Atatürk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi Aralık 2018 22(4): 2603-2617

Forecasting Monthly Sales of White Goods Using Hybrid Arimax and Ann Models

Melih YÜCESAN [*]

Abstract: *In this study, hybrid ARIMAX-ANN and SARIMAX-ANN sales forecasting models are proposed for a white goods wholesaler. White goods industry which is one of the durable goods sub-sector includes washing machines, dishwashers, refrigerators and small home appliances. In making forecasts, 46-month sales data of a white goods wholesaler are used. Factors influencing sales such as exchange rate, holidays, consumer confidence index (CCI), producer price index (PPI) and residential sales of the region are used as explanatory variables. The study contributes to the current literature by some aspects. First, there is no attempts applying the ARIMAX-ANN and SARIMAX-ANN hybrid models to forecast sales data in white goods industry. Second, the hybrid models combine the advantages of times series and ANN models. ARIMAX models are insufficient to solve complex nonlinear problems. On the other hand, ANN is sufficient to explain nonlinear relationships. On conclusion, use of hybrid models can increase the accuracy of the models.*

Keywords: *ARIMAX, SARIMAX, Monthly sales, White goods*

Jel Codes: *C45; C82; M10*

Aylık Beyaz Eşya Satışlarının ARIMAX ve YSA Hibrit Yöntemleri Kullanılarak Tahmin Edilmesi

Öz: *Bu çalışmada beyaz eşya toptancısı için ARIMAX-ANN ve SARIMAX-ANN satış tahmin modelleri önerilmiştir. Dayanıklı tüketim malları alt sektörlerinden biri olan beyaz eşya sanayiinde çamaşır makineleri, bulaşık makineleri, buzdolapları ve küçük ev aletleri bulunmaktadır. Tahminler yapılırken, beyaz eşya toptancısının 46 aylık satış verileri kullanılır. Döviz kuru, tatil, tüketici güven endeksi (CCI), üretici fiyat endeksi (ÜFE) ve bölgenin konut satışları gibi satışları etkileyen faktörler açıklayıcı değişkenler olarak kullanılmıştır. Çalışma, günümüz literatürüne bazı açılardan katkıda bulunmaktadır. İlk olarak, beyaz eşya endüstrisindeki satış verilerini tahmin etmek için ARIMAX-ANN ve SARIMAX-ANN hibrid modellerini kullanan herhangi bir girişim bulunmamaktadır. İkincisi, melez modeller, zaman serileri ve YSA modellerinin avantajlarını birleştiriyor. ARIMAX modelleri, karmaşık doğrusal olmayan problemleri çözmek için yetersizdir. Öte yandan, YSA, doğrusal olmayan ilişkileri açıklamak için yeterlidir. Sonuç olarak, hibrid modellerin kullanılması modellerin doğruluğunu artırabilir.*

***Anahtar Kelimeler*:** *ARIMAX, SARIMAX, Aylık satışlar, Beyaz eşya*

Jel Kodları: *C45; C82; M10*

Makale Geliş Tarihi: 31.03.2018

Makale Kabul Tarihi: 26.12.2018

[*] Dr.Öğr.Üyesi, Munzur Üniversitesi Mühendislik Fakültesi Makine Mühendisliği Bölümü (e-posta: melihyucesan@munzur.edu.tr)

I. Introduction

Forecasting is the procedure of compose educe about the possible consequences of future events. Decision makers can use the forecast approach in many disciplines such as demand forecast, economic forecast, technological forecast etc. (Gahirwal, 2013). Sale forecasting plays vital role for making short term and long-term planning (Vijayalakshmi et al. 2008). Sales forecasts are based on past sales and other explanatory variables on the market (Scott, 2001; Qin and Shi 2006). In order to make an effective sales forecast, past period data and explanatory variables must be fully recorded. Sales forecasting is one of the main issues handled by decision makers. Ineffective sales forecasting practice increases the costs of holding inventory, causing reduced productivity (Ramos et al. 2015). The productivity of today's businesses is directly related to their production planning activities. The first parameter leading decision makers to be able to make effective production planning is the sales quantities (Yucesan et al. 2017). If the data is stable and smooth, good results are possible even with simple statistical methods. If the data is irregular and does not show a uniform distribution, it is difficult to get accurate and practicable results. There are two main reasons for the development of forecasting approaches. One of them is to increase the accuracy of prediction. The other is to make accurate estimations with fewer sources (Gilliland and Sglavo, 2010; Arunraj et al 2015).

Sales forecasts directly affect other functions of the organization by means of accurate sale forecast: finance and accounting departments can determine costs, profitability levels and capital needs; sales department can determine how much products have to be in stores. Decision makers also can determine long and short-term production planning; marketing department can plan advertisement strategist for each product and logistic department can arrange logistic model for transport (Doganis et al 2008).

