Determining fluctuations and cycles of corn price in Iran

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Abstract: Corn is the third important agricultural product. It is an important input in the poultry production and the basic elements of edible oil, starch, glucose, and raw material in industrial production of ethanol and some other products. The aim of this study is to find strategies to avoid price volatility, hence, the harmonic method has been used to investigate the corn price cycle and the GARCH model has been used to investigate its fluctuation. The harmonic method results showed long-term cycles in the period of 21 months in analyzing the period and the GARCH model result indicated that the corn price fluctuations causes more fluctuations in the corn future prices, in addition the error terms that have less contribution in the conditional variance. Based on the characteristics of the corn price variation obtained in this study, the policymakers should provide a proper condition to encourage sellers and buyers to deal in the Agricultural Mercantile Exchange and use future and option contract to control the price volatilities.

Key words: corn, GARCH, harmonic pattern, Iran agricultural mercantile exchange, price fluctuations

Stability in the prices of commodities and services can cause a safer condition for economic growth and it also can provide a better condition for economic development. At the macroeconomic level, fluctuation in prices does have a destructive impact on the macroeconomic indicators such as investment, economic growth and social welfare. Because of these reasons, policy makers are trying to provide a stable condition in the market and they try to control the unpredicted fluctuation in the prices of the commodities by using different policy measures. Accurately forecasting volatility at distant horizons is critical for measuring, monitoring, and managing the long-term risk in agriculture (Wu and Guan 2010).

Producing agricultural commodities is a time-demanding procedure and it completely depends on the expectation of the producers about their revenue and expenditure. Moreover, the expectations of producers about the economic condition have a great impact on their decision for investigating and using other inputs in the production procedure. The research on volatility spillovers in agricultural commodity markets has become an important issue for market participants whose production and marketing decisions are often impacted by uncertainty and risks in commodity markets (Zhao and Goodwin 2011). Also, movements in prices may have important implications for resource allocation (Huchet-Bourdon 2011).

Price fluctuation has a negative impact on the government as well as producers. Governments in most of the developing countries are relying on the incomes which they gain from selling commodities. Also in these countries, specially those which have natural recourses, fluctuation in the price of commodities has an impact on the government's expenditure, in other words, they have to use their financial recourses for supporting policies. For example, farmers in some countries now face a number of risks that were formerly absorbed by the market and the price support policies (Matthews 2010). As a result, most of the governments in these countries are facing a huge debt in their budget, so the prediction and research on the price fluctuation of agricultural products captures a close attention and tends to be very valuable (Hai 2011).

Corn is one of the most important agricultural products in the world and it has an important role in animal feeding; for example about 70 percent of poultry feed is corn, so that any fluctuation in the price of this input may cause an inappropriate condition for the producers.

In the recent years, the development in the international agri-food markets was affected by the significant price volatility (Matošková 2011). This has raised concern about unexpected price spikes as a major threat to food security, especially in less developed countries, where food makes up a high proportion of the household expenditures (Hernandez et al. 2012). Because of the importance of price volatilities, many researches have been done in this field. Some of these researches state that price fluctuation can cause more volatility in future periods (O'Connor et al. 2009; Busse 2010; Gilbert and Morgan 2010; Dong et al. 2011; Onour and Sergi 2011).

Figiel et al. (2012) evaluated the levels and components of volatility in the period from July 2004 to April 2011 for nine selected EU countries. They found considerable differences when comparing various price volatility measures calculated, indicating that the wheat price risk exposure may vary across the EU.

