Journal of Economic Growth and Entrepreneurship JEGE
Spatial and entrepreneurial development studies laboratory
Year : 2022 Vol.5 No.3 pp:20-26

A comparative study between the two prediction methods: Holt-Winter and the ARIMA model using Census x13: a cas study "Al Najah milk production Company" in Maghnia

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ARTICLE INFO
Article history:
Received:18/07/2021
Accepted:03/06/2022
Online:08/10/2022

Keywords:
ARIMA
Holt-winter
forecast
censusx13
seasonality
JEL
Code:B23,B26,C01,C22

ABSTRACT
The aim of this research paper is to compare the accuracy of the two prediction methods, Holt Winter and ARIMA using CENSUS X13 feature, in the case of a commercial production company, whose sales are affected by seasonality, which in our case is "Al-Najah Milk Production Company", and with the help of the eviews 10 program, we got the forecast results for the company's sales for the year 2021 in both methods, and after comparing the prediction sales results with the real value of sales, we came to the conclusion that the ARIMA models using the census X13 property to correct seasonality and other influences, used in the American offices for studies, are the most accurate, where the sum of the squares of the differences between the real value of sales and the predicted sales results using ARIMA (census x13) it is smaller than its counterpart to the Holt Winter method, so the company can rely on the method in the future, for forecast it sales and even for make future decisions.

1. Introduction

There are many methods and stages of forecasting, and its models and fields of use are varied according to the needs of the user in general, and the production company in particular in this research paper, as the entreprise seeks to resort to systematic scientific forecasting to determine the future information, whether the value of future sales, the value of demand, the value of costs, etc., and on the basis of This prediction is the adoption of its future production program, but this model must be characterized by accuracy to the maximum degree, and in this context we will try in this research to compare the accuracy of the two methods of Holt Winter, and the ARIMA model with the use of the census x13 property to address the effect of seasonality, by applying them to a milk production company "Al-Najah" in Algeria, the state of Tlemcen, "Maghnia District", which carries out various production activities: pasteurized milk, pasteurized butter, and yogurt.

The aim of this study is to choose the optimal model for forecasting sales in the event of a seasonality effect, by estimating the ARIMA model after correcting the effect of seasonality using the census x13 property, as well as the holt-winter model that is usually used to predict if there is an effect of seasonality, and the comparison between them in terms of prediction accuracy.

Therefore, in this research paper, we will adopt the descriptive approach, where we will review each of the models ARIMA and Holt Winter, as well as the method of correcting the effect of seasonality through census x13.
Then an applied analytical study by applying various models to "Al-Najah" Company, then analyzing the results obtained using the eviews program, trying to find the optimal model, noting the difference in accuracy between the two models.

2. Literature review

There are many kinds of research works in the area of forcasting using time series analysis, holt-winter, ARIMA and census x13 methods. Some of the important tasks are mentioned here. A study deal with the comparaison of the two different types of Holt-Winter method; Holt-winter multiplicative and Holt-winter additive,the researchers took in his study several databases with quarterly data, we mention: the electricity consumption in Australia, the number of tourists to New Zealand, and others.After applying both methods holt-winter additive and multiplicative to databases, and based on the comparison between the two criteria RMSE and MAPE, the researcher reached that the multiplicative holt-winter method is more accuracy and had more performance than additive method (Wongoutong, 2021).

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Another study compared the models of Holt-Winter, and each of ARIMA(Autoregressive Integrated Moving Average) and NNAR (Neural Network Auto-Regressive) models.The researchers applied these models to predict the harmonized index of consumer prices in the countries of the European Union, and the countries of the Western Balkans. After comparing the accuracy of the models based on the following criteria: ME, RMSE, MAE, MPE, MASE.The researchers concluded that the NNAR model is the most accurate in prediction for the Western Balkans countries, while the ARIMA models are the most accurate for the European Union countries, followed by the Holt-Winter models that are suitable for both countries (Karadzic, 2021).