The durable consumer goods sector in the world has rapidly growing and evolving structure. Countries having followed a policy that prioritizes electrical and electronic household appliances appear to have made significant progress in terms of development in a short period of time Turkey has become one of Europe's leading white goods manufacturer. The household appliances sector (refrigerators, washing machines, dishwashers and ovens), which has the second largest capacity in Europe after Italy with a production capacity of more than 25 million units per year, employs 2 million people (Republic of Turkey Prime Ministry Investment Support and Promotion Agency, 2010). White goods sector which is one of the most important sectors in Turkey is changing by technological advances and globalization in recent years and located in extremely vulnerable sectors from experienced tough competition conditions (Alptekin, 2010); therefore, sales forecast is very important for this sector.

The most important criteria in determining the forecasting model taken into account are estimated time interval, the availability of the data, affordability and the consistency of the data (Herbig et al. 1993). The first methods used in sales forecasting in the literature are statistical methods such as trend analysis, exponential recovery. However, these methods are insufficient to determine the propensity of sales forecasts and explain the structure of the data (Chang and Lai, 2005). Time series are commonly used for

making sale forecast as they include both trend and seasonal patterns and allows the methods to be compared and the accuracy to be measured (Ramos et al. 2015).

In the current literature, either new forecasting methods have been proposed, or the performances of existing forecasting methods have been measured. Sales forecasting studies have been implemented in many areas but there has been a lack of the studies on sales forecasting in the literature for the white goods sector although it is highly needed. When literature is examined, it can be seen that hybrid approaches are frequently used in sales forecasts. Hybrid approaches is often used in combination with multiple methods and based on the principle of eliminating the weaknesses of the methods (Meyer-Nieberg and Pickl 2009). Time series forecast are used to make predictions about the future by taking advantage of past data. There are two indicators that determine the performance of the time series. One of them is expected degree of accuracy and the other is expected demand (Stevenson, 2007; Arunraj et al. 2016).

The accuracy of time series forecasting constitutes the most important stage of many decision-making processes. So, motivation to increase accuracy in time series haven't been completed yet. In this paper, we aim to propose a sales forecasting model for the white goods sector using ARIMAX-ANN and SARIMAX-ANN hybrid approaches. Time series in different structures can be captured with hybrid approaches. If we do not know the structure of the time series, the hybrid approach will improve the forecasting performance.

Proposed hybrid methods consist of two stages. In the first stage, forecasts are made using ARIMAX and SARIMAX approaches. As these methods fail to predict non-linear associations, residuals obtained from these methods include non-linear information. In the second step, a neural network model is developed with the residuals obtained from the ARIMAX and SARIMAX model and other explanatory variables.

Apart from the white goods sector, sales forecasting studies have been implemented in many areas. Some of these studies are summarized below. Arunraj and Ahrens (2015) developed SARIMA-MLR (Multi Linear Regression) and SARIMA-PR (Piecewise Regression) models to estimate sales of banana sold in a retail sector. Proposed approaches are better estimates than the conventional methods SARIMA and MNN (Multilayer Neural Networks). It has also been suggested that the SARIMA-PR method can provide more accurate estimates when the independent variables are less than SARIMA- MLR. Alon et al. (2011) made demand forecasts for the retail sector. Sales in the retail sector are determined to contain trend and seasonality. ANN and ARIMA methods are used to forecast and the obtained results are compared. Diaz-Robles et al. (2008) suggested that hybridization of ARIMA-ANN methods in forecasting air quality could lead to more effective results in both models. Anggraeni et al. (2015) and Suhartono et al. (2015) forecast sales for the clothing sector. Anggraeni et al. (2015) compared ARIMA and ARIMAX methods in estimating clothing demands of Muslim children. They have suggested that the ARIMAX method, which can better show the calendar effects, gives better results than the ARIMA method. Suhartono et al. (2015) applied ARIMAX method and linear regression method between 2002 and 2009 to

determine the effect of Ramadan Festival on sales of men and women trousers. As a result of the study, ARIMAX method with seasonal variables has been suggested to give better results than SARIMAX and ANN method. Karaatlı et al. (2012) made automobile sales forecasts using ANN method by using automobile sales data between 2007 and 2011 to help decision-making mechanisms in the automobile sector. Murlidharan and Menezes (2013) used hybrid genetic algorithms and ANN methods to select independent variables in sales forecasting. Ni and Fan (2011) proposed a forecasting model for clothes sales. Nonlinear prediction models are constructed. This method suggests that better results can be obtained than with conventional prediction models. Gahirwal (2013) has divided sales quantities into the time series trend, seasonality and irregularities. Each part is estimated separately. For these estimates, Holt-Winter and ARIMA methods are used in combination. It has been suggested that the proposed method gives better results than the Holt-Winter method. Gul and Guneri (2016) forecasted the number of patient's arrivals emergency service which is an important parameter in hospital management. Emergency service arrivals are estimated by short and medium-range with specific explanatory variables by Regression and ANN methods. The above literature review is summarized in Table 1.