Wang and Garcia (2011) implied that globalization has a significant effect on the corn price fluctuation. Apergis and Rezitis (2011) used the GARCH model to survey the impact of macroeconomic policies on the agricultural production price fluctuation in Greece and they expressed that these policies can cause uncertainty in the market, hence decision making for producers in this condition would be harder. Geysar and Cutts (2007) state that increasing the fluctuation in the corn price can cause a grater payment risk for specific commodities and under this condition, consumers would use derivative instruments to hedge. Jorddan et al. (2007) used the GARCH model for analyzing price fluctuation for agricultural products and implied that those farmers who showed a risk-averse behaviour are willing to produce wheat and soybean, while those farmers, who are not as risk averse as the first group, are willing to produce white and yellow corn and sunflower seed. Pop and Ban (2011) used the ARCH model for measuring the price risk on the Romanian and International Wheat Market. The estimated values of conditional volatility show an increase of the price risk between 2004 and 2010.

Arlt and Bašta (2010) used the harmonic analysis in their study to show that the yearly inflation rate might not always be an appropriate measure of inflation for the monetary policy of the Czech National Bank. The harmonic analysis shows that the yearly inflation rate deforms and delays the information with respect to the monthly inflation rate and it is thus delayed behind the true inflation at yearly levels.

In this paper, the cycle and fluctuation in the corn price time series have been calculated, so that the policy makers can use this implement for policy making to reduce price risks in future planes.

MATERIAL AND METHOD

Data

This research uses the daily corn price from 14/10/2007 to 11/10/2011which presented by the Iran Mercantile Exchange; and the U.S. exchange rate has been used to convert these prices to USD.

Methodology

In this study, first the price cycle in corn price has been determined, and then the econometrics model has been used for analyzing the price fluctuations in corn price.

Harmonic analysis

In recent decades, the econometricians pay more attention to the Spectral Analysis. In this method, a time series has been disintegrated to its component so researchers can have a better realization from the time series. This method has been used for macroeconomic data in 1960, after that the Spectral Analysis has been used for disintegrating the trend and cycle components of the time series. The most important aim of this method is to decompose a time series to the Sin and Cos function with the specific frequency. In fact, by using this method, the structure of a variable can be studied easily (Weiss 1970). The Spectral Analysis method is utilized for determining seasonal fluctuation especially in the agricultural commodity prices.

Each time series can have four different components.

$$X_t = T_t + C_t + S_t + \varepsilon_t \qquad (1)$$

where X_t is the time series, T_t shows the trend, C_t is the cycle component, S_t is the seasonal component and ε_t is the residual term.

There are different methods for disintegrating a time series, and one of these methods is the harmonic pattern. The harmonic pattern usually can be used for a time series with a long duration and it is not suitable for studying an annual time series. This method has been used for the estimation of seasonal fluctuation for a specific period of time, but at present it has been used for the determination of seasonal fluctuation. One of the most important features of the harmonic pattern is that the OLS can produce an efficient estimation for the seasonal pattern. The harmonic analysis is a branch of mathematics in which each function has been showed with its basic waves. Before using this method for the seasonal fluctuation analysis, the trend can be omitted from the data, but, whether the trend has been omitted or not, it does not have any effect on the results and the coefficients for in the harmonic analysis are the same. On the other hand, the existence of trend in the data does not have an effect on the *Sin* and *Cos* coefficients. A basic assumption of the time series harmonic analysis is that a time series can be shown as a cycle function:

$$Y_t = \alpha_0 + \alpha_1 \mathrm{Sin}\left(\frac{2\pi_t}{P}\right) + \beta_1 \mathrm{Cos}\left(\frac{2\pi_t}{P}\right) \quad (2)$$

where Y_t is the time series which is being studied, P is duration of the cycle, α_1 and β_1 are harmonic coefficients and t is the symbol of time. If the time series includea the trend (2), the equation should rewrite as:

$$Y_t = \alpha_0 + \alpha_1 \mathrm{Sin}\left(\frac{2\pi_t}{P}\right) + \beta_1 \mathrm{Cos}\left(\frac{2\pi_t}{P}\right) + \gamma_t + U_t \quad (3)$$

In Equation 3 γ_t is the trend and U_t is the residual term (Doran 1972).