In the next study, the researchers used a time series approach to predict future demand of food manufacturing, and tried to study how this prediction affects the supply chain. In this paper the methodology based on Box Jenkins and ARIMA models.As the results reached, the ARIMA model (1.0.1) is the best model for predicting the demand for food products, with high accuracy that the company can rely on, in making its future decisions (Ghosh, 2020).

Furthermore,in a study, the researchers tried to build a predictive study for the National Consumer Price Index of china, the data was from 2012 to 2019, and they based in this study on the census X13 property of ARIMA models, to correct the effect of seasonality, trend and Spring Festival. They used R program, and in the end, after estimating the model, and correct all effects they concluded that the model obtained using census x13 is very accurate, and the total average relative error is only 0.0117 (Ma, 2020)

3. Definition of the methods used

3.1. Holt-Winter exponential smoothing method

The Holt-Winter model is used to predict if there is a demand for a commodity that has the effect of seasonality, that is, there are gaps in seasonality (R.Bourbonnais, 2010, p. 73).

This model uses three coefficient (R.Bourbonnais, 2010, p. 74):

- Weighting constant α used to determine the effect of the mean,α € [0,1]
- The weighting constant σ is used to determine the effect of the trend,σ€[0,1]
- The weighting constant β is used to determine the effect of seasonal changes,β €[0,1]

Therefore, the Holt-Winter model consists of 3 equations:

First, the groping related to random changes:

$$S_t=\alpha Zt/(S_{t-s})+(1-\alpha)(S_{t-1}+b_{t-1}),\ t=1,2,\ldots,n \qquad (1)$$

Secondly, the preamble related to the general direction:

$$b_t=\sigma\ (S_t-S_{t-1})+(1-\sigma)b_{t-1},t=1,2,\ldots.,n \qquad (2)$$

Third, the groping related to seasonal variables:

$$S_t=\beta(\ Z_t/S_t)+(1-\beta)S_{t-s},t=1,2,\ldots,n \qquad (3)$$

Where(St) is the seasonal component at time (t) and (s)is the seasonal cycle

The applied value is given by the following relationship:

$$Z_t=(s_t+b_tt)S_{t-s},t=1,2,\ldots n \qquad (4)$$

The predictions of the relationship:

$$Z_n(l)=(S_n+b_nl)S_{n-s+l}\ ,\ l>0 \qquad (5)$$

3.2. ARIMA method

ARIMA (p, d, q) is called an autoregressive differential moving average model. It includes the moving average (MA) process, the autoregressive process (AR), the autoregressive moving average process according to whether the original sequence is stable, the part in the regression process (ARMA) and the hybrid autoregressive average process (ARIMA) (Meher, 2021, p. 44).

Its equation is often as follows (Nepal, 2020, p. 3):

$$Y_t= B_0+B_1Y_{t-1}+B_2Y_{t-2}+\ldots\ldots+B_pY_{t-p}+e_t+W_0-W_1e_{t-1}-W_2e_{t-2}\ldots\ldots\ldots-W_qe_{t-q} \qquad (6)$$

Y_t : dependent variable

P : is the number of delays of the auto-aggressive model, and is inferred from ACF(Autocorrelation function)

q: is the number of delays of the moyen average model, and is inferred from PACF(Parcial autocorrelation function)

3.3. Census x13 method

The census x13 method or as it is called x13 is based on taking into account all outliers and the effects of trading days, calendar, holidays,occasions, seasonality and trend, and this method is based on the following equation:

