Javadi et al. Agriculture & Food Security (2024) 13:23
https://doi.org/10.1186/s40066-024-00472-6

Agriculture & Food Security

RESEARCH

Open Access

Investigating the price volatility spillover effects in the poultry industry inputs market and the egg market in Iran: using the multivariate DCC-GARCH model

Akram Javadi[1*], Mohammad Ghahremanzadeh[1] and Elham Assadi Soumeh[2]

Abstract

Background This paper investigates the effects of price volatility spillover in the poultry industry's input markets, including soybean meal, day-old chicks and corn, and the foreign exchange market as an independent market, on the wholesale egg market in Iran. The experimental investigation is based on dynamic conditional correlation (GARCH-DCC). It is one of the most powerful and accepted methods for studying market volatility, whose representation is based on conditional variance. On the other hand, eggs are one of the main food items in the food basket of Iranian households, playing an important role in ensuring part of the food security of the country. However, the price volatilities of its inputs, which make up more than 70% of egg production costs, cause the instability of its price and the confusion of the producers of this sector. This is although in the relevant literature, there is little research on the issue of volatility spillover effects on agricultural product markets, especially in the country.

Results The findings show that any shock in the input market leads to volatility and instability in the market; on the other hand, these volatilities maintain their stability. In addition, there is a spillover of exchange market volatility into corn and soybean meal input markets.

Conclusions In that context, this article emphasizes the knowledge of market relationships and their consequences, thereby suggesting appropriate policies to control and support the domestic poultry industry.

Keywords Egg, Food security, Poultry industry's input, Price volatility spillover effects, DCC-GARCH

Introduction

Iran's poultry industry, especially egg production, is an integral part of social welfare, a country that consumes 230 eggs per capita, while the average egg consumption of the world is 190 [12]. Eggs can be considered the most natural and healthy source of protein that does not need to be cooked for a long time. For this reason, with the encouragement of government agencies and the help of banks, many investments have been made to develop domestic egg production.

As defined by the 2001 World Food Summit, food security is the state that exists when all people, at all times, have physical, social, and economic access to food to have an active and healthy life [13]. As eggs are nutritious food and one of the most important sources of protein for households and this product is easily accessible, it greatly contributes to ensuring the country's food security [8]. According to statistics provided by the Ministry

*Correspondence:
Akram Javadi
akramjavadi@tabrizu.ac.ir
[1] Department of Agricultural Economics, Faculty of Agriculture, University of Tabriz, Tabriz, Iran
[2] School of Agriculture and Food Sciences, Faculty of Science, University of Queensland, Brisbane, Australia

of Agriculture-Jihad, egg production in the country has increased significantly in recent years. Today, the country's poultry industry has risen to 10th place in the world, with an annual production of more than 1.2 million tons of eggs, almost doubling from 4 years ago [19]. It is worth mentioning that egg production has increased worldwide. Thus, over the past 30 years, the production of this animal product has increased from 35.07 million metric tons to 86.3 million metric tons, which shows that the volume of global egg production has increased by more than 100%.

On the other hand, in recent years, with the sharp increase in prices of other protein sources, such as red meat and chicken, and their consumption decreasing by 30–50%, the proportion of eggs in the household protein basket has increased significantly [22]. Meanwhile, domestic sales and export markets have recently faced serious challenges. One of the problems of this industry is the volatility of the prices of the required inputs, which can lead to unprofitable egg production. Since typically more than 70% of egg production costs are covered by production inputs, fluctuations in their prices cause volatility in egg prices and confusion for producers. At the same time, investigating such an issue has received little attention, especially in Iran. This article addresses this topic, focusing on the impact of exchange rates on this instability.

One of the reasons for fluctuating poultry feed prices is that these inputs are highly dependent on imports (approximately 95% of soybean meal and 70% of corn), which is also affected by volatile international prices [19]. In addition, issues such as exchange rate changes or sanctions cause input prices to fluctuate and tend to rise. In recent years, foreign exchange prices in Iran have been volatile strongly and tended to increase rapidly, causing volatility through spillover effects on the imported input market and another level of the market, the egg commodity market.

The interdependence and communication among different markets is a topic that has been extensively analyzed. As different markets become more integrated every day, developments and shocks created in one market can affect other markets. Regarding the spillover effect of price volatility related to variance, it can be argued that if the price volatility in any one market has a significant effect on the formation of price volatility in another, there will be price volatility spillover between these two markets [14].

Simply put, the spillover effect of price volatility shows that price volatility in different markets can be influenced by each other. In particular, the range of price volatility in one market can be affected not only by past price volatility but also by price volatility in other markets. In other words, their price volatility information can be transferred between different markets [27]. Therefore, given the decisive consequences of spillovers on financial policy, optimal resource allocation, risk measurement, capital requirements, and asset pricing, it is important to understand the underlying mechanism of this problem [24].

Meanwhile, modeling the volatility of price returns in different markets and the relationship among these markets is an important issue because it is used in forecasting, which is one of the main objectives of the financial and economic system.