The cycle for all kinds of data such as daily, weekly, monthly, seasonal and annual can be specified by using the harmonic model. If annual data has been used in a research, only a long term cycle can be determined. after the estimation of the function that was mentioned in Equation 3. The significance of coefficients for $\mathrm{Sin}\left(\frac{2\pi_t}{P}\right)$ and $\mathrm{Cos}\left(\frac{2\pi_t}{P}\right)$ must be investigated, if one of the coefficients has been meaningful, the length of the cycle for the time sires data can be calculated.

After the function estimation, the value of Y_t is calculated, then the difference between the maximum of Y_t and the minimum of Y_t is calculated, after that any function which presents the largest difference between the maximum of Y_t and the minimum of Y_t is considered as a harmonic function for that time series and the value of P is considered as the length of cycle.

In this research, the radian has been used for the calculation of *Sin* and *Cos*. To clarify the analysis, π is equal to 3.14, so 2π is equal to 6.28, which it would indicate a perfect round circle or on the other hand, a perfect cycle. In this case, for a cycle of 30 days (one month) will be:

$$\frac{2\pi}{P} \approx \frac{6.28}{30} \approx 0.2093 \Rightarrow Y_t =$$

$$= \alpha_0 + \alpha_1 \mathrm{Sin}(0.2093) + \beta_1 \mathrm{Cos}(0.2093) \quad (4)$$

So each day is equal to 0.2093 radians (12 degrees) and it takes 30 days for a perfect circle.

Modelling the fluctuations

The general form of *ARMA(p,q)* is a combination of the auto regressive and the moving average model which is showed in Equation 5:

$$Y_t = \alpha + \sum_{j=1}^{p} \beta_j Y_{t-j} + e_t \quad (5)$$

In Equation 5, the residual term (e_t) follows a moving average model:

$$e_t = \sum_{i=1}^{q} \gamma_i e_{t-1} + \varepsilon_t \quad \varepsilon_t \approx NID(0,1) \quad (6)$$

If time series is not stationary, the data needs to be differenced to make it stationary, so the basic time series follows an Autoregressive Integrated Moving Average (ARIMA).

In the traditional econometrics models, having a fixed variance in the residual term was a basic assumption. Engle (1982) tried to get rid of this restriction so he established a new method called the ARCH. The assumption of this method is that the residuals have a serial correlation but the variance of this term is based on the past information, and also the mean of this residual is zero. Another reason for the use of the ARCH model is that there are both small and large errors in the prediction, on the other hand, in some periods the prediction errors have a small fluctuation and in some periods they have a grate fluctuation. Under such conditions, the expectation is that the variance of the time series is not fixed and the variance is a function of the residual behaviour.

In fact, the advantage of the ARCH models is that the conditional variance can be explained by using the past value of variance. After that, Bollerslev (1986) presented the GARCH model. In this model, two equations for the mean and variance have been estimated for modelling fluctuation.

Mean equation

Mean equation for the ARCH and GARCH models is as follows:

$$Y_t = \mu_t + \sigma_t Z_t \qquad Z_t \approx NID(0,1) \quad (7)$$

and

$$\mu_t = a + \sum_{i=1}^{k} b_i X_{it} \quad (8)$$

where Y_t is a conditional mean which is dependent on the exogenous variables and their coefficients. Z_t is a residual term which is Independently and Identically Distributed (IID). The positive fluctuation is determined by σ_t and σ_t can be calculated by using different kind of the ARCH and GARCH model, plus the residual term for the adjusted mean equation is obtained by multiplying σ_t on Z_t.

