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Fluctuations and volatility of white eggs consumer prices in the Mexico Valley

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ABSTRACT

Objective: To develop a time series model and analyze the characteristic fluctuations of the average white eggs consumer prices in the Mexico Valley (AWECP), quantifying the seasonal and cyclical fluctuations of said prices.

Design/methodology/approach: A Moving Average Time Series Smoothing method was used to reduce the variation of a data set, and separate cyclical, seasonal, and OLS variations to calculate the trend line.

Results: The Seasonal Component (SC) indicates that in autumn-winter the AWECP is volatile above the annual average by 6.3% while in spring-summer it declines by 9.13% on average. The price volatility is largely explained by external factors and the biological process of poultry animals throughout one year. The cyclical component (CC) was 34 months and occurs irregularly.

Limitations on study/implications: This research focused on finding the SC, T, and CC, but not their respective indices. To make short-term forecasts, it is necessary to calculate the indices and compare them to other time series analysis methodologies.

Findings/conclusions: The analysis of the AWECP in the Mexico Valley indicates the presence of SC and an upward CC trend in the time series. The AWECP volatility has harmful effects on the basic basket of the middle and lower-class population in the Mexico Valley given that this food is the most complete, cheap, and accessible source of animal protein in the Mexican market.

Keywords: Poultry farming, Time series, Moving averages, Price fluctuations, Agricultural economy.

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INTRODUCTION

Chicken eggs are the most complete and cheapest source of protein in the Mexican livestock sector, and due to their competitive price, the most accessible animal protein in local markets (Luis-Rojas *et al.*, 2019). From 1994 to 2021, *per capita* consumption went from 16.7 to 23.7 kg, with an average annual growth rate (AAGR) of 2.08% (UNA, 2021). The *per capita* egg consumption growth in Mexico, despite its volatility, is explained by the competitive price of other protein sources. The Comisión Nacional de Salarios Mínimos (National Commission on Minimum Wages, CONASAMI) set the general minimum wage for 2021 at 141.71 $MXN (CONASAMI, 2021). This amount implies that in Mexico's central economic area, 4.2 kg of eggs or, 2.83, 1.21, and 1.42 kg of chicken, pork, and beef could be purchased. Indicating that egg protein continues to be the cheapest.

The main producing states in Mexico are Jalisco (55.84%), Puebla (12.77%), Sonora (7.88%), the Comarca Lagunera region (Durango and Coahuila) (5.12%), and Yucatán (4.92 %) from the national total (UNA, 2022).

Feeding, packaging, and labor costs are three of the most important inputs in egg production, representing 63.4%, 5.7%, and 4.4% respectively (UNA, 2022).

Tomek and Kaiser (2014) point out that the raw material price behavior results from a complex mix of changes, associated with trend, seasonal, cyclical, and random factors.

According to García-Mata *et al.* (2003), the price volatility and instability that characterize agricultural product markets are due to the derived demand and primary supply being typically inelastic, supply partially depends on random processes (climate, diseases, among others). It is frequently seasonal in nature because producers and dealers must use expected prices for decision-making and expectations introduce systematic changes in prices and quantities.

Separating the components that generate characteristic price fluctuations is important since it permits assessing the nature of the fluctuation, determines whether certain non-random patterns occur or not, and allows isolating and studying each of its components (Martínez-Jiménez and García-Salazar, 2020).

The objective of this research is to develop a moving average time series smoothing model to analyze the characteristic fluctuations of the average price of white eggs to the consumer in the Valley of Mexico (AWECP) and quantify the seasonal, cyclical, and random fluctuations of said prices. The proposed hypothesis is that the seasonal, cyclical, and random components predominantly explain the fluctuation of the AWECP that occurred in the Valley of Mexico recently.

MATERIALS AND METHODS

To evaluate the AWECP behavior and calculate its components, we used a historical series of white eggs' monthly prices to the consumer from the Central de Abastos de la Ciudad de Mexico (Mexico City Supply Central, CEDA-CDMX). This market, considered the world's largest, is a reference to consumer and wholesale prices at a national level in Mexico (SADER, 2023). We also used data provided by the Unión Nacional de Avicultores (National Union of Poultry Farmers, UNA) and the Sistema Nacional de Información de Mercados (National Market Information System, SNIIM) of the Secretaría de Economía (Ministry of Economy, SE). The AWECP series covers 22 years (January 2000 to December 2022), said prices are expressed in nominal Mexican pesos per kilogram ($MXN kg^{-1}).

