MODELLING THE DEVELOPMENT OF EGGS PRICES IN THE CR

Marie Pechrová [a], Ondřej Šimpach [b]

[a] Institute of Agricultural Economics and Information, [b] University of Economics, Prague

pechrova.marie@uzei.cz, ondrej.simpach@vse.cz

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Abstract:
The aim of the paper is to examine the long term development of consumer prices of eggs, analyse possible sources of volatility, and project them into future. We applied Box-Jenkinson methodology on monthly data from 01/2001 to 08/2016 obtained from agris.cz. The stationarity was tested by ADF test and the type of the ARIMA model was identified from ACF and PACF functions. It was found that the best model for modelling the consumer prices of eggs was ARIMA(1, 0, 0) with constant and impulses in crisis months (03, 05, 07/2012). Based on the results we can expect that the price will slightly increase from 2.56 CZK/pc to 2.61 CZK/pc in next 12 months.

Introduction

Eggs are an important and cheap source of proteins and therefore needed for healthy nutrition. World market with eggs is characterized by increased production and consumption in many countries. For the Czech Republic (CR) it is typical that the imports of eggs are high, because the prices of foreign (especially Polish) eggs are lower. The self-sufficiency level of the CR in eggs was 85.5% in 2015, and of inhabitants 42.7% (this % of congeries of eggs was noted at households). Annual consumption of eggs was 14.3 kg/inhabitant (249 eggs / inhabitant / year). (Ministry of Agriculture – MoA, 2016). From this amount 21.3% of eggs were coming from domestic breeding. In year 2015 the egg market was characterized by the year-to year decrease of the average number of laying hens, decreasing of the egg production and increasing of imports and exports, decreasing consumption and slight decrease of price.

Unlike other agricultural sectors, poultry is not directly subsidized. On the other hand, there are requirements on welfare of laying hens. Starting from January 2012, the farms in EU had to widen the battery cages and hence adjust the production halls. The date of force of the legislation was decided in already in 1999, but not all member states took necessary investments and therefore tried to postpone the force of the directive. Czech producers belonged to the group that obtained new battery cages on time. "The production capacities stayed larger as according to the legislation, the farmers could keep old production halls when they were not housing there any hens", (Pechrová and Medonos, 2016). Eggs producers had to adjust to the requirements of the welfare agricultural policy in 2012 when small battery cages were banned. Necessary investments into new cages might have influenced the costs of the farms. There was a concern that those higher costs would be reflected in the higher prices of the products eggs. Truly, the average price was the highest in March 2015 from period 2001–2016.

The aim of the paper is to examine the long term development of consumer prices of eggs, analyse possible sources of volatility, and project them into future. „Traditionally, future egg price has been predicted using a combination of regression analysis and experienced-based intuition to build a model, which is then fine-tuned to prevalent market conditions", (Ahmed and Mariano, 2006). Our article is structured as follows. First, the results of previous researches in the sector of eggs production are presented. Next section describes used data and method. Then the results of the analysis are displayed and discussed in the next. Last section concludes.

1. Literature review

Modelling of prices of eggs can be done by various methods. For example, Li et al. (2013) used chaotic neural network. They elaborated a short-term prediction model of weekly retail prices for eggs from 01/2008 to 12/2012 in China. Predicted prices were compared with results of Autoregressive Moving Average (ARIMA) model. "The result shows that the chaotic neural network has better nonlinear fitting ability and higher precision in the prediction of weekly retail price of eggs", (Li, Li and Wang, 2013). Similarly, for the case of China, Li, Li and Wang (2010) used econometric model to assess monthly prices of eggs from 03/2000 to 09/2009. Explanatory variables were commercial price, feed market prices and first-order and second order lag of monthly eggs. For the case of Japan egg prices, Oguri et al. (1992) applied autoregressive model and modified multiple regression model on monthly and yearly wholesale egg prices for years 1986–1990. The multiple regression model was more useful and predictable than the autoregressive model. However, the t-value of dummy coefficient of partial regression was low. Neural networks for prices of eggs projections were also used by Ahmad and Mariano (2006). The advantage is that the neural networks recognize the pattern in previous annual egg prices and then predict the future price more efficiently. For extended discussion see research of Ahmad (2011) "Results suggest that neural networks may be a more reliable method of egg price forecasting than simple regression analysis if reliable data are collected and manipulated for such models," (Ahmad and Mariano, 2006).