Variance equation:

ARCH(q) model:

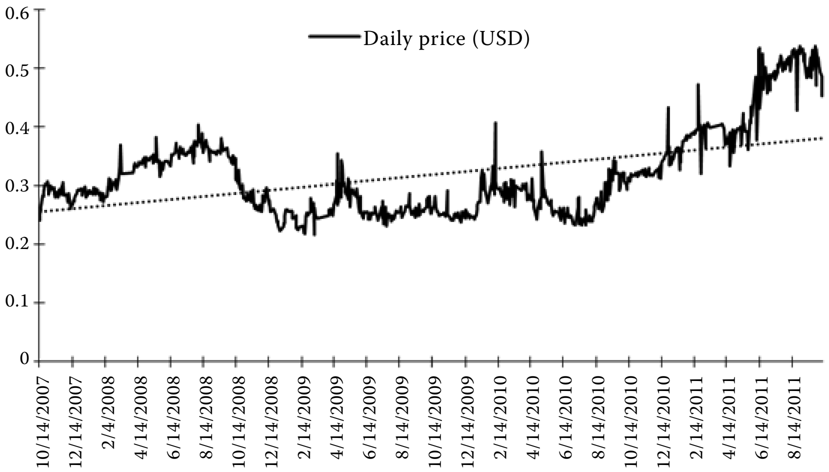

Figure 1. The daily price of corn (P_t)

Source: Iran's Agricultural Commodity Exchange

$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \ \dots + \alpha_q\varepsilon_{t-q}^2 = \alpha_0 + \sum_{i=1}^{q}\alpha_1\varepsilon_{t-1}^2$$

$$\alpha_0 > 0,\ \ \alpha_1 \geq 0,\ i \geq 0 \qquad (9)$$

GARCH(p,q) Model:

$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \ \dots + \alpha_q\varepsilon_{t-q}^2 + \ \dots + \beta_p\sigma_{t-p}^2 =$$

$$= \alpha_0 + \sum_{i=1}^{q}\alpha_1\varepsilon_{t-i}^2 + \sum_{i=1}^{p}\beta_i\sigma_{t-i}^2 \qquad (10)$$

In this model, α_1, … ,α_p and β_1, … ,β_q should be estimated. In this autoregressive process, those unforeseeable shocks in t do not appear in t+1, it means that the shocks effect is investigated separately.

RESULTS AND DISCUSSIONS

The aim of this study is the investigation of the corn price fluctuation and its cycle, hence, the corn price chart at the beginning of this study will be discussed.

As the Figure 1 showed, corn price has a large fluctuation around its mean, and this fluctuation has increased in some periods. Statistical investigation of the time series also shows these fluctuations.

Price dispersion along the upward trend in Figure 1 and great difference between the maximum and minimum prices and the high standard deviation which was presented in Table 1 are indicating the need for a careful review of corn price.

As the mean, maximum and minimum of the domestic and world corn price show, the domestic price is higher than the world price. Moreover, comparing standard deviations demonstrates that the domestic price has more fluctuation around its mean than the world price.

Table 1. Statistics of corn price (USD)

Statistic		Corn price (USD)	
		domestic	world
Mean		0.317	0.189
Maximum		0.538	0.309
Minimum		0.217	0.115
Standard deviation		0.07	0.057
Normality	statistic	307.7	19.87
	probability	0.00	0.00

Source: Research findings

Model estimation

To estimate models, first the data stationary should be checked, to check the stationarity of the time series the augmented Dickey-Fuller has been used and the result is presented in Table 2.

As the results in Table 2 showed, corn prices have a unit root, but after the first difference, the corn price time series becomes stationary.

Harmonic model estimation

For estimating the harmonic model, first the data stationary should be checked and after that, if data has a trend, it should be omitted and by using this data, the harmonic method can be estimated.

After all procedures mentioned, the harmonic method has been estimated for the logarithm of corn price and its results are presented in Table 3. In the estimated model for corn price, 6 cycles have been identified, which can define about 89% of the price change.