If $P_t = (P_1, P_2, P_3, ..., P_n)$ is a time series of the AWECP, then the univariate approach of historical series states that a historical series $(P_t = f(t))$ of prices is made up of four components, Trend (T), Seasonal Variation (S), Cyclical Fluctuations (C), and Irregular or random Movement (E).

The separation of the four components is considered independent of one another, which implies that their estimation will be successive rather than simultaneous (García-Mata *et al.*, 2003), so each component is multiplicatively related as follows:

$$AWECP_{t\alpha} = T_{t\alpha} * S_{t\alpha} * C_{t\alpha} * E_{t\alpha} \quad (1)$$

Where $AWECP_{t\alpha}$ is the average price of white eggs to the consumer in Mexico, for month t in the year α, expressed in real terms, $T_{t\alpha}$ is the Trend component, $S_{t\alpha}$ is the seasonal component, $C_{t\alpha}$ is the cyclical component and $E_{t\alpha}$ is the irregular or random component.

The Time Series Moving Average Smoothing Method

It has the property of reducing a data set variation and consists of using appropriate order movements to separate cyclical, seasonal, and irregular variations, only leaving the trend movement.

Since the $AWECP_{t\alpha}$ series is expressed in months, and because the twelve-month moving average falls between successive months (June and July) instead of the month's center, the centered twelve-month moving average is calculated, as follows:

$$AWECP_7 = \frac{1}{2}\left(\frac{P_1 + P_2 + P_3 + ... + P_{12}}{12} + \frac{P_2 + P_3 + P_4 + ... + P_{13}}{12}\right) \quad (2)$$

In this research, a twenty-two-year period is considered t=1,2,3,..., n=22 with twelve months each year α=1,2,3,..., m=22.

To estimate price fluctuations caused by white eggs prices' seasonality, it is first necessary to obtain the real egg prices $(RAWECP_{t\alpha})$, to eliminate the inflation effect on current prices. This was obtained by dividing the nominal (current) price between the national consumer's price index, based on the 2nd half of July 2018 = 100, provided by Banco de México (Equation 3).

The seasonal index (SI) calculation was estimated with the average movement percentage method, which indicates each month's percentage based on a typical month of each year (annual average value) (García-Mata *et al.*, 2003). To obtain the SI, first, the monthly average price of the observations for each year was calculated (equation 4), the relative price was then calculated by dividing the real price of month t in year a by the average price calculated in equation (5), multiplied by 100 (Martínez-Jiménez and García-Salazar 2020).

The monthly SI (SIt) is obtained from the previous data, by dividing the sum of the respective monthly relative price of each year by the total number of years of the analyzed period (22), as indicated in equation (6).

Next, each month's real price $(RAWECP_{t\alpha})$ is then divided by its corresponding SI to de-seasonally the price of the white egg $(SP_{t\alpha})$ for month t in year a, as indicated in equation (7).

$$RAWECP_{t\alpha} = \left(\frac{APWEC_{t\alpha}}{PCNI_{t\alpha}} \right) * 100 \quad (3)$$

$$\overline{AWECP_{t\alpha}} = \frac{\sum_{t=1}^{n} RAPWEC_{t\alpha}}{n} \quad (4)$$

$$PPe_{t\alpha} = \left(\frac{RAPWEC_{t\alpha}}{AWECP_{\alpha}} \right) * 100 \quad (5)$$

$$SI_{t} = \frac{\sum_{t=1}^{n} PPe_{t\alpha}}{m} \quad (6)$$

$$SP_{t\alpha} = \left(\frac{RAWECP_{t\alpha}}{SI_{t\alpha}} \right) * 100 \quad (7)$$

To calculate the trend component (T), García-Mata (2003) states that it may be obtained through ordinary least squares (OLS), this method assumes that the trend can be graphically represented using a best-fit mathematical line, assuming that the previously de-seasonally adjusted price contains the trend component $\left(T_{t\alpha}\right)$ and the random error $\left(u_{t\alpha}\right)$.