2. Methodology and Data

The data about consumer prices of eggs were obtained from internet pages www.agris.cz for the period from January 2001 until August 2016. From 2011, the data were observed with week periodicity. Until that, they were collected weekly, so they were transformed on monthly data by calculating the arithmetic mean. Two gaps in 2015 were filled by a value which was the average of two neighbour-hooding values. Average annual prices are presented in FIG 1.

FIG. 1: Average annual prices of eggs (CZK/pc)

Year	2001	2002	2003	2004	2005	2006	2007	2008
Price (CZK/pc)	2.79	2.39	2.44	2.78	2.35	2.34	2.51	2.80
Year	2009	2010	2011	2012	2013	2014	2015	2016
Price (CZK/pc)	2.60	2.49	2.32	3.59	3.07	3.09	3.07	3.10

Source: own elaboration. Note: Average for 2016 includes first 8 months.

The time series was tested by augmented Dickey-Fuller test (ADF test) whether it was stationary. There are 3 types of ADF test with constant and trend, with constant only, and without constant and trend. The first case is calculated according the equation (1)

$$\Delta Y_t = \beta_1 + \beta_2 t + \beta_3 Y_{t-1} + \sum_{i=1}^{m} \alpha_i Y_{t-i} + \varepsilon_t , \qquad (1)$$

where ΔY_t is the first difference of the examined variable, t is trend variable, ε_t is pure white noise error term, m is the maximum length of the lagged dependent variable, and α, β are parameters (β_1 represents the constant). Box and Jenkins (1970) introduced the models that are working with autoregressive (AR) and moving average (MA) processes. When the time series is not stationary, its difference of d^{th} order must be done. When there is a seasonal term, the form is SARIMA(P, D, Q)(p, d, q). Diagnostic of the model type is done by Autocorrelation function (ACF) and Partial Autocorrelation function (PACF) that were plotted in order to determine the order p of AR process and order q of MA process. Despite that the Fisher F-test for seasonality revealed that it is present, the coefficients for SARIMA model were not statistically significant. Therefore, in our case, an ARIMA(p, d, q) model is sufficient (2).

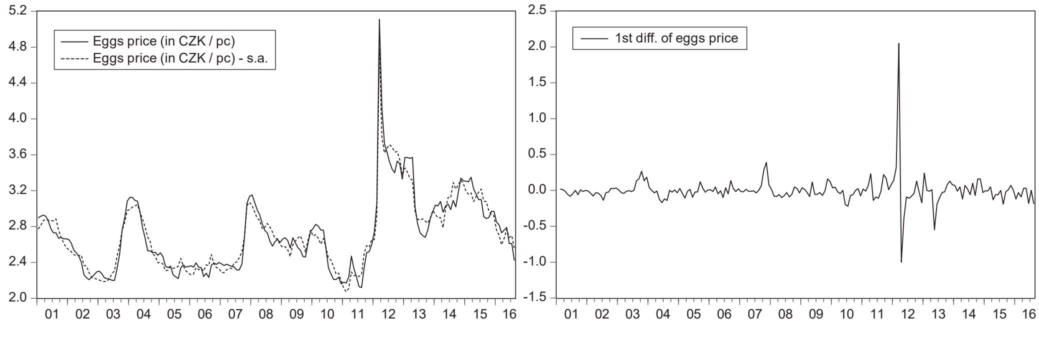
$$Y_t = \beta + \sum_{i=1}^{p} \alpha_i Y_{t-i} + \sum_{j=1}^{q} \delta_j \varepsilon_{t-j} \qquad (2)$$