Table 1. Review of sales forecasting application studied in literature

Author	**Application Area**						**Method**											
	Food	Retail sector	Textile	Environment	SARIMA	Others	ANN	MLR	PR	Box-Jenkins	MNN	ARIMA	ARIMAX	SARIMA	SARIMAX	Box-Jenkins	Data mining	Holt Winter
Arunraj and Ahrens (2015)	X							X	X					X				
Alon et al. (2001)		X					X	X		X						X		
Dı´az-Robles et al. (2008)				X			X				X	X						
Anggraeni, et al. (2015)			X									X	X					
Suhartono et al. (2015)			X								X		X		X			
Karaatlı et al. (2012)						X	X											
Murlidharan and Menezes (2013)						X											X	
Ni ve Fan (2011)			X								X							
Gahirwal (2013)						X						X						X
Gul and Guneri (2016)						X	X	X										

II. Material And Method

A. Data Set

In this study, the sales of a district dealer refrigerators, washing machines, dishwashers, televisions and small home appliances are used between 2014-2017. The average monthly sales of refrigerators washing machines, dishwashers, television and small home appliances products are calculated as 19, 18, 11, 44, and 42 respectively. Monthly sales quantities of the products are shown in Fig. 1.

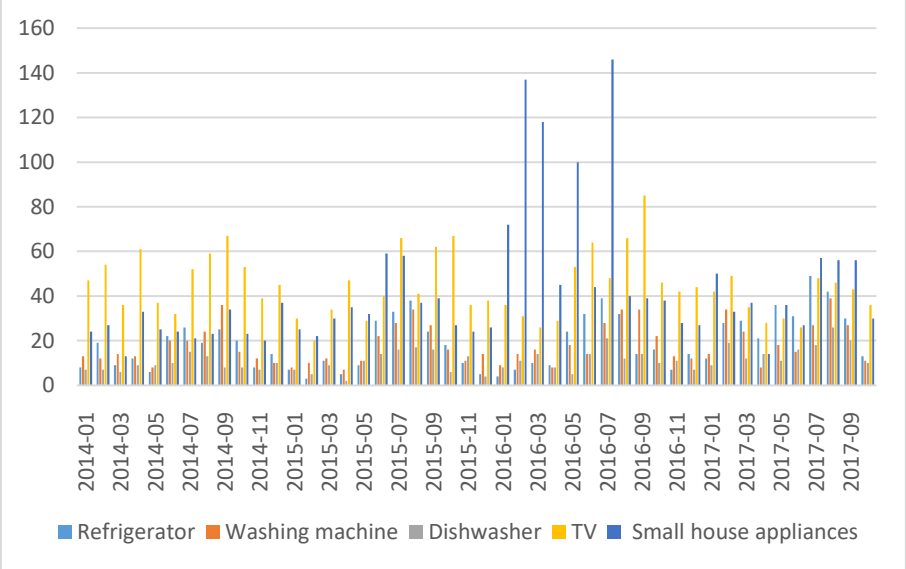


Figure 1. Sales of White Goods

When the sales of the products are examined, it is seen that the sales of the products varied according to the month. Dummy variables which are January to December are used to explain calendar effect. In addition, PPI, CCI, dollar exchange rate, holidays and residential sales of the region are used as input variables. The PPI is an index that measures price changes by comparing the producer prices of manufactured goods and services over time in the country's economy. CCI is a measure aimed at measuring the current situation assessments of consumers' personal financial situation and general economy with the monthly consumer tendency survey and future upcoming expectations and expenditure and saving trends in the near future. Explanatory variables are used in this study was obtained Turkey Statistical Institute (TUIK, 2017). The PPI and dollar exchange rates followed a steadily increasing trend. Residential sales of the region have been used as explanatory variables because purchasing a new home will cause the purchase of white goods.

B Methodology

In this study, monthly white goods sales are modeled by using *ARIMAX-ANN* and *SARIMAX-ANN*. The MAPE values, which are the performance evaluation criterion of forecasting methods are calculated for each model. Then, the most effective model among these models are determined. Descriptions of the methods are presented in the subsections.

1. ARIMAX-ANN Hybrid Method

The ARIMAX method uses past observations to predict the future trend of data. This approach is very often used in the literature because of the relatively simple and easy to application (Zang, 2003). The ARIMAX model consists of four parts. These sections are Auto Regressive (AR), Integrated (I), Moving Average (MA), and External Variable (X) (Sutthichaimethee and Ariyasajjakorn 2017).

Bierens (1987) has been generalized the ARIMAX method. This method is derived from the ARIMA method. The most important feature that distinguishes the ARIMAX method from the ARIMA method is that dependent variable can be expressed better with the explanatory variables. ARIMAX model can be expressed as Eq 1.

$$\left(1 - \sum_{s}^{p} \alpha_s L_s\right)\Delta y_t = \mu + \sum_{s=1}^{q} \beta_s L^s x_t + \left(1 + \sum_{s=1}^{r} \gamma_s L^s\right)e^t \quad (1)$$

Where, L is the usual lag operator $\gamma_s L^s = y_{t-s}$, $\Delta y_t = y_t - y_{t-1}, \mu \in$, $\alpha_s \in R, \beta_s \in R^k$ and $\gamma_s \in R$ are the unknown parameters and e_t are the errors (Arya et al. 2015).

Neural Networks has been modeled on the basis of the working principles of the human brain. They consist of several neurons. These neurons with neuron can store the information and pass information to the output node (Hahn et al.2009). ANNs are one of the most powerful computer modeling techniques based on statistical methods (Yucesan et al., 2017).