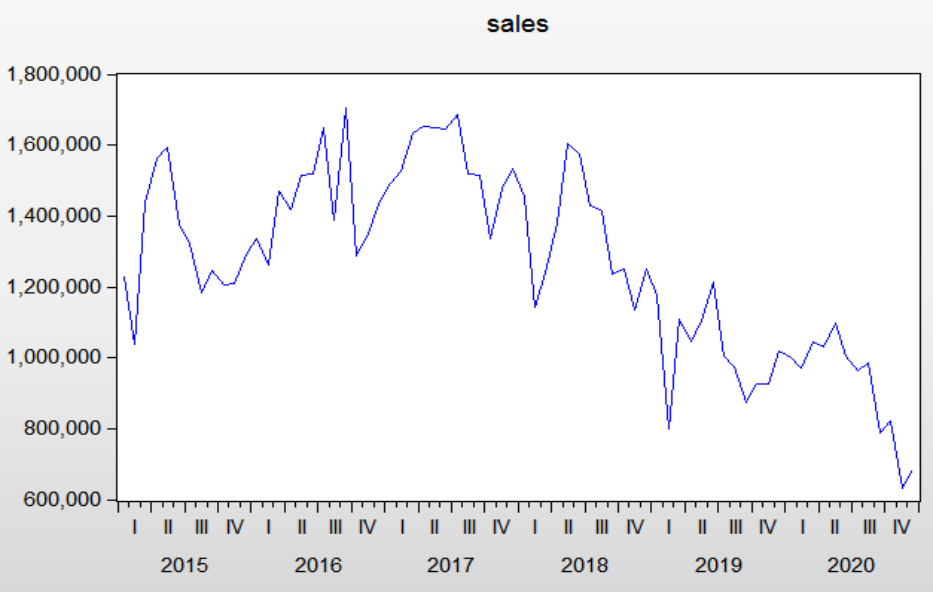
$$y_t= y_t^{SA}+y_t^{S},\ t=1\ldots\ldots n, \qquad (7)$$

where Y_t^{SA} represents the seasonally adjusted series, and Y_t^{S} represents the seasonal components And non-seasonal. Once we give the results we do not need to review it because it takes all cases into account. It is also based on seasonal and trend analysis using Loess Regression (STL) where it analyzes the series Y_t considering the trend cycle αt, seasonality S_t component and it irregular component using loess warnings and moving averages in loess warnings. This method is included in eviews 10 program we can use it automatically, and it will offer us all the results that we need: seasonality adjustment, the best model of ARIMA, and the predictive value (Abeln, 2021, p. 4).

4. View and analyze study data

The Sales series reflects the monthly milk sales of "Al-Najah company" from January 2015 to December 2020, and the following figure shows us more about the behavior of this serie.

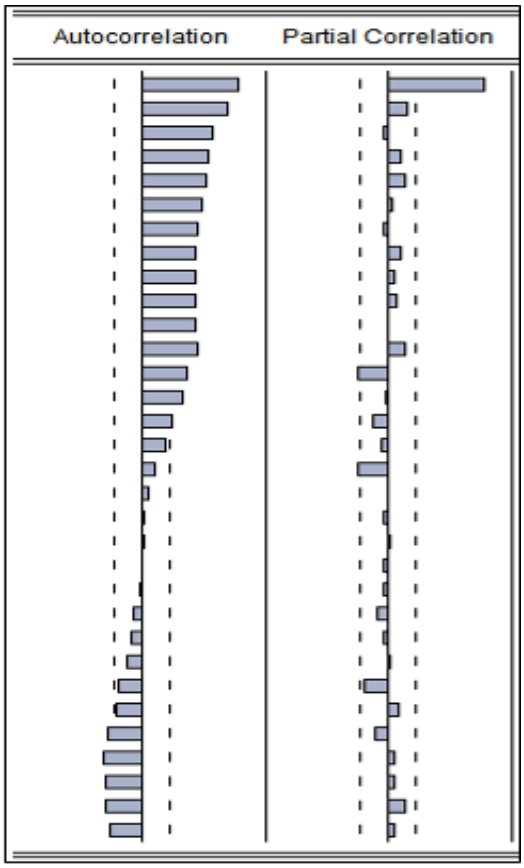
Figure 1: Milk sales curve for 2015-2020



Source: output of eviews10

It is well clear from the previous curve in figure 1 that the series is not stable, as well as there is an effect of seasonality and we will confirm more through the graphic representation of the autocorrelation function and the partial.

