **2022**, *24*, 1–11.
26. Gürsoy, S.İ. Addressing the Challenge of Food Security in Turkey. In *Environmental Law and Policies in Turkey*; Springer: Berlin/Heidelberg, Germany, 2020; pp. 127–140.
27. Abbott, P.C.; Hurt, C.; Tyner, W.E. *What's Driving Food Prices?* Farm Foundation: Oak Brook, IL, USA, 2008.
28. Harri, A.; Nalley, L.; Hudson, D. The relationship between oil, exchange rates, and commodity prices. *J. Agric. Appl. Econ.* **2009**, *41*, 501–510. [CrossRef]
29. Shahnoushi, N.; Sayed, S.; Hezareh, R.; Tirgari Seraji, M. Investigation of Relationship Between World Food Prices and Energy Price: A Panel SUR Approach. In Proceedings of the 2017 Annual Meeting, Mobile, Alabama, 4–7 February 2017.
30. Bartoli, A.; Cavicchioli, D.; Kremmydas, D.; Rozakis, S.; Olper, A. The impact of different energy policy options on feedstock price and land demand for maize silage: The case of biogas in Lombardy. *Energy Policy* **2016**, *96*, 351–363. [CrossRef]
31. Chen, S.-T.; Kuo, H.-I.; Chen, C.-C. Modeling the relationship between the oil price and global food prices. *Appl. Energy* **2010**, *87*, 2517–2525. [CrossRef]
32. Tejeda, H.A.; Goodwin, B.K. Price Volatility, Nonlinearity, and Asymmetric Adjustments in Corn, Soybean, and Cattle Markets: Implications of Ethanol-Driven (Market) Shocks. In Proceedings of the 2009 Conference, St. Louis, MI, USA, 20–21 April 2009.

33. Nazlioglu, S.; Soytas, U. World oil prices and agricultural commodity prices: Evidence from an emerging market. *Energy Econ.* **2011**, *33*, 488–496. [CrossRef]
34. Salisu, A.A.; Ayinde, T.O. Testing for spillovers in naira exchange rates: The role of electioneering & global financial crisis. *Borsa Istanb. Rev.* **2018**, *18*, 341–348.
35. Abbott, P.; de Battisti, A.B. Recent global food price shocks: Causes, consequences and lessons for African governments and donors. *J. Afr. Econ.* **2011**, *20*, i12–i62. [CrossRef]
36. Yan, M.; Terheggen, A.; Mithöfer, D. Who and what set the price of walnuts for small-scale farmers in Southwest China? *J. Agribus. Dev. Emerg. Econ.* **2017**, *7*, 135–152. [CrossRef]
37. Birthal, P.; Negi, A.; Joshi, P. Understanding causes of volatility in onion prices in India. *J. Agribus. Dev. Emerg. Econ.* **2019**, *9*, 255–275. [CrossRef]
38. Mitchell, D. *A Note on Rising Food Prices*; World Bank: Washington, DC, USA, 2008.
39. Reboredo, J.C.; Ugando, M. US dollar exchange rate and food price dependence: Implications for portfolio risk management. *N. Am. J. Econ. Financ.* **2014**, *30*, 72–89. [CrossRef]
40. Mawejje, J.; Nampewo, D. Food prices, money growth and informal cross-border trade: Evidence from Uganda. *Afr. J. Econ. Manag. Stud.* **2018**, *9*, 72–87. [CrossRef]
41. Akanni, L.O. Returns and volatility spillover between food prices and exchange rate in Nigeria. *J. Agribus. Dev. Emerg. Econ.* **2020**, *10*, 307–325. [CrossRef]
42. Çelik, Ş. Impact Of İnflation, Dollar Exchange Rate and İnterest Rate On Red Meat Production İn Turkey, Vector Autoregressive (VAR) Analysis. *Chin. Bus. Rev.* **2015**, *14*, 367–381.
43. Urak, F.; Bozma, G.; Bilgic, A. Estimating Volatility Transmission in Real Prices of Wheat, Barley, Gasoline, and Exchange Rate in Turkey Using VAR (1)-Asymmetric BEKK-GARCH (1, 1) Model. *KSU J. Agric. Nat.* **2018**, *21*, 565–579.
44. Buguk, C.; Hudson, D.; Hanson, T. Price volatility spillover in agricultural markets: An examination of US catfish markets. *J. Agric. Resour. Econ.* **2003**, *28*, 86–99.