Concerning financial time series and market volatility analysis, many models have been proposed to represent volatility (conditional variance) in econometrics. The ARCH model family is one of the most powerful and at the same time the most complex group of time series models and has been extensively reviewed by Higgins and Bera [11] as well as Bollerslev [3].

Most studies in the field of volatility spillovers focus on financial markets and stock assets and few studies have been conducted in the area of the relationship of exchange rates with agricultural markets, especially the input market in the poultry industry, and the spillover of its volatility on the egg market. Most studies have been done on the impact of oil prices on consumer goods, as well as the impact of exchange rates on domestic prices and the economy of countries, and less have been used in the field of agricultural products market. However, in the past decade following the food price crisis, price volatility in agricultural and food markets has also attracted the attention of policymakers worldwide.

Rezitis and Stavropoulos [23] investigated rational expectations in the commodity sector using a structural econometric model with endogenous risk. They used a multivariable GARCH model for the Greek meat market (beef, veal, pork, and chicken) for the period 1993–2006. The results indicated that the uncertainty caused by price volatility is a limiting factor for the growth of the Greek meat industry. Khaligh et al. [15] used a multivariable GARCH model to investigate the volatility spillover effect in the input, product, and retail broiler markets in Iran. According to the results of this study, both input prices and retail prices could lead to changes in producer prices.

Baikzadeh et al. [1] carried out a study to assess and analyze the price volatility of chicken and veal as well as their production inputs in Iran. They collected the monthly price time series of these products for the years 2002–2017 and used ARCH autoregressive conditional heteroskedasticity variance family models in a linear and nonlinear manner. Their results showed that the price volatility in the mentioned goods responded asymmetrically to positive and negative price shocks so that the impact of positive shocks on price volatility was greater than that of negative shocks. This showed that, due to the perceptibility of price volatility in the market of these items, the management of price volatility and fluctuation—despite the use of various policy tools—had not been optimal. Kuchuk et al. [16], in a study using the GARCH-BEKK model (1.1), determined the spillover effects of long-term fluctuations between the egg and feed wheat markets in Turkey considering COVID-19 as an exogenous variable. They determined that the conditional variances in wheat and egg prices were positively affected by long-term exchange rate uncertainty, while they were negatively affected by the volatility caused by COVID-19. Finally, they concluded that the devaluation of the Turkish lira caused an increase in the prices of imported products such as animal feed, which accounted for a significant portion of the cost of egg production, and as a result, increased the price of eggs and uncertainty in the long term.

Overall, research on these issues in Iran is limited, and therefore, this is an important issue to be addressed in this study. This study aims to investigate the possibility of a spillover of wholesale eggs from the input market of this industry (including soybean meal, maize, and day-old chicks). Another innovation of this study is the use of the foreign exchange market as an independent market to influence the input market and, ultimately, the egg market. The main objective of this study is to investigate whether volatility in egg prices is caused by volatility in input prices, as well as volatility in the exchange rates. These goals are pursued by relying on the application of the dynamic conditional correlation (GARCH-DCC) method, which is a creative method for studying these questions in the literature.

The analysis of this study can contribute to the planning and management agencies to control the egg market and reduce the risks caused by the volatility of the input market. In addition, considering controlling and stabilizing the market volatility in the market for inputs and egg products has always been one of the goals and policies of market regulation in Iran and one of the means to achieve this goal is to identify the source of this volatility, it is important to study and analyze the impact of volatility in the input markets of the poultry industry and the final egg product so that appropriate policy tools can be designed and implemented to control them. Considering that the stability of the market for this product facilitates physical and economic access, therefore, this study contributes in one way or another to the formulation of policy solutions for food security.

The paper is organized as follows: in “Materials and methods”, the mathematical topic of dynamic conditional correlation (GARCH-DCC) is discussed. It is then followed by “Results”, which presents the research findings. Finally, the last section concludes and presents relevant recommendations.

Materials and methods

A simple criterion for measuring the volatility of asset price returns is their variance over time. However, this measure, which is unconditional in terms of variance, does not include volatility clustering in nature and does not include the history of returns. Meanwhile, the meaning of volatility in the time series data of asset returns is as a measure of auto-correlated variance heterogeneity, which in econometric literature is known as autoregression conditional heteroskedasticity and is called ARCH. This criterion also takes into account the dynamic volatility of these returns [10].

As the objective of this study is to focus on modeling price volatility spillover between markets, models based on conditional correlation have the potential to achieve this goal, because the spillover effect of price volatility is related to price variance. Today, one of the most powerful econometric models proposed in cross-market volatility spillover analysis is the ARCH family of models. ARCH models formulate the existence of autocorrelation in the heteroskedasticity of asset return variance using conditional variance. The first example of ARCH models is the ARCH (q) model presented by Engel, where the conditional variance is a function of the square of the residuals lags. In the ARCH (p,q) model, the conditional variance equation also depends on p of the past lags of the realized variance, in addition to the square of the lags of the residuals. If a stationary linear process is considered as follows:

$$Y_t|I_{t-1} = \alpha + \beta X_t + u_t \tag{1}$$

where Y_t is the value of the random variable (egg price return) depending on the information available up to time (t-1) as a function of the variable vector X_t (the input price return variables and foreign exchange rate). u_t is the random error term according to the information available up to time (t-1), and it has a normal distribution with mean zero and variance δ_t^2.