According to the harmonic method, t coefficients showed that the predicted cycles for corn price are

Table 2. Augmented Dickey-Fuller results for corn price time series

Level / Variable	Optimum lag	Estimated models	Estimated t-value	Critical value (%) 99	95	90
Corn price (P_t)	3	with constant	−1.07	−3.34	−2.86	−2.57
		with constant and trend	−1.6	−3.97	−3.41	−3.13
		without constant and trend	0.64	−2.58	−1.94	−1.61
Corn price first difference (DP_t)	4	with constant	−25.94	−3.44	−2.86	−2.57
		with constant and trend	−25.94	−3.97	−3.41	−3.13
		without constant and trend	−25.93	−2.57	−1.94	−1.61

Source: Research findings

Table 3. Harmonic model estimated results for the logarithm of the price of corn (*LPt*)

	Coefficients	Critical value (99%)	Probability
Constant (C)	−0.06	−22.78	0.00
Sin (0.01 *t*)	0.27	37.23	0.00
Sin (0.011 *t*)	−0.06	−7.86	0.00
Sin (0.017 *t*)	0.11	31.72	0.00
Cos (0.03 *t*)	−0.03	8.85	0.00
Cos (0.035 *t*)	0.07	20.88	0.00
Cos (0.057 *t*)	−0.03	10.19	0.00
AIC = 2.5	SC = 2.47	Log likelihood = 1100.27	DW = 1.53 R^2 = 0.87

AIC = Akaike Info Criterion, SC = Schwars Criterion

Source: Research findings

equal to 110, 179, 209, 369, 570 and 628 days, which are equals to 4, 6, 7, 12, 18 and 21 months. The 628-day cycle means that starting from the maximum price and reaching the minimum price (complete cycle) needs 628 days (21 months).

In Figure 2, the harmonic model diagram for logarithm of corn price has been showed.

ARCH and GARCH model

To estimating the ARCH and GARCH model, first we should test the heteroskedasticity between the residual terms of time series by using the LM-TEST. In this test, first the mean equation should be gained and then its residual should be checked.