45. Assefa, T.T.; Meuwissen, M.P.; Oude Lansink, A.G. Price volatility transmission in food supply chains: A literature review. *Agribusiness* **2015**, *31*, 3–13. [CrossRef]
46. Newbery, D.M.G.; Stiglitz, J.E. *The Theory of Commodity Price Stabilization: A study in the Economics of Risk*; Oxford University Press: Oxford, UK, 1981.
47. Serra, T. Volatility spillovers between food and energy markets: A semiparametric approach. *Energy Econ.* **2011**, *33*, 1155–1164. [CrossRef]
48. Kesavan, T.; Aradhyula, S.V.; Johnson, S.R. Dynamics and price volatility in farm-retail livestock price relationships. *J. Agric. Resour. Econ.* **1992**, *17*, 348–361.
49. Piotr, F.; Witold, O. Nonlinear Granger causality between grains and livestock. *Agric. Econ.* **2018**, *64*, 328–336. [CrossRef]
50. Luo, W.; Liu, R. Analysis of meat price volatility in China. *China Agric. Econ. Rev.* **2011**, *3*, 402–411. [CrossRef]
51. Khiyavi, P.K.; Moghaddasi, R.; Eskandarpur, B.; Mousavi, N. Spillover effects of agricultural products price volatilities in Iran (Case Study: Poultry Market). *J. Basic Appl. Sci. Res.* **2012**, *2*, 7906–7914.
52. Zhen, M.; Rude, J.; Qiu, F. Price volatility spillovers in the western Canadian feed barley, US corn, and Alberta cattle markets. *Can. J. Agric. Econ./Rev. Can. D'agroeconomie* **2018**, *66*, 209–229. [CrossRef]
53. Fakari, B.; Aliabadi, M.M.F.; Mahmoudi, H.; Kojori, M. Volatility spillover and price shocks in Iran's meat market. *Custos Agronegocio Line* **2016**, *12*, 84–98.
54. Miljkovic, D.; Zhuang, R. The exchange rate pass-through into import prices: The case of Japanese meat imports. *Appl. Econ.* **2011**, *43*, 3745–3754. [CrossRef]
55. Lahiani, A.; Nguyen, D.K.; Vo, T. Understanding return and volatility spillovers among major agricultural commodities. *J. Appl. Bus. Res.* **2013**, *29*, 1781–1790. [CrossRef]
56. Ling, S.; McAleer, M. Asymptotic theory for a vector ARMA-GARCH model. *Econom. Theory* **2003**, *19*, 280–310. [CrossRef]
57. Martinez, C.C.; Maples, J.G.; Benavidez, J. Beef cattle markets and covid-19. *Appl. Econ. Perspect. Policy* **2021**, *43*, 304–314. [CrossRef]
58. Abdallah, M.B.; Farkas, M.F.; Lakner, Z. Analysis of meat price volatility and volatility spillovers in Finland. *Agric. Econ.* **2020**, *66*, 84–91. [CrossRef]
59. Adeosun, O.A.; Olayeni, O.R.; Ayodele, O.S. Oil-food price dynamics in an oil-dependent emerging economy. *Int. J. Energy Sect. Manag.* **2020**, *15*, 36–57. [CrossRef]
60. Tosun, D.; Demirbas, N. What are the problems of the red meat processing industry?: A case study from Turkey. *Food Sci. Technol.* **2020**, *41*, 522–528. [CrossRef]
61. Akgunduz, Y.E.; Cilasun, S.M.; Tok, E.O. *Dana Eti ve Sut Sektorlerinde Tedarik Zinciri ve Karlilik Analizi*; Research and Monetary Policy Department, Central Bank of the Republic of Turkey: Ankara, Turkey, 2020.
62. Chadwick, M.; Baştan, E. *Beef Price Volatility in Turkey: Can Import Policy Affect the Price and Its Uncertainty?(17/09)*; Central Bank of the Republic of Turkey: Ankara, Turkey, 2017.