In the classical linear regression model, it is assumed that the variance of the error term is constant ($\delta_t^2 = \delta$), but taking into account the ARCH effect, following Engel, the conditional variance (conditional on I_{t-1} information) will be as follows [6]:

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 \tag{2}$$

that α_0 and α_1 are positive and that $\alpha_1 < 1$. This equation shows that the variance of the error term is equal to a constant value plus the product of a constant value in the square of the error term in the previous period.

If $v_t = u_t^2 - \sigma_t^2$, an ARCH (q) is equal to

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i u_{t-i}^2 \tag{3}$$

Equivalently,

$$u_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i u_{t-i}^2 + v_t \tag{4}$$

If there is an ARCH effect, the estimated α can be tested according to the statistical significance of the coefficients. However, the ARCH (q) model has some shortcomings, and estimating the *q* coefficients of the autoregressive term requires many degrees of freedom. On the other hand, there is no guarantee that the estimated coefficients are all positive. Therefore, the literature on this subject suggests to using the generalized autoregressive conditional variance heteroskedasticity model or GARCH presented by Tim Bollerslev [3] instead of higher degrees of ARCH. GARCH models are much smaller than ARCH models. The GARCH (1,1) pattern can be said to be equivalent to ARCH(q) as *q* increases.

A GARCH (1,1) process has the following conditional variance function [3]:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i u_{t-i}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2 \tag{5}$$

In this expression, the conditional variance at time *t* depends not only on the square of the error term with a lag at the time (*t-1*) but also on the variance term with a lag at the time (*t-1*). Note that ARCH (q) requires the $q+1$ coefficient to be estimated, whereas only three coefficients are estimated for the GARCH (1,1) model. The GARCH (1,1) model is the most commonly used structure for many financial asset time series [21].

The main goal in modeling price volatility spillover is to study the response of price volatility in one market to shocks and price volatility in other markets. If the price volatility behavior is nonlinear, ignoring it will lead to erroneous conclusions about the significance and scope of the price volatility spillovers [20]. Estimation of spillover parameters using univariate GARCH models does not consider possible causal relationships between volatility in either direction nor does it provide information about the covariance between the two-time series. Using multivariate GARCH models is, therefore, a more effective way to achieve this [17]. The multivariate GARCH models are classified as Table 1.

Table 1 Multivariate GARCH models

Classic and standard models	Linear combination of univariate models	Nonlinear combination of univariate models
VEC	OM-GARCH	CCC
BEKK	GO-GARCH	DCC
FM-GARCH		GDC
FF-GARCH		Copula-MGARCH

Source: [2]

In general, a linear combination of univariate GARCH models is a linear combination of multiple univariate models. However, the nonlinear combination of univariate GARCH models allows the researcher to specify each conditional variance separately on the one hand and on the other hand to specify a conditional correlation matrix. Among these models, BEKK and VEC are the most widely used in financial time series modeling [24].

The first multivariable GARCH model, introduced by Bollerslev et al. [5], was called the VEC model. If it is assumed that vector *art* is the asset return at time t and I_t*-1* is the sum of the information collected up to time *t-1*,

$$r_t = \mu_t(I_{t-1}) + \varepsilon_t \tag{6}$$

where μ_t is the expected return vector of period t according to the set of information in the past, that is

$$\mu_t = A_0 + \sum_{i=1}^{p} A_i r_{t-i} \tag{7}$$

The vector ε_t also represents the residual in period t, which can be defined as follows:

$$\varepsilon_t = H_t^{\frac{1}{2}}(I_{t-1})Z_t \tag{8}$$

where $H_t^{\frac{1}{2}}(I_{t-1})$ is a positive definite matrix *N*N* and Z_t is a random vector in the form of *N*1* and has the following first and second moments:

$$\begin{aligned} &E(Z_t) = 0 \\ &Var(Z_t) = I_n \end{aligned} \tag{9}$$

where I_n is an *N*-dimensional matrix and it can be easily shown that the conditional variance matrix r_t is equal to H_t.

Therefore, the model VEC(1,1) is written as follows [5]:

$$\text{vech}(H_t) = c + \sum_{j=1}^{q} A_j \text{vech}\left(\varepsilon_{t-j}\varepsilon_{t-j}'\right) + \sum_{j=1}^{p} B_j \text{vech}(H_{t-j}) \tag{10}$$

The vech operator is defined on a square matrix and gives the values on and below the main diameter as a vector. A_j and B_j are $N(N+1)/2*N(N+1)/2$ matrices of parameters, and c is an $N(N+1)/2*1$ vector.