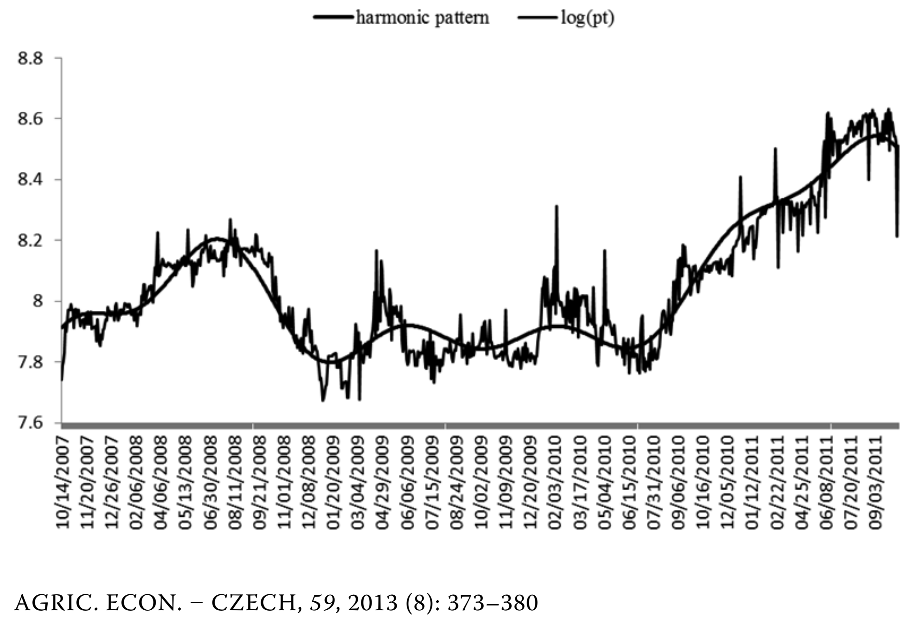

Figure 2. Logarithm of the daily corn price and the harmonic model estimation

Source: Research findings

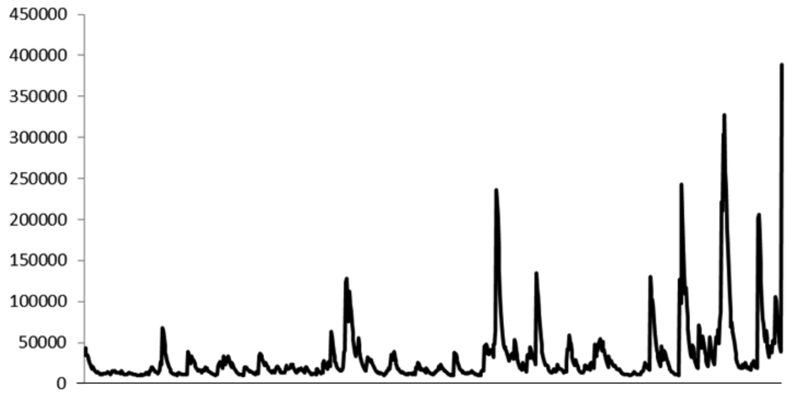

Figure 3. Conditional variance of corn price

Source: Research findings.

Table 4. Result of LM-TEST

Variable	*F*-statistic	Probability
First difference of corn price (DP_c)	16.84	0.00

Source: Research findings

Results which have been presented in Table 4 showed that the mean equation of the first difference of corn price (DP_c) has a heteroskedasticity, hence, according to the research methodology, one of the ARCH and GARCH model should be used. By using the AIC[1] and SC[2], the GARCH(1,1) has been picked for this time series.

Table 5 presented results for the GARCH(1,1). According to this table, three lags of corn price have a negative impact on corn price in the time of t. The results also showed that the first lag of the residual term has an impact on the corn price fluctuation, it means that the fluctuation on those variables which were not considered can cause a price fluctuation for corn. The results also showed that the first lag of the conditional variance of corn price has the greatest impact on the corn price volatility. So, this result indicates the importance of controlling the price of corn.

In the Figure 3, the conditional variance of corn price has been showed.

According to Figure 3, we can state that in those areas, in which corn price has many fluctuations, the conditional variance has changed considerably.

CONCLUSION

In this research, the harmonic analysis was used to investigate the corn price cycle and also the GARCH(1,1) has been used for analyzing the corn price volatility.

Table 5. Result of GARCH(1,1) estimation for first difference of corn price (DP_c)

Variable	Coefficients	*Z*-statistic	Probability
Mean equation			
Constant (*C*)	–0.29	–0.13	0.90
DP_{t-1}	–0.46	–2.67	0.00
DP_{t-2}	–0.56	–12.60	0.00
DP_{t-3}	–0.12	–2.98	0.00
Variance equation			
Constant (*C*)	201.16	8.31	0.00
$(\varepsilon_{t-1})^2$	0.18	7.79	0.00
(h_{t-1})	0.78	37.21	0.00
SC = 12.93	AIC = 12.89	Log of likelihood = –5666094	R^2 = 0.29 DW = 2.18

AIC = Akaike Info Criterion, SC = Schwars Criterion

Source: Research findings

[1]Akaike Info Criterion
[2]Schwars Criterion

The results of the harmonic method showed a 21-monthes cycle in the corn price time series, on the other hand, any increase or decrease in the corn price would repeat in 21-monthes cycle. The GARCH model estimation showed that the corn price fluctuation can cause more volatility in future periods. The conditional variance of corn price has a great impact on price volatility, in other words, it means that a risky condition can cause a greater volatility in corn price; this point is obvious in Figure 3.

According to the corn price cycle and its fluctuation, the government should use some appropriate strategies to control this volatility, so that this problem does not have negative effects on farmers, consumers, buyers and sellers.

Widespread studies in this subject show that it has a great importance for researchers and politicians and these studies showed that the Future Contract and Option Contract can be powerful tools to control price volatility, so using these contracts by buyers and sellers and the encouragement of producers and buyers for trading in the agricultural commodity exchange can be very useful tools for controlling the corn price fluctuation. Finally, creating the Regional Agricultural Commodity Exchange can create better conditions for the farmers to sell their commodity.

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