In this research, it was estimated using a polynomial function where the de-seasonally adjusted price $\left(SP_{t\alpha}\right)$ is the dependent variable, and the independent variable is the time (x) equation (8).

$$SP_{t\alpha} = \widehat{T}_{t\alpha} + u_{t\alpha} = \beta_0 + \beta_1 X_{t\alpha} + \beta_2 x_{t\alpha}^2 + \beta_3 x_{t\alpha}^3 + \beta_4 x_{t\alpha}^4 + u_{t\alpha} \quad (8)$$

After estimating equation 8, a new series (CI) is generated, resulting from the quotient of the de-seasonally adjusted price $\left(SP_{t\alpha}\right)$ divided by the $\left(T_{t\alpha}\right)$ trend component.

$$C_{t\alpha} * E_{t\alpha} = \frac{SP_{t\alpha}}{T_{t\alpha}} \quad (9)$$

With the new series data, obtained from equation (9), the cyclical component $\left(C_{t\alpha}\right)$ was in turn obtained using the centered twelve-month moving average, that is:

$$C_{t\alpha} = \left(\frac{(CI)_{t,\alpha} + 2*(CI)_{t,1\alpha} + 2*(CI)_{t,2\alpha} + \ldots + 2*(CI)_{t-1,\alpha} + (CI)_{T}}{24} \right) \quad (10)$$

Where t is months of the year (t=1, 2, 3,..., T=13), the results of the new smoothed series allow us to assess the cyclical behavior and consequently its duration.

RESULTS AND DISCUSSION

The white egg price volatility to consumers in Mexico

The series indicates a strong white egg price volatility to the consumer in Mexico City Supply Central. This price is the starting point for white egg price at a national level. Registering during July 2000, a minimum of 8.13 pesos per kg price, and a 541% maximum price higher than the minimum price in July 2022.

The high coefficient of variation (42.35 %) denotes high price volatility. This is largely explained by the food inflation environment, given that, until the first half of January 2022, the Mexican annual inflation rate was 7.9%. This, in addition to the avian influenza impact in 47 of the 57 states of the United States of America (USA), which forced the sacrifice of 57.9 million birds, causing smuggling from Mexico to the USA (El País, 2023), and consequently, an excessive price increase in this food for Mexican consumers (Table 1).

Seasonal Component (SC)

The SC shows the percentage increase or decrease that the SC produces in each month of the year. The SI reaches its maximum values from December to January, coinciding with the beginning of winter, respectively. That is, those are the months in which the egg supply in markets decreases, which makes the SC have its greatest price impact.

Throughout the year, white egg prices to consumers had a marked seasonality, a product of climatic variation that exists throughout the year, which impacts the biological process in hens. This results in supply variations, which have an impact on white egg consumer prices in Mexico City.

During autumn-winter, mainly at the beginning of March, the price remains 6.32% above the average, since production is reduced by the season due to the cold weather. In turn, June reports a 9.13% minimum below the average. This is because production increases, due to spring-summer favorable conditions increasing production (Figure 1).

The SC in white egg prices to consumers in the Mexico Valley is present in its characteristic price fluctuations. The price seasonality is explained by the physiological and climatological characteristics of birds, which require heat hours for laying, consequently impacting optimal egg production as well as the market demand uniformity. internally throughout the year. Therefore, it is not possible to influence and mitigate this effect, although there may be other alternatives to reduce the price volatility impact on said product.

Table 1. Statistical indicators of the nominal retail price of white eggs to consumers in the Central de abasto de la Ciudad de México (Mexico City Supply Central, CEDA), January 2000 to December 2022.

	Mean	Median	Mode	Minimum	Maximum	Standard deviation	Coef. of variation
	Mexican pesos per kilogram						
Mexico City	21.08	20.45	30.00	8.13	44.00	8.93	42.35

Source: prepared by authors.

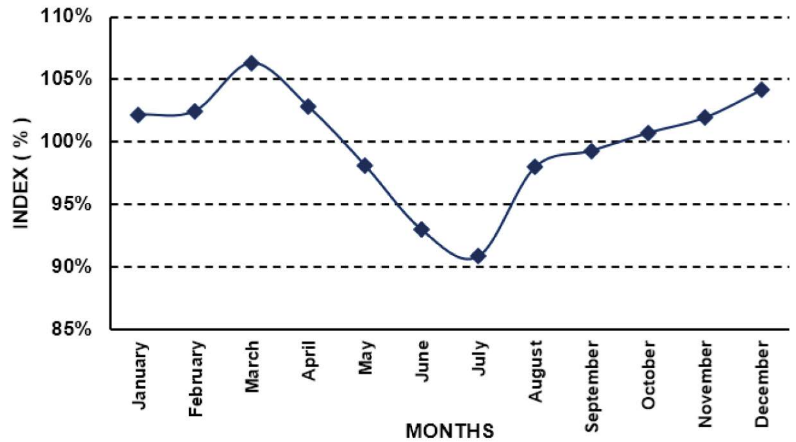

Figure 1. Seasonal index of monthly real price $\left(P_{t^{*}=E}\right)$ of white eggs to consumers in (%), July 2000 - June 2022.