In a VEC model, it is difficult to guarantee the positivity and definiteness of H_t without applying strong constraints, and the number of parameters in this model is very large and requires many calculations. New models have also been presented to study the volatility spillover in the markets. The DCC model is called the dynamic conditional correlation model and was introduced by Engle [7]. This model indirectly models the conditional covariance matrix by estimating the conditional correlation matrix. Engle defined the correlation matrix as follows [7]:

$$R_t = \mathrm{diag}(Q)^{-1/2} Q_t \mathrm{diag}(Q)^{-1/2} \quad (11)$$

where R is the conditional correlation matrix and Q_t is in the form of relation (12):

$$Q_t = (1-\alpha-\beta)\overline{Q} + \alpha\left(u_{t-1}u'_{t-1}\right) + \beta Q_{t-1} \quad (12)$$

The matrix $\overline{Q}$ is an unconditional correlation matrix with dimensions $N*N$ from the standardized residuals $\mathrm{u_{it}} = \frac{\varepsilon_{it}}{\sqrt{h_{iit}}}$:

$$\overline{Q} = \mathrm{Cov}(u_t u'_t) = E[u_t u'_t] \quad (13)$$

In addition, α and β are nonnegative scalar parameters that establish the condition $\alpha+\beta<1$.

The general structure of the DCC (P,Q) model can be written as follows [7]:

$$Q_T = \left(1 - \sum_{i=1}^{p}\alpha_i - \sum_{j=1}^{q}\beta_j\right)\bar{Q} + \sum_{i=1}^{p}\alpha_i(u_{t-1}u'_{t-1}) + \sum_{j=1}^{q}\beta_j Q_{t-1} \quad (14)$$

The main considerations when developing such models are their effectiveness in identifying relationships between series and high predictive accuracy. However, care must be taken when specifying these models to ensure that they are flexible enough to express conditional variance–covariance dynamics. On the other hand, since the number of model parameters increases as the order increases, multivariate models should move toward simplifying model estimation, making model parameters easier to interpret. Of course, there should be a balance between being frugal and flexible. Another important feature of multivariate models is that the covariance matrix must be positive and definite [2].

The main considerations in developing such models are their effectiveness in identifying relationships between series and high predictive accuracy. However, care must be taken when specifying these models to ensure that they are flexible enough to express conditional variance–covariance dynamics. On the other hand, since the number of model parameters increases as the order increases, multivariate models should move toward simplifying model estimation, thereby making the model parameters easier to interpret. This creates difficulties in model estimation, and thus an important goal in building new MGARCH models is to make them reasonably parsimonious while retaining flexibility. Another important feature of multivariate models is that the covariance matrix must be positive and definite [2]. Ensuring the positive definition of a matrix, usually through an eigenvalue–eigenvector decomposition, is a numerically difficult problem, especially in large systems. However, designing easy-to-use, automated estimation processes will enable widespread use of these models.

In this study, the effects of price volatility spillover in the input markets of the poultry industry, including corn, soybean meal, and day-old chicks, and the foreign exchange market as an independent market on the wholesale egg market in Iran are modeled using the aforementioned model. Considering that the price return is a good indicator to show the price fluctuations of the time series leading to market volatility, the price return variable was used to compare these fluctuations. It means the price change over a particular period, which is considered weekly in this study. For this purpose, a series of their weekly returns for the period from January 2020 to January 2023 are used. Taking p_t as the price at time t, the corresponding transformation to obtain the efficient series or in other words, the price growth, i.e., s_t, has in the form of $s_t = \ln\frac{p_t}{p_{t-1}}$. It should be noted that the relevant time series of prices are weekly prices per kilogram of eggs, soybeans, and corn (the price of a day-old chicken in numbers) and are expressed in terms of the country's common currency, the Rial and have been provided by the State Livestock Affairs Logistics of the Ministry of Agriculture Jihad of Iran and available at the web site https://itpnews.com//price. Fortunately, the database in question has provided a comprehensive set of data regarding poultry industry inputs over the past few years, which did not pose problems during the period under review in this study. However, these data have encountered limitations in previous years.

Results

First, the descriptive statistics of the variables are reported in Table 2. As the data in Table 2 show, inputs for soybeans and day-old chicks are skewed to the left. An interpretation of negative skewness is that a return with a positive sign is more likely to occur because most of the probability density lies on the right side of the distribution of that return. This means that the probability that the price will rise this week compared to last week is higher than the probability that the price will fall. In other words, market information shows the market's tendency to increase prices. The kurtosis of all variables shows evidence of a fat-tailed distribution. This is because the skewness of the return distribution is greater than the skewness of the normal distribution in all cases. Overstretching indicates that a higher probability is assigned to the final value of the return compared to the normal return distribution. This means that the markets studied are likely to experience sudden and sharp price increases or decreases. To investigate this issue, the Jarque–Bera normality test was used, which is a reliable test for time series and also matches the skewness and kurtosis of the data to see if it matches a normal distribution or not. This statistic refutes the assumption of the normality of the distribution of returns at any level of probability (Table 2).

Since the variables used in the VAR model must be stationary, the Augmented Dicky–Fuller (ADF) test is used to test the unit roots of the variables, because the non-stationary nature of the data leads to the unreliability of the estimates and provides fake results. The results show that all variables are stationary. These results seemed probable because we have converted the raw price into a price return (which represents price growth). In fact, it is because the data has been differencing in some way and this causes them to be stationary. Table 3 shows the results of the augmented Dickey–Fuller unit root test for the variables.