63. Ozertan, G.; Saghaian, S.; Tekgüç, H. Dynamics of Price Transmission and Market Power in the Turkish Beef Sector. *Iktisat Islet. Finans.* **2015**, *30*, 53–76. [CrossRef]
64. Engle, R.F.; Kroner, K.F. Multivariate simultaneous generalized ARCH. *Econom. Theory* **1995**, *11*, 122–150. [CrossRef]

65. Rahman, S.; Serletis, A. Oil price uncertainty and the Canadian economy: Evidence from a VARMA, GARCH-in-Mean, asymmetric BEKK model. *Energy Econ.* **2012**, *34*, 603–610. [CrossRef]
66. Salisu, A.A.; Oloko, T.F. Modeling oil price–US stock nexus: A VARMA–BEKK–AGARCH approach. *Energy Econ.* **2015**, *50*, 1–12. [CrossRef]
67. Grier, K.B.; Henry, Ó.T.; Olekalns, N.; Shields, K. The asymmetric effects of uncertainty on inflation and output growth. *J. Appl. Econom.* **2004**, *19*, 551–565. [CrossRef]
68. Bollerslev, T. Generalized autoregressive conditional heteroskedasticity. *J. Econom.* **1986**, *31*, 307–327. [CrossRef]
69. TSI. *Consumption Spending Statistics*; Turkish Statistical Institute: Ankara, Turkey, 2018.
70. TOB. *Economic Indicators*; Ministry of Agriculture and Forestry: Ankara, Turkey, 2018.
71. Choudhry, T. Stock market volatility and the crash of 1987: Evidence from six emerging markets. *J. Int. Money Financ.* **1996**, *15*, 969–981. [CrossRef]
72. Dickey, D.A.; Fuller, W.A. Distribution of the estimators for autoregressive time series with a unit root. *J. Am. Stat. Assoc.* **1979**, *74*, 427–431.
73. CBRT. *The Food and Agricultural Product Markets Monitoring and Evaluation Committee*; CBRT: Ankara, Turkey, 2019.
74. Abdelradi, F.; Serra, T. Asymmetric price volatility transmission between food and energy markets: The case of Spain. *Agric. Econ.* **2015**, *46*, 503–513. [CrossRef]
75. Abdelradi, F.; Serra, T. Food–energy nexus in Europe: Price volatility approach. *Energy Econ.* **2015**, *48*, 157–167. [CrossRef]
76. Cabrera, B.L.; Schulz, F. Volatility linkages between energy and agricultural commodity prices. *Energy Econ.* **2016**, *54*, 190–203. [CrossRef]
77. Gardebroek, C.; Hernandez, M.A.; Robles, M. Market interdependence and volatility transmission among major crops. *Agric. Econ.* **2016**, *47*, 141–155. [CrossRef]
78. Mensi, W.; Beljid, M.; Boubaker, A.; Managi, S. Correlations and volatility spillovers across commodity and stock markets: Linking energies, food, and gold. *Econ. Model.* **2013**, *32*, 15–22. [CrossRef]
79. Sadorsky, P. Correlations and volatility spillovers between oil prices and the stock prices of clean energy and technology companies. *Energy Econ.* **2012**, *34*, 248–255. [CrossRef]
80. Rezitis, A.N.; Stavropoulos, K.S. Modeling pork supply response and price volatility: The case of Greece. *J. Agric. Appl. Econ.* **2009**, *41*, 145–162. [CrossRef]
81. Apergis, N.; Rezitis, A. Agricultural price volatility spillover effects: The case of Greece. *Eur. Rev. Agric. Econ.* **2003**, *30*, 389–406. [CrossRef]
82. Ziemer, R.F.; Collins, G.S. Granger causality and US Crop and Livestock prices. *J. Agric. Appl. Econ.* **1984**, *16*, 115–120. [CrossRef]
83. Broll, U.; Welzel, P.; Wong, K.P. Price risk and risk management in agriculture. *Contemp. Econ.* **2013**, *7*, 17–20. [CrossRef]
84. Hayran, S.; Külekçi, M.; Gül, A. Perception and risk management strategies for ranchers and their determinants: A case study from Turkey. *Ciência Rural* **2021**, *51*, e20200456. [CrossRef]
85. Burakov, D. Oil prices, exchange rate and prices for agricultural commodities: Empirical evidence from Russia. *AGRIS -Line Pap. Econ. Inform.* **2016**, *8*, 33–47. [CrossRef]
86. Özdemir, F.; Urak, F.; Bilgiç, A.; Yavuz, F. Estimating Volatility Transmission in Real Prices of Mutton, Fattening Fodder, Gasoline, and Exchange Rate in Turkey Using VAR-Asymmetric BEKK-GARCH (1, 1) Model. *KSU J. Agric. Nat.* **2020**, *23*, 1270–1285.
87. Comtrade. *United Nations Commodity Trade Statistics Database*; Comtrade: Belgrade, Serbia, 2020.