The seasonal variation of the real consumer price of white egg (RCPWE) oscillates between 20% above and 15% below the average price. However, there are atypical (aberrant) data outside that range, such as those during May 2012, with a 33% drop below the average price, while in April 2020 a 29.6% increase occurred. In the first case, due to supply excess, causing the price decrease, while in the second, due to the beginning of the confinement procedures for the COVID-19 pandemic control in Mexico, causing panic buying, dragging this food price upward (Figure 2).

Trend Component (T)

The AWECP series shows an upward trend, masked by a marked seasonality product of climatic variation throughout the year (García-Mata *et al.*, 2003) (Figure 3).

Parameters $\hat{\beta}_0, \hat{\beta}_1, \hat{\beta}_2, \hat{\beta}_3$, and $\hat{\beta}_4$ were calculated using Ordinary Least Squares, this method provides small error intervals, because the method itself minimizes them. For

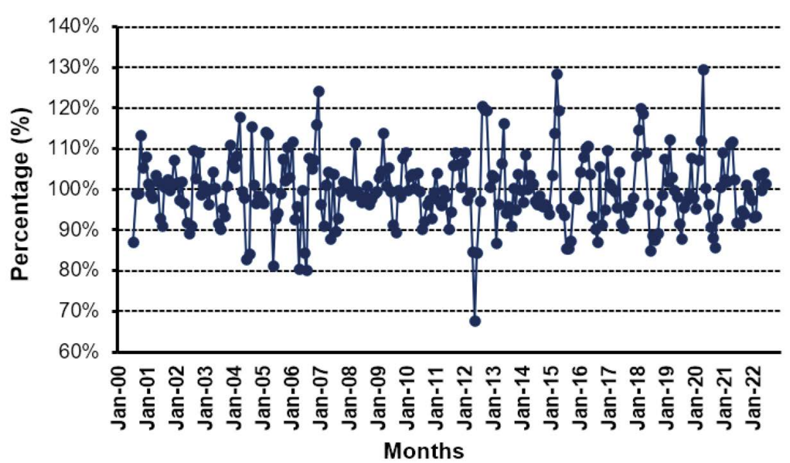

Figure 2. Seasonal variation of real monthly prices $\left(P_t = S\right)$ of white eggs to consumer in (%), July 2000 - June 2022.

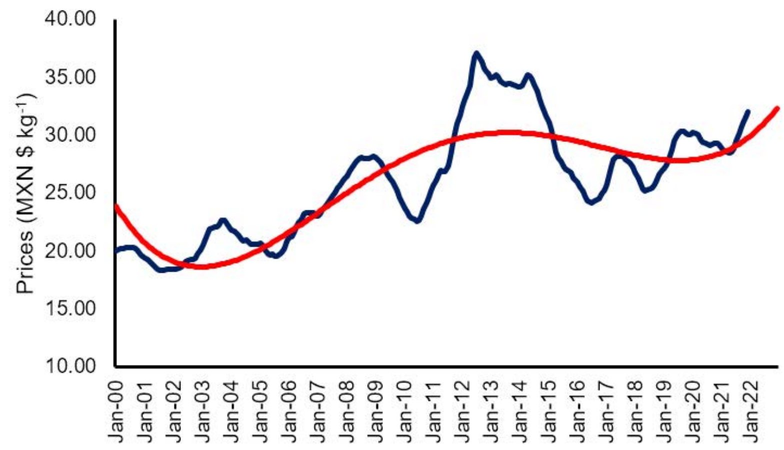

Figure 3. Monthly adjusted prices to white egg consumers trend, 2000 – 2022.

a moderate model to be considered, those parameters whose absolute *t*-statistic is greater than 2 or whose *p*-values are less than 0.05 must be included. Therefore, beta estimators are highly significant.