The model is applied on seasonally adjusted time series. The adjustment was done by algorithm elaborated by Census X13-ARIMA. Verification of the model for was done for by Breusch-Godfrey serial autocorrelation LM test. Null hypothesis states that there is no serial autocorrelation. If the calculated value exceeds the tabled criterion from Fisher and χ^2 distribution the null hypothesis is rejected and there is autocorrelation. Heteroscedastity was tested by Autoregressive Conditional heteroscedasticity (ARCH) test. Null hypothesis was again that there is no heteroscedasticity. The test is also using Fisher and χ^2 critical values and rejects the null hypothesis when the calculated value of the test exceeds the table values. Finally, the normality was tested using Jarque-Bera test with null hypothesis that the residues are normally distributed. Calculated value of the test is compared to critical value of Jarque-Bera distribution. If the value exceeds the table one, null hypothesis is rejected. Based on the ARIMA model, the predictions are done for 12 months with 95% confidence intervals. We used software Eviews 8.

3. Results

During the period 2001 to 2016, the prices fluctuated mostly between 2 to 4 CZK per piece. The lowest price was in 2011 (2.32 CZK/pc) and the highest the year after (3.59 CZK/pc) when new battery cages were required. In 03/2012, the average price in the CR achieved 5.11 CZK/pc. Taking into account that this year the Easters were at the beginning of April, the producers could profit from higher demand for eggs (The price was 4.11 CZK/pc at that time.). High average price did not last; it decreased to 3.33 CZK/pc by the end of the year. However, it got back under 3 CZK/pc (as in 01/2012 – 2.74 CZK/pc) only in 06/2013 (2.83 CZK/pc). In 01/2014, the price was again over 3 CZK/pc (3.04 CZK/pc). Next decrease of the prices under this threshold was noted only in 08/2015. In last available month – 08/2016 was the price as low as it was not for almost four years. Lower price than 2.42 CZK/pc the most recently occurred in 09/2011. The development of the prices of eggs is displayed at FIG 2. First differences could have been used to make the time series stationary. After this transformation the process that generated consumer price of eggs became a white noise process and could not been modelled. Due to this fact, we did not integrated the time series. Seasonally adjusted time series has character of log-normal distribution with mean of 2.71 2.66 CZK/pc, median 2.66 CZK/pc, and standard deviation 0.40 CZK/pc.

FIG. 2: Development of consumer prices of eggs (CZK/pc) from 01/2001 to 08/2016 (left – empirical and seasonally adjusted data, right – first differences)



Source: own elaboration

ADF model with trend and constant, constant and without trend and constant were elaborated. After the differentiation (integration of the first order) the eggs consumer prices becomes a white noise process and hence it is not predicable. Only in the case ADF model without constant and trend, the time series is non-stationary, other models are stationary at 5% significance level. The F-test for seasonality revealed that the seasonal term is present (with 0.01% level of significance), but its value is low. In SARIMA model, no parameter was statistically significant. Therefore, we used ARIMA model and applied it on seasonal adjusted time series. A Census X13-ARIMA algorithm was applied. There had to be put a unit impulse on observations 03, 05, 07/2012 (the impulses should not be in the months in the row, there is a danger of autocorrelation) in order to accommodate the shock in 2015. The results are presented at FIG. 3. IMP is a time series of dummy variables with IMP 1 = 03, 05, 07/2012. Model was due to high variability estimated in natural logarithms.