Table 3 The results of the unit root test of augmented Dickey–Fuller

Variable	ADF statistic	Significance level 0.05	Significance level 0.01
Soybean meal	– 10.6	– 2.88	– 3.47
Day-old chicks	– 13.7	– 2.88	– 3.47
Corn	– 11.9	– 2.88	– 3.47
Egg	– 12.4	– 2.88	– 3.47
Exchange rate	– 9.2	– 2.88	– 3.47

Source: Research calculations

As shown by the figures in Table 3, all variables are static at the 1% significance level. In the next part, the graphs related to the time series pattern of the variables are presented. In general, the charts report volatility in the variable markets.

As seen from Figs. 1, 2, 3, 4, 5 presented in the above section, more volatility can be detected in the poultry input markets (soybean meal, day-old chicks, and corn) than in the egg market or the exchange rate market. Of course, the market volatility of the two inputs soybean meal and corn, which are mainly imported, is higher than that of the other input, day-old chicks. However, it is not possible to intuitively see movements in the same direction between the volatility of market returns from the cha rts.

In this part, taking into account the market of poultry inputs (soybean meal, day-old chicks, and corn), eggs, and exchange rate and using the multivariate GARCH approach—dynamic conditional correlation, the results of the volatility spillover between these markets are investigated. The software used to estimate the DCC model is Stata 14 software, which estimates the model based on the maximum likelihood method and

Table 2 Descriptive statistics of price returns

Variable	Max	Min	Mean	Standard deviation	Skewness	Kurtosis	Jarque–Bera statistic
Soybean meal	6.65	– 5.18	0.58	4.45	– 0.26	14.58	1164.59* (0.00)
Day-old chicks	8.44	– 5.76	0.47	3.56	– 0.38	14.88	1228.37* (0.00)
Corn	8.18	– 4.39	0.49	2.97	1.61	13.80	1101.36* (0.00)
Egg	7.49	– 7.79	0.60	8.37	0.60	47.77	17,384/07* (0.00)
Exchange rate	7.18	– 6.07	0.46	3.65	10.24	115.94	114,187.5* (0.00)

Source: Research calculations. (The numbers in parentheses indicate the probability level and * represents significance at the 1 percent level)

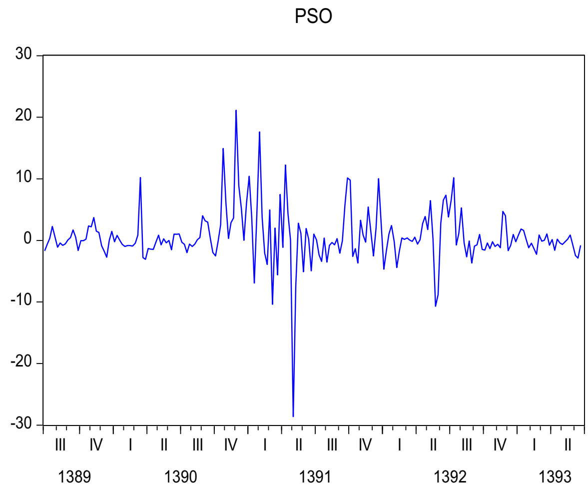

Fig. 1 Soybean meal price return time series

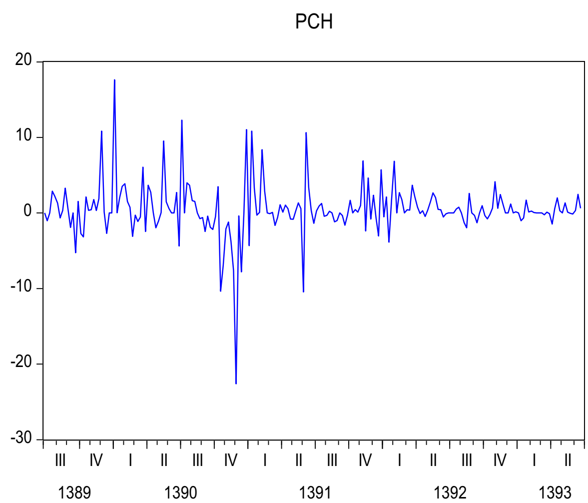

Fig. 2 Day-old chicks price return time series

optimization with the BHHH algorithm. The results of the DCC method are shown in Table 4.