The coefficient of determination (R^2=0.706) indicates that the regression model explains 70.6% of the Y variable variance (RWECP), so it is assumed that, if more variables are added to the model, this value may increase, decreasing the dependent variable variance. Given that the absolute value of the calculated F (155.76) is greater than the F table value, the null hypothesis is rejected and concluded that the "Y" (RWECP) variable depends on the variable "X" (time), that is to say, it is highly significant (Table 2).

Cyclic Component (CC)

The relevant months that define the RWECP behavior cycles are presented. The CC is also present in white egg prices. For the Mexico City supply central prices, the maximum cycle point occurs during January- June; the minimum is during July-December.

The length of a cycle in price fluctuation goes from a maximum to a minimum, or from a minimum to a maximum. Based on this, from 2000 to 2022, eight complete cycles are observed for prices in the Mexico Valley. The first from May 2001 to January 2002, the second from January 2004 to March 2006; Finally, the eighth cycle from April 2020 to October 2021. On average, the cycle duration is 34 months (2 years 10 months) (Table 3).

Table 2. Trend estimation for the RAPWEC series by ordinary least squares (OLS).

Dependent Variable	Intercept	Independent variables				R^2	Calculated F	Prob>F
Trend (RWECP)	Intercept	X1	X2	X3	X4	0.706	155.76	<0.0001
	24.189	−0.345	0.0065	−3.576E-05	6.152E-08			
Standard error	1.099	0.052	0.0007	3.971E-06	7.117E-09			
t ratio	22.00	−6.64	8.84	−9.01	8.64			

Table 3. Economic cycle duration of white eggs real monthly consumer prices, 2000-2022.

Price maximums and minimums	Average cycle length (months)	Duration of the complete cycle (months)	Duration of the complete cycle (years)
MAX may 2001			
	8		
MIN january 2002		32	2 years 8 months
	24		
MAX january 2004		50	4 years 2 months
	26		
MIN march 2006		40	3 years 4 months
	14		
MAX may 2007		17	1 year 5 months
	3		
MIN august 2007		20	1 year 8 months
	17		
MAX january 2009		40	3 years 4 months
	23		
MIN december 2010		51	4 years 3 months
	28		
MAX april 2013		39	3 years 3 months
	11		
MIN march 2014		15	1 years 3 months
	4		
MAX july 2014		34	2 years 10 months
	30		
MIN january 2017		43	3 years 7 months
	13		
MAX february 2018		23	1 year 11 months
	10		
MIN december 2018		26	2 years 2 months
	16		
MAX april 2020		34	2 years 10 months
	18		
MIN october 2021		18	1 year 6 months
AVERAGE	**17**	**34**	**2 years 10 months**

Regarding the strategies to face the cycles in the characteristic price fluctuations of poultry products in Mexico, the Unión Nacional de Avicultores (National Union of Poultry Farmers, UNA) was created in 1958. This organization is in charge of studying and implementing all the necessary measures to solve the technical, economic, and social problems related to poultry production and distribution in Mexico (UNA, 2022).

The cycles in plate egg prices are closely related to the variation in their input prices. In products such as plate eggs, about 63.4% of production costs are dollarized, which causes the costs of raw materials to increase and, as soon as possible, producers pass food costs to the ultimate consumer (Luis-Rojas *et al.*, 2019).

In the plate egg market, the planning of egg and chicken production through the purchase of grains from national or international producers in a regulated manner through import quotas, as well as vertical integration and technological progress of Mexican poultry farming have been important factors for unit costs to decrease, so supply is displaced faster than demand by population and income.

The genetic improvement of birds has made poultry farming capable of producing a greater product volume with the same amount of input food, and therefore with the same total costs and lower unit costs. The technological change in this activity contributes to the RAWECP having a downward trend in real-term prices; however, the irregular components (diseases, earthquakes, inflation, etc.) alter prices at the producers' level and consequently to the consumer, vulnerating agricultural planning.

CONCLUSIONS

The analysis of consumer prices for white eggs in the Mexico Valley indicates the presence of the SC. The CC upward trend in the time series, according to that proposed by the price components of agricultural products. The AWECP volatility has harmful effects on the basic basket prices for the middle- and lower-class population in the Mexico Valley, since this food is the most complete and cheapest source of protein from the livestock sector in Mexico. Due to the price competition being the most accessible animal protein in the Mexican market, hence a necessity to assess these components to suggest policies that allow avoiding the seasonal and cyclical components of the consumer price of white eggs for dishes in the Mexico Valley.

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