Figure 2: Graphical representation of the autocorrelation and partial function of the sales serie



Source: output of eviews10

The figure 2 represent autocorrelation and partial function, shows well the most of the vertices outside the confidence interval, and this indicates that the series is non-stationary, but to ensure the presence of seasonality, we will resort to an dummy regression using the method of least squares, where the dependent variable is sales and the independent variables: sales(1) to sales (12).The result via the eviews program is in the following table:

Table 1: dummy regression results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
SALES(1)	0.539777	0.142332	3.792383	0.0004
SALES(2)	0.228975	0.172521	1.327224	0.1908
SALES(3)	-0.222730	0.175502	-1.269105	0.2107
SALES(4)	0.001090	0.181718	0.005999	0.9952
SALES(5)	0.167374	0.182481	0.917212	0.3637
SALES(6)	0.110780	0.182824	0.605938	0.5475
SALES(7)	-0.197629	0.183140	-1.079115	0.2860
SALES(8)	-0.019633	0.182565	-0.107541	0.9148
SALES(9)	0.050421	0.181665	0.277551	0.7826
SALES(10)	0.013626	0.181213	0.075191	0.9404
SALES(11)	-0.075034	0.171267	-0.438114	0.6633
SALES(12)	0.240448	0.150351	1.599250	0.1165
C	234046.2	127558.9	1.834809	0.0729

Source: output of eviews10

The table 1 shows us the results of dummy regression, depending on the t-student, show that there is an effect of seasonality where the variable sales(1) is significant, where t_c=3.79 >t_{tab}=1.96, from which we reject the null hypothesis and accept that the variable is significant, so there is an effect of seasonality.And based on these results, we will pass to predictions using ARIMA models using the census x13 property, and then the Holt-Winter models.

4.1. Prediction by ARIMA models using census x13 feature

The census x13 feature allows us to automatically correct the effect of seasonality, and the effect of the trend, if it's present, taking into account the days of holidays, and then choosing the appropriate model for ARIMA according to the Jenkins box methodology. The various results are presented to us directly by eviews program, which are as follows:

Table2: The results of the application of CENSUS X13

ARIMA Model: (0, 1, 1)(0, 0, 1)
Nonseasonal differences: 1

Parameter	Estimate	Standard Errors
Nonseasonal MA		
Lag 1	0.3100	0.11182
Seasonal MA		
Lag 12	-0.4277	0.10610
Variance	0.15931E+11	
SE of Var	0.26738E+10	

Source: output of eviews10

After the automatic correction for both seasonality and trend using census x13, the program estimates more than 26 models were reached, and the optimal model selected automaticaly by eviews proram using census x13 method is ARIMA (0, 1,1) (0, 0,1) that's mean:

AR lag = 0;
degree of integration=1;
MA lag = 1;
SAR=0;
SMA=12;
according the last model we get the following prediction sales results :

Table3: Prediction results (01/2021 to 12/2021) using census x13

Date	Forcast	Standard error
2021.Jan	694795.99	126217.852
2021.Feb	724930.29	153347.002

2021.Mar	705499.25	176350.957
2021.Apr	720032.72	196682.528
2021.May	756318.24	215100.845
2021.Jun	696931.05	232061.911
2021.Jul	705518.54	247865.059
2021.Aug	722845.14	262719.326
2021.Sep	646456.89	276777.530
2021.oct	653968.04	290155.403
2021.Nov	558920.13	302943.089
2021.Dec	572361.50	3152122.423

Source: made by researchers used outputs of eviews 10

The above table shows us the forecasted values of sales for the year 2021, using the obtained model ARIMA (0,1,1)(0,0,1) based on census x13.