The ARIMAX model is quite successful in interpretation linear relationships. On the other hand, the ANN method gives us very satisfactory results on nonlinear problems. But none of them presents good results in all cases. It is quite difficult to identify and decompose the linear and nonlinear parts of the white goods industry's sales. Therefore, hybridization of the ARIMAX and ANN methods is expected to increase the predictive accuracy.

Proposed hybrid method consists of two steps. The ARIMAX model is created in the first step. In the second step, in addition to the explanatory variables used in the ARIMAX model, the error values obtained in the ARIMAX model are used as input variables. Necessary procedures performed in the steps are summarized below.

Step 1: The logarithm of the dependent variable or difference of dependent variable is used to decide which one should be used. First, Equality (2-3) is estimated.

$$D(y_t^2) = \alpha_1 + \beta_1 y_t \quad (2)$$
$$Dlog(y_t^2) = \alpha_2 + \beta_2 log y_t \quad (3)$$

The t statistic values of β_1 and β_2 coefficients are calculated. The model with smaller t coefficient is selected. The appropriate level of differencing dependent variable is determined by the Augmented Dickey Fuller test. EViews uses model selection to determine the appropriate ARMA order. Model selection is a way of determining which type of model best fits a set of data and is often used to choose the best model from which to forecast that data. The AIC value is used for the appropriate ARMA order selection. The maximum levels of the AR and MA terms are determined. All options are then evaluated and the model with the minimum AIC value is determined (Eviews User manual, 2017; Areekul et al. 2010).

Step 2: Factors influencing sales such as exchange rate, holiday days, consumer confidence index (CCI), producer price index (PPI) and residential sales of the region are used as explanatory variables used as input variables. In addition to these variables residuals obtained by using the ARIMAX method are also used as input variable. Mean absolute percentage error (MAPE) was used to measure the accuracy of this method. MAPE are defined as in Eqs. (4).

$$MAPE = \frac{100}{n}\sum_{i=1}^{n}\left|\frac{y_i - f_i}{y_i}\right| \tag{4}$$

Where f_i is as vector of n forecasting, and y_i represent of actual values.

2. SARIMAX-ANN Hybrid Method

A non-seasonal ARIMA (p,d,q) model represents a time series with p autoregressive terms, q moving average terms and d non-seasonal differences (Aburto and Weber, 2007). When the ARIMA approach is developed in a way that expresses in seasonal effects, SARIMA method is obtained. (Espinoza et al. 2005). SARIMA model can be expressed as Eq 5.

$$\phi_p(B)\phi_p(B^S)(1-B)^d(1-B^S)^D Z_t = \Theta_q(B)\Theta_Q(B^S)\varepsilon_t \tag{5}$$

Where $\phi_p(B)$ seasonal autoregressive operator with p-order, $\Theta_q(B)$, seasonal moving average operator with q-order, $(1-B)^D$ Seasonal differencing operator of order D, $(1-B)^d$and S - Seasonal length.

SARIMAX model is extension of SARIMA model using with explanatory variables called SARIMAX $(p,d,q)(P,D,Q)_S(X)$ X represent explanatory variables. SARIMAX model can be represented as Eq 6.

$$Y_t = \beta_0 + \beta_1 X_{1,t} + \beta_2 X_{2,t} + \beta_3 X_{3,t} + \cdots\cdots + \beta_k X_{k,t} + \omega_k \tag{6}$$

Where $X_{1,t}, X_{2,t}, X_{3,t} \cdots X_{k,t}$ are observation of k number of explanatory variables of Y_t ; $\beta_0, \beta_1, \beta_2 \cdots \beta_k$ are regression coefficients; ω_k is stochastic residual and represent Eq. 7

$$\omega_k = \frac{\theta_q(B)\theta_Q(B^S)}{\phi_p(B)\phi_p(B^S)(1-B)^d(1-B^S)^D}\varepsilon_t \quad (7)$$

According to the complex behavior of sales in white goods, it is inevitable to include both linear and non-linear sections. Therefore, applying SARIMAX or ANN models alone will not be sufficient. Hybrid modeling can be a good methodology for practical use and by combining SARIMAX with ANN approach. The proposed hybrid SARIMAX-ANN model consisting of two steps. The SARIMAX model is created in the first step. In the second step, in addition to the explanatory variables used in the SARIMAX model and the error values obtained in the SARIMAX model are also used as input variables for ANN approach.

The solution of the SARIMAX model consists of the following stages. In the first stage, the model's AR level (p), MA level (q) seasonal AR (P), seasonal MA (Q), order of differencing dependent variable (d) and order of seasonal differencing (D) determined using with AIC value. In the second stage, the determined explanatory variables are added to the SARIMA model. So, the model is now called SARIMAX (Shukla and Jharkharia, 2013).

After estimates from the SARIMAX model have been obtained, the residues and other explanatory variables of this model are used as input variables to the ANN model. MAPE, the performance measurement indicator is calculated.