The coefficients α and β represent the spillover effect and the stability of the conditional volatility within each of the variables. α represents the ARCH effect, and β represents the GARCH effect. As can be seen from Table 5, the spillover effect of internal shocks is significant in the wholesale egg market and the input markets for soybean meal and corn. This effect is greater in the case of the egg market ($\alpha = 0.88$), which means that the volatility of the previous period of the market has an influence and spillover on the volatility of the current period. This result is consistent with the study results of Ghahremanzadeh et al. [9], who concluded that in the short run, the demand side of the poultry industry

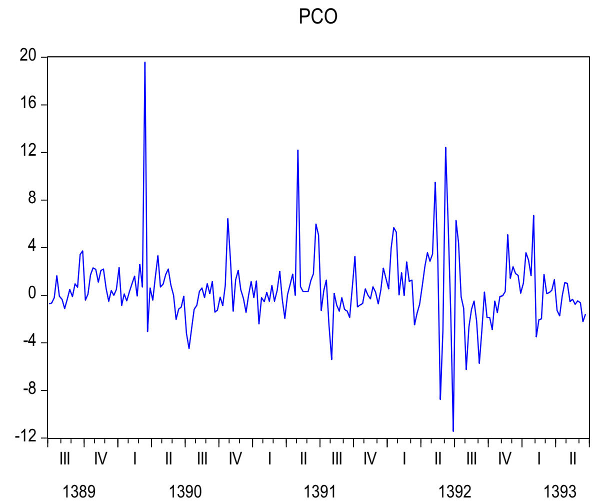

Fig. 3 Corn price return time series

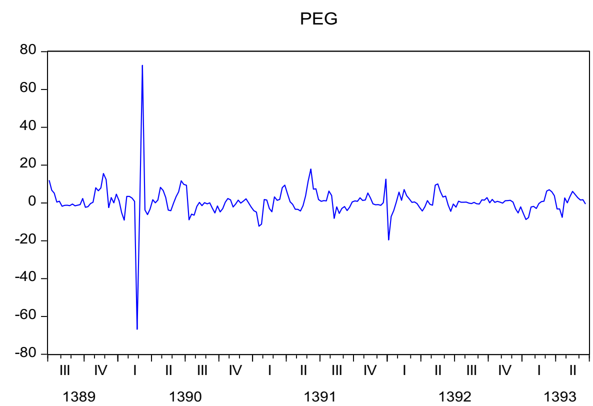

Fig. 4 Egg price return time series

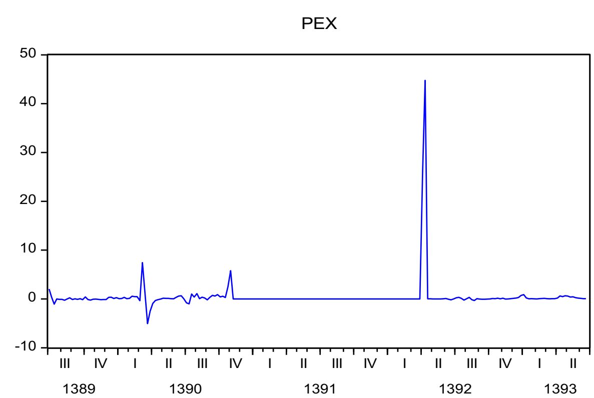

Fig. 5 Exchange rate price return time series

market causes price fluctuations, and in the long run, the supply side creates this volatility. However, they obtained spillover effects of price volatility shocks

Table 4 The results of DCC model estimation

	Corn	Day-old chicks	Soybean	Egg
α	0.43* (0.031)	0.002 (0.435)	0.73* (0.036)	0.88* (0.024)
β	0.64** (0.000)	0.098** (0.000)	0.58** (0.000)	– 0.001 (0.834)
Exchange rate	0.07* (0.022)	– 0.36 (0.104)	0.051* (0.016)	– 0.01 (0.193)

(The numbers in parentheses indicate the probability level, * represents significance at the 0.05 level, and ** is significance at the 0.01 level). Source: Research findings

Table 5 Conditional correlation between variables

	Day-old chicks	Soybean meal	Egg
Corn	0.017 (0.834)	0.284 (1/000)	0.014 (1.000)
Day-old chicks		0.015 (0.984)	0.094 (0.764)
Soybean meal			0.037 (1.000)

(The numbers in parentheses indicate the probability level). Source: Research findings

or new news on the chicken meat market. Comparing this estimate with the results of the present study shows that there is a spillover effect of price shocks on the chicken meat and egg markets in Iran. In addition, Khaligh et al. [15] confirmed the existence of volatility in the country's poultry industry input market. Their estimates show greater volatility in the domestic poultry industry's retail prices than the volatility of the industry's input prices. It can be concluded that, in the poultry industry, the volatility of the products of this industry, i.e., chicken meat and eggs, is greater than the volatility of input prices.

The coefficients β, which somehow represent the stability of volatility in each market, appear significant for all three entries. It is clear from Table 5 that the value of the coefficients β (GARCH effect) is larger than the value of the coefficients α or the ARCH effect, indicating that the long-term stability of the volatility in the input markets is greater than their short-term stability. This means that when the market becomes volatile, it will sustain this instability longer. This result is the same as the results obtained by Vajdi et al. [26]. However, they investigated this question for the input market of chicken in the domestic poultry industry. They concluded that the long-term stability of the volatility in the input market and the chicken market is more than their short-term stability. This is probably related to the way of supplying the inputs of both products (chicken and eggs) which are mainly imported and react the same to currency shocks.