4.2. Forecasting using the Holt-Winter method

We will get the results using Eviews 10 program, which will choose the optimum model, and the optimal parameters alpha, Beta, and gamma for which the sum of square errors is minimum, and we get the following results:

Table4: The result of choosing the optimal alpha, Beta and gamma

Parameters:	Alpha		0.5000
	Beta		0.1000
	Gamma		0.1000
Sum of Squared Residuals			8.52E+11
Root Mean Squared Error			108781.1
End of Period Levels:	Mean		730109.9
	Trend		-25098.72
	Seasonals:	2020M01	0.988572
		2020M02	0.865485
		2020M03	1.031784
		2020M04	1.056429
		2020M05	1.128695
		2020M06	1.104718
		2020M07	1.061181
		2020M08	1.000854
		2020M09	0.969645
		2020M10	0.923954
		2020M11	0.897671
		2020M12	0.971011

Source: output of eviews10

So the optimal parameters for which the value of sum of squared Residuals is minimum are:

Alpha= 0.5 Beta= 0.1 gamma= 0.1

The results of prediction using the Holt Winter method are as follows:

Table5: Prediction results using the Holt Winter method

Date	Forcast
2021.Jan	738087.9
2021.Feb	638735.4
2021.Mar	752418.0
2021.Apr	761898.1
2021.May	804795.2
2021.Jun	779702.0
2021.Jul	743394.5
2021.Aug	693184.0
2021.Sep	668668.5
2021.oct	627300.5
2021.Nov	606582.7
2021.Dec	648320.1

Source: made by researchers used outputs of eviews 10

5. Comparison of forecasting accuracy for sales for both of methods

To find out the most accurate and appropriate method for the "EL-Najeh company" and predict its future sales, we will compare the sum of squared residual, which represents the difference between the real sales values and the values predicted by the two methods: Holt Winter, and ARIMA model using the census X13 method.

Table6: The results of calculating the sum of squared residual of both methods

Months(t)	V.R	H.W	ARIMA	E_t^2 H.W	E_t^2 ARIMA
January/21	731915	738087.9	694795.99	38104694,41	1377820903
February/21	717928	638735.4	724930.29	6271467895	49032065,24
March(3)	691542	752418.0	705499.25	3705887376	194804827,6
April(4)	706250	761898.0	720032.72	3096699904	189963370,6
				$\sum_{t=1}^{4}$ H. W E_t^2 =13112159869	$\sum_{t=1}^{4}$ ARIMAE_t^2 =1811621167

Source: made by researchers used outputs of eviews 10

V.R: real value of sales
H.W: the forecast value of sales using the Holt Winter method
ARIMA: the forecast value of sales using ARIMA model with census x13 method
E_i^2 *H.W* : Square the difference between real sales and forecast sales using holt-winter
E_i^2 *ARIMA* : Square the difference between real sales and forecast sales using ARIMA (census x13)
By comparing the sum of squares errors for both methods, we find the smallest $\sum_{t=1}^{4}$ ARIMAE_t^2 = 1811621167, and based on this result, the best and most accurate way to predict the sales of "Al-najeh company" is: ARIMA models based on the census x13 algorithm to correct seasonality and other effects.

6. Conclusion

Forecasting is very important in the company with its various activities, because through its outputs its future activities are planned, and the more accurate it is, the fewer costs, and the higher the profitability of this company. Accordingly, we have applied two different methods to "Al-Najah" Milk Production Company to predict its future sales, trying to choose the best method in terms of accuracy, so that it can rely on this method in its future activities. After applying both methods: Holt Winter and ARIMA using the census X13 feature to adjust seasonality, on the monthly milk sales data from 2015 to 2020, we got the forecast sales values for the months (January, February, March and April) for the year 2021

After calculating the squared difference between the values predicted by the Holt Winter method and the real values of sales, as well as between the values predicted by the census x13 method and the real values of sales, we compared the sum of the squared differences for both cases and concluded that the smallest of them is for the ARIMA models prediction method using census X13,based on this, we adopted the prediction method using ARIMA models and the census-x13 feature to adjust for seasonality, as the best method for "El-najeh" company for predicte it future sales.

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