III. Results and Discussion

In this study, sales forecasts are made using ARIMAX-ANN and ARIMAX-ANN hybrid methods, which are widely used in different fields in the literature to estimate the monthly sales quantities of a white goods wholesaler but have not been used previously for the white goods sector.

The ARIMAX-ANN hybrid method consists of two steps. In the first step, estimation will be done with ARIMAX method. The residual obtained from ARIMAX method will be used as input variables in ANN method together with other explanatory variables. ARIMAX-ANN model of washing machine sales is formed as follows.

Step 1: The dependent variable is examined for stability. Dependent variable (sales of washing machine) is determined to be stationary at the level. After that it was determined which transformation would be applied to the dependent variable. Eq. 8-9 are estimated.

$$D(Washing\ Machine)^2 = c_1 + \beta_1(Washin\ Machine) \quad (8)$$

$$\text{Dlog}(Washing\ Machine)^2 = c_2 + \beta_2 \log(Washin\ Machine) \quad (9)$$

The t statistical values of β_1 and β_2 are determined to be 1.884595 and -0.452037, respectively. A logarithmic model was selected when $\beta_1 < \beta_2$.

AIC was used to determine the appropriate ARMA order. Minimum AIC value was determined as (4,0). The AIC values of the other top 20 models are shown on the Fig.2.

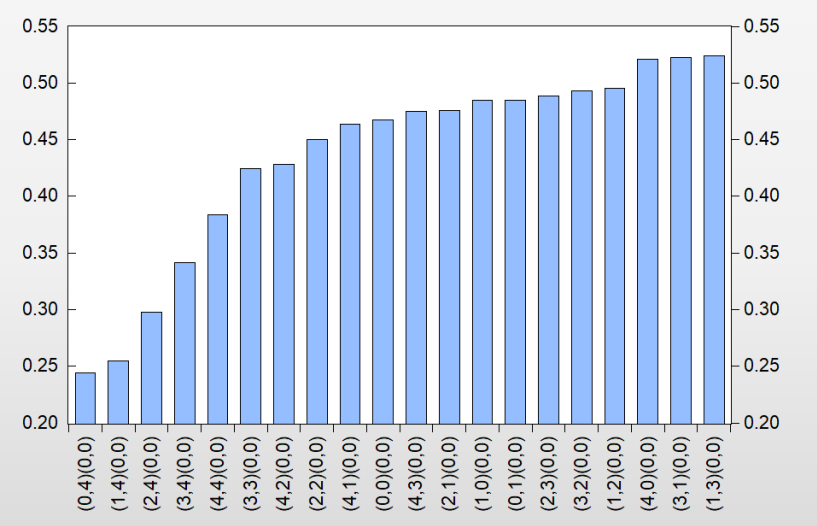


Figure 2. Top 20 models according to AIC ranking

$$log(y_t) = \sum_{i=1}^{12} c_j\, M_{j,t} + dCCI_t + ePPI_t + fV_t + gH + jDO + \rho_1\vartheta_{t-1} + \rho_2\vartheta_{t-2} + \rho_3\vartheta_{t-3} + \rho_4\vartheta_{t-4} \quad (10)$$

Where y_t refers to washing machine sales, $M_{j,t}$ month of the year, CCI_t CCI, PPI_t PPI, V_t number of holidays, DO dollar exchange rate and H residential sales of the region. ρ_p shows the model parameters for the autoregressive terms. The ARIMAX model is used to estimate the sales of the washing machine, then the actual values are subtracted from the obtained values and the residuals are found. The performance measurement results of ARIMAX models given Table 2.

Table 2. The performance measurement results of ARIMAX models

Forecasting Variable	Transformed independent variable	Selected model	$\mathbf{R^2}$	AIC
Washing machine	LOG(Washing machine)	(0,0,4)	0.8957	0.24418
Dishwasher	DLOG(Dishwasher)	(0,1,3)	0.8099	1.19689
Refrigerator	(Refrigerator)	(4,0,4)	0.9152	6.74422
TV	LOG(TV)	(3,0,3)	0.7285	0.34772
S. Household appliances	S. Household appliances	(3,0,3)	0.6859	9.63947

Based on the estimated parameters, ARIMAX model equation can be written to predict washing machine sales as follows:

LOG(Washing machine) = 1.90225538667 - 0.124961170555 JANUARY + 0.38665957494* FEBRUARY + 0.368521898449* MARCH - 0.23064972071* APRIL + 0.224931919837* MAY + 0.511885944527* JUNE + 0.936238402964* JULY + 1.09426747423* AUGUST + 1.08761440078* SEPTEMBER + 0.427318974808* OCTOBER + 0.0717717225766* NOVEMBER + 1.98254116537e-06* H - 0.00840353367726*V + 1.08272536705*DO+0.0324996242461*CCI-0.0176163010541*PPI + [MA(1)=-0.0377783175763,MA(2)=-3.06356361184e-,MA(3)=0.03777825177,MA(4)=-0.999970306]*

Step 2. Commercial software MATLAB is used in order to create ANN model. Before the input and output matrices are constructed, the data obtained from the ARIMAX model was applied (-1,1) normalization, other explanatory variables are (0,1) normalization. We run the proposed model for different number of hidden layer neurons in order to reach maximum R. R value is obtained as 0.99806, 093022, 0.97011 for training and validation and test respectively. The validation performance and regression plot of the best network are presented in Figure 3. MAPE calculated to measure the performance of the generated ARIMAX-ANN model.