The coefficients related to the exchange rate variable also indicate the impact of volatility in the exchange rate variable in other markets. This effect is significantly observed in the soybean and corn markets, which is likely because most of these two inputs are imported, which in turn are affected by the volatility in the exchange rate market. This is an even more serious problem for countries that rely on imports to provide livestock and poultry feed. So that, Kuchuk et al. [16] similar results obtained in this case for mainly imported animal feed. Their findings show that imported feed prices have increased due to the fall in the value of the Turkish lira.

Table 5 presents the values related to the conditional correlation between the variables, which are the estimated results of the DCC model.

As noted, the numbers observed in Table 5 are values related to the conditional correlation between variables and represent simultaneous movement between variables. Among the variables, the simultaneous movement of soybean meal and corn in the same direction is more important than the others, which may be because these two inputs are imported. In other words, the volatile foreign exchange market leads to simultaneous volatility in the market of strategic inputs such as soybean meal and corn, which account for a large amount of imports in the agricultural sector.

Conclusion

In this study, using dynamic conditional correlation (GARCH-DCC), the spillover effects of volatility in the wholesale egg market and poultry industry inputs (soybean meal, corn, and day-old chicks) and the foreign exchange market as an independent variable were discussed.

The results showed that the spillover volatility due to shocks within the market exists in all markets except the day-old chicks market, and of course, the stability of the volatility in all three input markets was significant. This means that the occurrence of any shock in the market of these inputs causes volatility and instability in the market; on the other hand, volatility remains stable. This feature leads to confusion and an inability to make correct decisions regarding the buying and selling of these inputs in the market. In this regard, it is suggested due to the influence of the egg market from production input markets, policies should be implemented to regulate production input markets and reduce volatility in these markets for example through the development of the futures markets in the form of futures contracts to ensure that the welfare of consumers and confusion of producers must be prevented, and the government should avoid interfering in the preparation of imported inputs at the government's exchange rate. This act is an interventionist policy and will cause much disturbance in the market by rent-seeking. This means the government will allow exchange rates to be freely determined based on the balance between market supply and demand. Furthermore, with the development of communication networks, the intervention of market disruptors is reduced and the instability of the input supply system is also reduced.

In addition, the results showed the importance of spillover effects from exchange rate market volatility on corn and soybean meal markets, as these inputs are imported. In this way, proposals in this direction are presented to the country's planners and decision-makers. According to the principle of comparative advantage, the production of strategic and imported inputs such as corn and soybeans should be increased domestically to avoid market dependence of these two inputs on fluctuations in exchange rates, which are mainly caused by political tensions and economic instability. It is recommended to minimize political tensions in the country as much as possible and that policymakers as well as economic and political planners should aim for peace in the economic and political environment and avoid tensions. In addition, egg producers should use risk management tools such as income insurance.

On the other hand, according to the obtained correlations, an association relationship between the volatility of corn and soybean markets was also observed, which shows the correlation between these two markets. Currently, corn and soybeans are considered strategic inputs for our country's poultry industry, accounting for a large proportion of the agricultural industry's imports each year. Therefore, the occurrence of a shock in the market for one of these inputs will also affect the market for the other input and this problem will not be beneficial for the agricultural sector and, therefore, for the poultry industry of the country. In this regard, the government must ensure that because of the interrelationship of input markets, plans, and policies developed for these markets are not implemented in isolation from one another. Price volatility leads to changes in consumer welfare. On the other hand, the unpredictability caused by price fluctuations hinders the planning and investment of poultry farmers and discourages them from producing more. At the same time, this problem reduces farmers' income, reduces access to food as one of the aspects of food security, and deprives the country of the ability to promote viable food security programs.

These characteristics, as mentioned earlier, eventually cause poultry feed prices to fluctuate and often increase in price which ultimately reduces the production of this product, causing problems in its availability, which is another dimension of food security. Therefore, given the importance of egg products in the food baskets of Iranian households and ensuring part of their food security, in addition to being the tenth producer of this product in the world, it is important to know how to communicate between relevant markets and it creates the basis for making the proper policies to help the country's poultry industry because ensuring food security is one of the important tasks of policymakers in the country's development plans.

Acknowledgements
Not applicable.

Author contributions
All the authors contributed to the study conception and design. Conceptualization: AJ, MG, and EAS. Methodology: AJ, MG. Data collection and analysis: AJ and EAS. The first draft of the manuscript was written by AJ and reviewed and edited by MG and EAS. All the authors commented on previous versions of the manuscript. All the authors read and approved the final manuscript.

Funding
The authors declare that no funds, grants, or other support was received during the preparation of this manuscript.

Availability of data and materials
The datasets generated and/or analyzed during the current study are available in the [State Livestock Affairs Logistics of the Ministry of Agriculture Jihad of Iran] repository, [https://www.itpnews.com].

Declarations

Ethics approval and consent to participate
Not applicable.

Competing interests
The authors declare that they have no competing interests.