FIG. 3: ARIMA(1, 0, 0) with constant model of eggs consumer prices (CZK/pc) from 01/2001 to 08/2016 with projection to 09/2016 to 09/2017

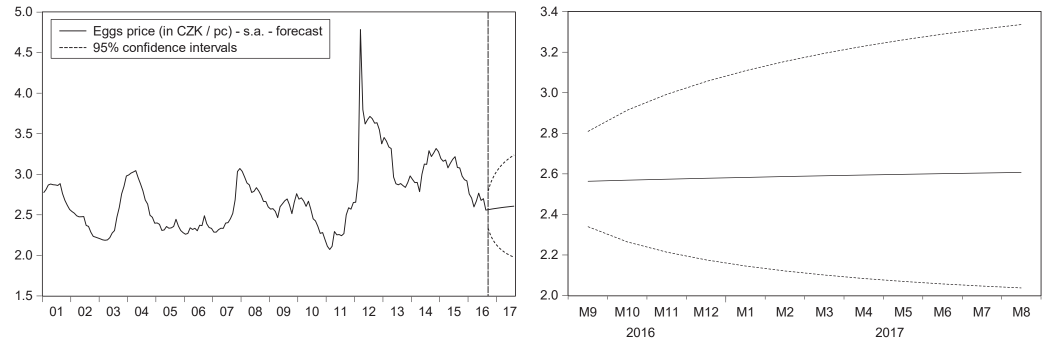
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.977104	0.059470	16.43025	0.0000
IMP	0.114081	0.019136	5.961471	0.0000
AR(1)	0.943877	0.024379	38.71672	0.0000

R-squared	0.897623	Akaike info criterion	-3.323117
Adjusted R-squared	0.896510	Schwarz criterion	-3.271281
F-statistic	806.6390	Hannan-Quinn criter.	-3.302113
Prob(F-statistic)	0.000000	Durbin-Watson stat	1.900726

Source: own elaboration

There was no heteroscedasticity and autocorrelation. However, due to the long time series, they were not normally distributed at the 0.05% level of significance. Nevertheless, this requirement does not have to be necessary fulfil. The consequence is only in the confidence intervals of the predictions that might have been biased (wider) than that would be in the case when the residues were normal.

FIG. 4: Prediction of consumer prices of eggs (CZK/pc) for 09/2016-08/2017



Source: own calculation

The prediction of price of eggs was done in the original data (non-logarithm). The results are displayed at FIG 4. On the left graph, you can see the development from the beginning of the time series. Right graph shows the detail of the projection. According to the results the price of eggs will slightly increase. It shall be 2.56 CZK/pc in August 2016 and increase to 2.61 CZK/pc in August 2017. No significant changes are expected. Upper bound of 95% confidence intervals show that the price shall be higher than 2.79 CZK/pc and lower than 3.24 CZK/pc. Taking into account the lower bound of the interval, the price shall be lower than 2.33 CZ/pc and higher than 1.98 CZK/pc.

4. Discussion

Researchers usually find that the agricultural time series are non-stationary and stationary after first differentiation (see for example Rumánkova, 2016). In our case, the differentiation of the first order caused that the process that generated the tine series of consumer prices of eggs was only a white noise. It is not possible to model it. Therefore, we used the integration of order 1. It reveals that modelling of the prices of eggs is complicated. Besides consumer prices are derived from farmers' prices. There might be some other more suitable methods for modelling the agricultural prices – e.g. neural networks as applied by Ahmad and Mariano (2006). Also expert guesses are quite reliable. For example agrarian analyst Havel (2012) expected that the high prices of eggs caused by the change of legislation at the beginning of 2012 will not last. He was right that the lack of eggs was not a treat and that the prices decreased after the crisis.

Conclusion

The aim of the paper was to model the development of consumer prices of eggs, and project them into future. Knowing the future consumer price reduces the market risks of the egg producers as those prices are related. We applied ARIMA(1,0,0) model with constant on the data from 01/2001 to 08/2016. The highest price was noted in 2012, but it decreased and stabilized later. Prediction from 09/2016 up to 08/ 2017 suggests slight increase of the consumer price of eggs (from 2.56 CZK/pc to 2.61 CZK/pc) without dramatic changes. Also 95% confidence intervals do not expect any significant increase (max. 3.24 CZK/pc) or decrease (min. 1.98 CZK/pc) at the end of the period. The challenge for future is to predict the consumer price of eggs also by other methods (e.g. regression model with relevant explanatory variables) and compare the results.

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