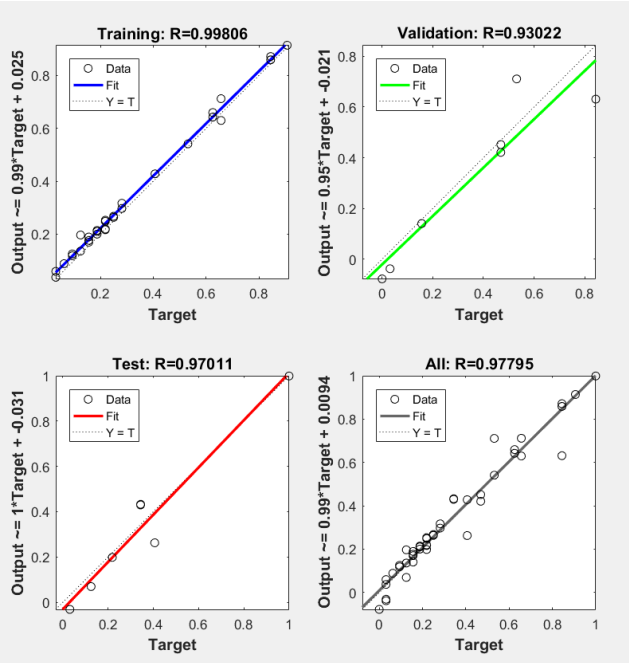


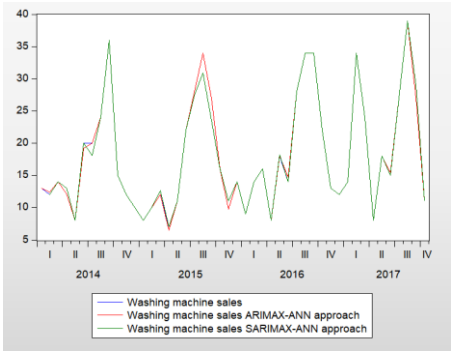
Figure 3. The validation performance and regression plot

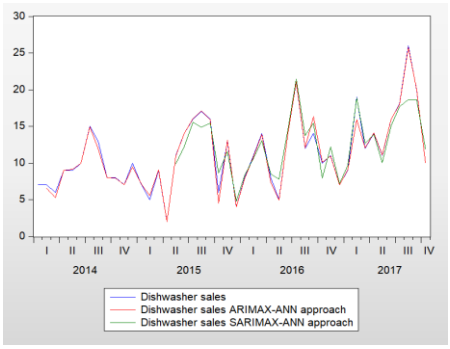
The white goods sector is affected by many parameters and it is difficult to determine the relationship between these parameters. Seasonal effects are observed when we examine the input and output variables. Therefore, using the SARIMAX method, which includes seasonal effects in the ARIMAX method, is thought to yield effective results.

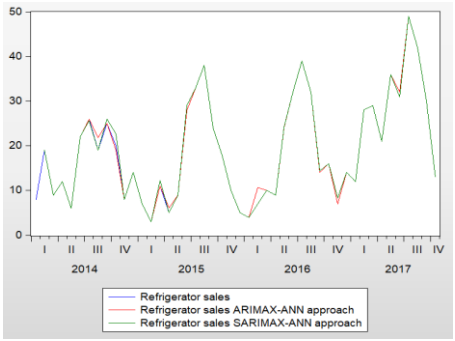
The SARIMAX method also succeeds in expressing non-linear relationships such as the ARIMAX method. Therefore, hybridizing the ANN method with the SARIMAX method will provide better estimation results. As in ARIMAX-ANN method, SARIMAX model is created first in this SARIMAX-ANN method. Residuals obtained from the SARIMAX model are used as input variable for ANN model. In Figure 4. The estimated value with the actual value of the products shown on the graph.

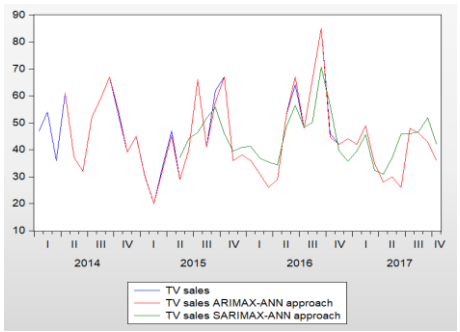
Based on the estimated parameters, ARIMAX model equation can be written to predict washing machine sales as follows:

LOG(Washing machine) = 1.90225538667 - 0.124961170555 JANUARY + 0.38665957494* FEBRUARY + .368521898449* MARCH - 0.23064972071* APRIL + 0.224931919837* MAY + 0.511885944527* JUNE + 0.936238402964* JULY + 1.09426747423* AUGUST + 1.08761440078* SEPTEMBER + 0.427318974808* OCTOBER + 0.0717717225766* NOVEMBER + 1.98254116537e-06* H - 0.00840353367726* V + 1.08272536705*DO + 0.0324996242461* CCI - 0.0176163010541* PPI + [MA(1)=-0.0377783175763,MA(2)=-3.06356361184e-07,MA(3)=0.0377782025177,MA(4)=-0.99999770306*









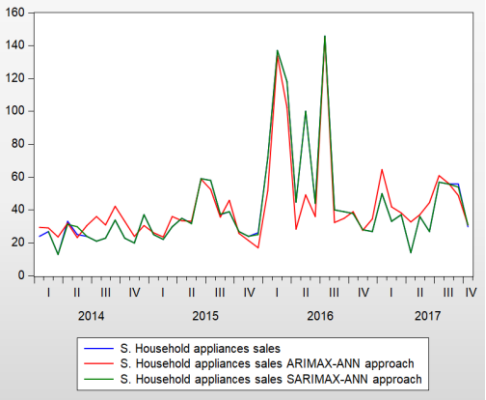


Figure 4. Comparison of actual and forecasted sales of products

MAPE values are calculated after all sales are forecasted with ARIMAX, SARIMAX, ARIMAX-ANN and SARIMAX-ANN methods. MAPE is a measure of performance in forecasted models. Accuracy is increasing as the MAPE value decreases. The MAPE calculated for all products is shown in Table 3.

Table 3. MAPE values for all products with respect to five methodologies

MAPE (%) value	ARIMAX (Yucesan, 2018)	ANN (Yucesan, 2018)	SARIMAX	ARIMAX-ANN	SARIMAX-ANN
Washing machine	17,63	7,70	16,57	0,89	1,04
Dishwasher	29,32	9,00	26,42	2,90	11,40
Refrigerator	40,75	15,10	40,66	2,40	1,19
TV	17,04	5,80	14,10	0,57	17,43
S. Household appliances	34,48	11,70	48,76	21,30	0,85

IV. Conclusion

Forecasting is to estimate the value of an unknown parameter using the known parameters for a future state. It is necessary to carry out an effective sales forecasting in order to achieve powerful production planning. In this respect, sales forecasting plays a key role in the success of business enterprises.

As far as we know, there is no sales forecast for the white goods sector in the literature. This study will be the first to guide the other studies. The sales of a district dealer; refrigerators, washing machines, dishwashers, televisions and small home appliances is used between 2014-2017. PPI, CCI, dollar exchange rate, holidays and

residential sales are considered to have an impact on white goods sales. Therefore, these variables are used as explanatory variables.

In this study, it is aimed to forecast the sales of white goods with the hybrid methods ARIMAX-ANN and SARIMAX-ANN. MAPE values, which are the performance criterion of all methods, are calculated. When we compare the MAPE for each model, it can be understood that using ARIMAX, SARIMAX and ANN method alone did not give satisfactory results. This result shows us that sales of white goods have included linear and non-linear patterns. It has been determined that hybrid methods for the white goods sector give better results than other single methods. Sales of dishwashers, TVs and washing machines do not include seasonal patterns so the use of the ARIMAX method in sales forecasting of these products allows better estimation than using the SARIMAX method. SARIMAX models regarding sales of small household appliances and refrigerators result in better accuracy. This shows that these products include seasonal patterns.

Our work has some limitations. Firstly, the last 46-month data is used for sales forecasts. More observations are needed to make a more accurate prediction. Secondly, the lack of data held on a regional basis has led to insufficient explanatory variables. There may be other important factors we have not taken into consideration. Thirdly, performance of these forecast models has only been tested on a white goods wholesaler. More white goods vendors should be added to study to gain a more general judgment on the performance of forecast models.

Referances

Aburto, L., & Weber, R. (2007). A sequential hybrid forecasting system for demand prediction. Machine Learning and Data Mining in Pattern Recognition, 518-532.

Alon, I,; Qi, M,; Sadowski, R. J. 2001: Forecasting aggregate retail sales: A comparison of artificial neural networks and traditional methods. Journal of retailing and consumer services, 8(3): 147-156

Alptekin, N. (2010). Analitik ağ süreci yaklaşımı ile Türkiye'de beyaz eşya sektörünün pazar payı tahmini

Anggraeni, W., Vinarti, R. A., & Kurniawati, Y. D. (2015). Performance Comparisons Between Arima and Arimax Method in Moslem Kids Clothes Demand Forecasting: Case Study. Procedia Computer Science, 72, 630-637.

Areekul, P., Senjyu, T., Toyama, H., & Yona, A. (2010). Notice of violation of IEEE publication principles a hybrid ARIMA and neural network model for short-term price forecasting in deregulated market. IEEE Transactions on Power Systems, 25(1), 524-530.

Armstrong J. Scott, (2001), ―Combining Forecasts. Principles of Forecasting‖, A Handbook for Researchers and Practitioners, Norwell, MA: Lower Academic Publishers.

Arunraj, N. S., & Ahrens, D. (2015). A hybrid seasonal autoregressive integrated moving average and quantile regression for daily food sales forecasting. International Journal of Production Economics, 170, 321-335.