Received: 13 July 2023 Accepted: 29 February 2024
Published online: 06 June 2024

References
1. Baikzadeh S, Ghahremanzadeh M, Mahmoodi A. Evaluation of price volatility of veal and chicken meat and major livestock and poultry inputs in Iran. J Animal Sci Res. 2020;30(3):85–103. https://doi.org/10.22034/as.2021.36121.1521.
2. Bauwens L, Laurent SVK, Rombouts J. Multivariate GARCH models: a survey. J Appl Econom. 2006;29:79–109. https://doi.org/10.1002/jae.842.
3. Bollerslev T. Generalized autoregressive conditional heteroskedasticity. J Econom. 1986;31(3):307–27. https://doi.org/10.1016/0304-4076(86)90063-1.
4. Bollerslev T. Modelling the coherence in short-run nominal exchange rates: a multivariate generalized ARCH model. Rev Econ Stat. 1990;72(3):498–505.
5. Bollerslev T, Engle RF, Wooldridge JM. A capital asset pricing model with time-varying covariances. J Polit Econ. 1988;96(1):116–31.
6. Engle RF. Autoregressive conditional heteroscedasticity with estimates of variance of United Kingdom inflation. Econometrica. 1982;50(4):987–1008. https://doi.org/10.2307/1912773.
7. Engle RF. Dynamic conditional correlation: a simple class of multivariate generalized autoregressive conditional heteroskedasticity models. J Bus Econ Stat. 2002;20(3):339–50. https://doi.org/10.1198/073500102288618487.
8. FAO. Eggs: harnessing their power for the fight against hunger and malnutrition, held at the FAO Global Forum on Food Security and Nutrition (FSN Forum) from 23 October to 13 November 2018. 2018.

9. Ghahremanzadeh M, Dashti Gh, Rasoli Beyrami Z. Price volatility spillover effect in Iran's poultry and livestock market. J Agric Dev. 2016;30(3):173–87. https://doi.org/10.22067/JEAD2.V30I3.52833.
10. Gujarati D. Econometrics by example. Red Globe Press; 2015.
11. Higgins ML, Bera AK. A class of nonlinear ARCH models. Int Econ Rev. 1992;33:137–58.
12. International Egg Commission. World Egg Organization. 2022.
13. Javadi A, Ghahremanzadeh M, Sassi M, Javanbakht O, Hayati B. Economic evaluation of the climate changes on food security in Iran: application of CGE model. Theor Appl Climatol. 2023;151(1–2):567–85. https://doi.org/10.1007/s00704-022-04289-w.
14. Katusiime L. Investigating spillover effects between foreign exchange rate volatility and commodity price volatility in Uganda. Economies. 2019;7(1):1. https://doi.org/10.3390/economies7010001.
15. Khaligh P, 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(8):7906–14.
16. Kuchuk N, Urak F, Bozma G, Bilqich A. The long-term volatility spillovers between egg and feed wheat prices during the COVID-19 Pandemic in Turkey. Türk Tarım ve Doğa Bilimleri Dergisi. 2022;9(3):741–53. https://doi.org/10.30910/turkjans.1128935.
17. Lutkepohl H, Kratzik M. Applied time series econometrics. Cambridge University Press; 2003. https://doi.org/10.1017/CBO9780511606885.
18. Mamipour S, Yazdani S, Sepehri E. Examining the spillover effects of volatile oil prices on Iran's stock market using wavelet-based multivariate GARCH model. J Econ Finance. 2022;46:785–801. https://doi.org/10.1007/s12197-022-09587-7.
19. Ministry of Agriculture-Jihad of Iran. Deputy of planning and economy. The Center of Information and Communication Technology. 2021.
20. Nomikos N, Salvador E. The role of volatility regimes on volatility transmission patterns. 2011. An electronic copy is available at: http://ssrn.com/abstract=1854403.
21. Poon SH, Granger CWJ. Forecasting volatility in financial markets: a review. J Econ Lit. 2003;41(2):478–539. https://doi.org/10.1257/002205103765762743.
22. Poultry farm union of Iran. Statistics and Information Center. 2022.
23. Rezitis A, Stavropoulos KS. Price volatility and rational expectations in a sectoral framework commodity model: a multivariate GARCH approach. Agric Econ. 2010;42(3):419–35. https://doi.org/10.1111/j.1574-0862.2010.00521.x.
24. Seyyed Hosseini SM, Babakhani M, Ebrahimi B. An introduction to volatility spillover models in the stock market. Bors Press. 2013. (In Persian).
25. Taheri SH, Ataaabadi AA, Arman MH, Vaziri Sarashk M. The mechanism of volatility spillover and noise trading among financial markets and the oil market: evidence from Iran. J Syst Manag (JSM). 2023;9(1):1–13. https://doi.org/10.30495/JSM.2022.1960629.1656.
26. Vajdi F, Ghahremanzadeh M, Hosseinzad J. Risk spillover effect of exchange rate on chicken market and its major inputs in Iran. J Agric Econ Dev. 2018;32(3):213–25. https://doi.org/10.22067/JEAD2.V32I3.70821.
27. Xiong Z, Han L. Volatility spillover effect between financial markets: evidence since the reform of the RMB exchange rate mechanism. Financ Innov. 2015;1:9. https://doi.org/10.1186/s40854-015-0009-2.

Publisher's Note