Arya, P.; Paul, R. K.; Kumar, A.; Singh, K. N.; Sivaramne, N.; Chaudhary, P., 2015: Predicting pest population using weather variables: an ARIMAX time series framework. International Journal of Agricultural and Statistics Sciences, 11(2), 381-386.

Bierens, H. J. (1987). ARMAX model specification testing, with an application to unemployment in the Netherlands. Journal of Econometrics, 35(1), 161-190.

Chang, P. C., & Lai, K. R. (2005, May). Combining SOM and fuzzy rule base for sale forecasting in printed circuit board industry. In International Symposium on Neural Networks (pp. 947-954). Springer, Berlin, Heidelberg.

Díaz-Robles, L. A., Ortega, J. C., Fu, J. S., Reed, G. D., Chow, J. C., Watson, J. G., & Moncada-Herrera, J. A. (2008). A hybrid ARIMA and artificial neural networks model to forecast particulate matter in urban areas: The case of Temuco, Chile. Atmospheric Environment, 42(35), 8331-8340. Economics, 43(2), 175-192.

Doganis, P., Aggelogiannaki, E., & Sarimveis, H. (2008). A combined model predictive control and time series forecasting framework for production-inventory systems. International Journal of Production Research, 46(24), 6841-6853.

Espinoza, M., Joye, C., Bemans, R., De Moor, B., 2005. Short-term load forecasting, profile identification and customer segmentation: A methodology based on periodic time series. IEEE Transactions on Power Systems 20 (3), 1622–1630.

EViews 10 tutorial. (2017). http://www.eviews.com/Learning/basics.html, access (26.03.2018)

Gahirwal, M. (2013). Inter Time series sales forecasting. arXiv preprint arXiv:1303.0117.

Gilliland, M., & Sglavo, U. (2010). Worst Practices in Business Forecasting. Analytics, 12–17.

Gul, M., & Guneri, A. F. (2016). Planning the future of emergency departments: Forecasting ED patient arrivals by using regression and neural network models. International Journal of Industrial Engineering, 23(2), 137-154.

Hahn, H., Meyer-Nieberg, S., & Pickl, S. (2009). Electric load forecasting methods: Tools for decision making. European journal of operational research, 199(3), 902-907.

Herbig, P. a., Milewicz, J., & Golden, J. E. (1993). The do's and don'ts of sales forecasting. Industrial Marketing Management, 22(1), 49–57.

Karaatlı, M., Helvacıoğlu, Ö. C., Ömürbek, N., & Tokgöz, G. (2012). Yapay Sinir Ağları Yöntemi İle Otomobil Satış Tahmini. Uluslararası Yönetim İktisat ve İşletme Dergisi, 8(17), 87-100.

Murlidharan, V., & Menezes, B. (2013). Frequent pattern mining-based sales forecasting. Opsearch, 50(4), 455-474.

Ni, Y., & Fan, F. (2011). A two-stage dynamic sales forecasting model for the fashion retail. Expert Systems with Applications, 38(3), 1529-1536.

Qin, L. X., & Shi, Z. Z. (2006). Efficiently mining association rules from time series. International Journal of Information Technology, 12(4), 30-38.

Ramos, P., Santos, N., & Rebelo, R. (2015). Performance of state space and ARIMA models for consumer retail sales forecasting. Robotics and computer-integrated manufacturing, 34, 151-163.

Republic of Turkey Prime Ministry Investment Support and Promotion Agency, 2010, Turkey and Electronic Appliances Sector Report retrieve from: ww.iso.org.tr/file/BEYAZ.ESYA.ELEKTRONIK.SEKTORU_INVEST-469.pdf

Shukla, M., & Jharkharia, S. (2013). Applicability of ARIMA models in wholesale vegetable market: an investigation. International Journal of Information Systems and Supply Chain Management (IJISSCM), 6(3), 105-119.

Stevenson, W. J., & Hojati, M. (2007). Operations management (Vol. 8). Boston: McGraw-Hill/Irwin.

Suhartono, L. MH, & Prastyo, DD,(2015),"Two levels ARIMAX and Regression Models for Forecasting Time Series Data with Calendar Variation Effects". In AIP Conference Proceedings (Vol. 1691, p. 050026).

Sutthichaimethee, P., & Ariyasajjakorn, D. (2017). Forecasting energy consumption in short-term and long-term period by using arimax model in the construction and materials sector in thailand. Journal of Ecological Engineering, 18(4).

Yucesan, M., Gul, M., & Celik, E. (2017). Application of Artificial Neural Networks Using Bayesian Training Rule in Sales Forecasting for Furniture Industry. Wood Industry/Drvna Industrija, 68(3).

YÜCESAN, M. (2018). YSA, ARIMA ve ARIMAX Yöntemleriyle Satış Tahmini: Beyaz Eşya Sektöründe bir Uygulama. J Bus Res Turk, 10(1), 689-706.

Zhang, G. P. (2003). Time series forecasting using a hybrid ARIMA and neural network model. Neurocomputing, 50, 159-175.