Acta logistica - International Scientific Journal about Logistics
Volume: 6 2019 Issue: 2 Pages: 35-41 ISSN 1339-5629

doi:10.22306/al.v6i2.117

Received: 05 Mar. 2019
Accepted: 02 Apr. 2019

RAW MATERIALS INVENTORY MODEL APPLIED BY REGIONAL ENTERPRISES OF THE INDUSTRIAL CLUSTER

Olga Mihailovna Perminova
Kalashnikov Izhevsk State Technical University, 7 Studencheskaya St., Izhevsk, 426069, Udmurt republic, Russian Federation, olgaa@istu.ru (corresponding author)

Galina Anatolievna Lobanova
Kalashnikov Izhevsk State Technical University, 7 Studencheskaya St., Izhevsk, 426069, Udmurt republic, Russian Federation, gallobanova@mail.ru

Rinat Vasilovich Faizullin
Kalashnikov Izhevsk State Technical University, 7 Studencheskaya St., Izhevsk, 426069, Udmurt republic, Russian Federation, rf85@mail.ru

Keywords: regional industrial cluster, raw materials inventory, inventory control, mathematical model

Abstract: For the effective functioning of the industrial enterprises and optimization of the production capacities it is necessary to predict the optimum inventory level of a production line on the basis of logistical approaches and studying the demand for products. Studies were conducted using the example of one industrial enterprise from the Udmurt Republic and there was proposed the inventory control model with the help of exponential smoothing and confidence interval.

1 Introduction

In the constantly changing business environment there is a need for implementation of logistical approaches for managing cluster formations. In Russia there is a great interest in clusters as the mechanism of regional development [1-3]. Today there is a growing need for logistic management approach implementation [4]. The formation of the regional industrial cluster in the Udmurt Republic makes it possible to consider federal and regional interests in addressing problems of military-industrial complex, filling idle capacities and preserving employment [5].

2 Technique of inventory control model development applied by the regional industrial cluster

Different resources are needed for the continuous production of innovative products: the metal of certain grade, hard alloy, labour power, electricity and other resources. This involves significant financial cost, because raw materials must be purchased and stored somewhere. Consequently, there is a need for the proper management of raw materials inventory control system, which will help to reduce production costs and release some working capital. There is data on the demand for the enterprise products in 2017-2018 (Table 1, Figure 1).

Table 1 Data on the demand for the products of the regional enterprise belonging to the industrial cluster in the Udmurt Republic

Date	01.2017	02.2017	03.2017	04.2017	05.2017	06.2017	07.2017	08.2017
Demand volume	260	300	290	310	270	250	290	280
Date	09.2017	10.2017	11.2017	12.2017	01.2018	02.2018	03.2018	04.2018
Demand volume	320	300	280	290	270	280	300	310
Date	05.2018	06.2018	07.2018	08.2018	09.2018	10.2018	11.2018	12.2018
Demand volume	280	300	270	260	290	310	300	290

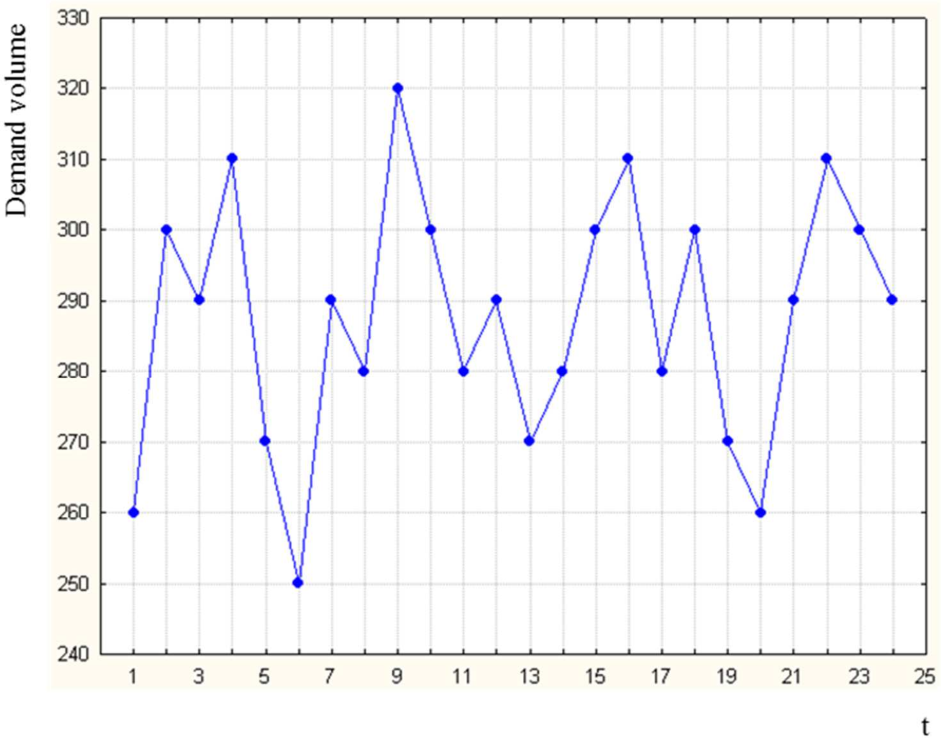

Figure 1 The demand chart for the products of the regional enterprise belonging to the industrial cluster in the Udmurt Republic

Before developing the control system for raw materials inventory, it is necessary to choose one of the factors determining the volume of raw material stocks, which will be used in the analysis. The main indicator that determines the volume of raw material stocks is the volume of the demand for manufactured products. In our case, the demand can be considered to be a random value.

It should also be noted that not the current level of demand, but its predicted value plays an important role in deciding volume of raw materials stocks. Therefore, it is necessary to predict the volume of the demand for products at least for one period of time ahead, based on the available data on the demand volume for several previous periods.

One of the most popular methods for time series analysis is exponential smoothing (in our case, demand values are linked to the periods of time, which means they can be considered as the time series).

A simple time series model is designed according to the following formula (1):

$$x_t = b + \varepsilon_t \tag{1}$$

Where b - constant and ε_t - accidental error.

The b constant is relatively stable at every period of time, but may also change slowly over time. One of the clear ways to distinguish b is to use moving average smoothing, in which weights applied to each of the past observations decrease exponentially.

Simple Exponential Smoothing is designed in such a way that weighting factors decrease exponentially, but unlike moving average all past observations are considered.

The formula of Simple Exponential Smoothing is as follows (2):

$$S_t = aX_t + (1-a)S_{t-1} \tag{2}$$

When this formula is calculated recursively, then each new smoothed value (which is also a prediction) is calculated as a weighted average of the current and smoothed time series. It is clear that the result of the smoothing depends on the parameter (alpha). If α = 1, then the past observations are completely ignored. If α = 0, then the current observations are ignored. Values ofαbetween 0 and 1 can show intermediate results. Empirical studies have shown that very often simple exponential smoothing can give a fairly accurate prediction [6].

We will use the software product «Statistica 6» developed by StatSoft Inc. to forecast values of the demand.

We will use values of the demand level in 2017 as the baseline data. Firstly, we will predict the demand value in January 2018. After that, we will have not 12, but 13 values, and we will predict the 14th and so on by the 24th (December 2018). In the future, these data will help us in drawing up a plan for the raw materials purchase. Initial data are shown in Figure 2.

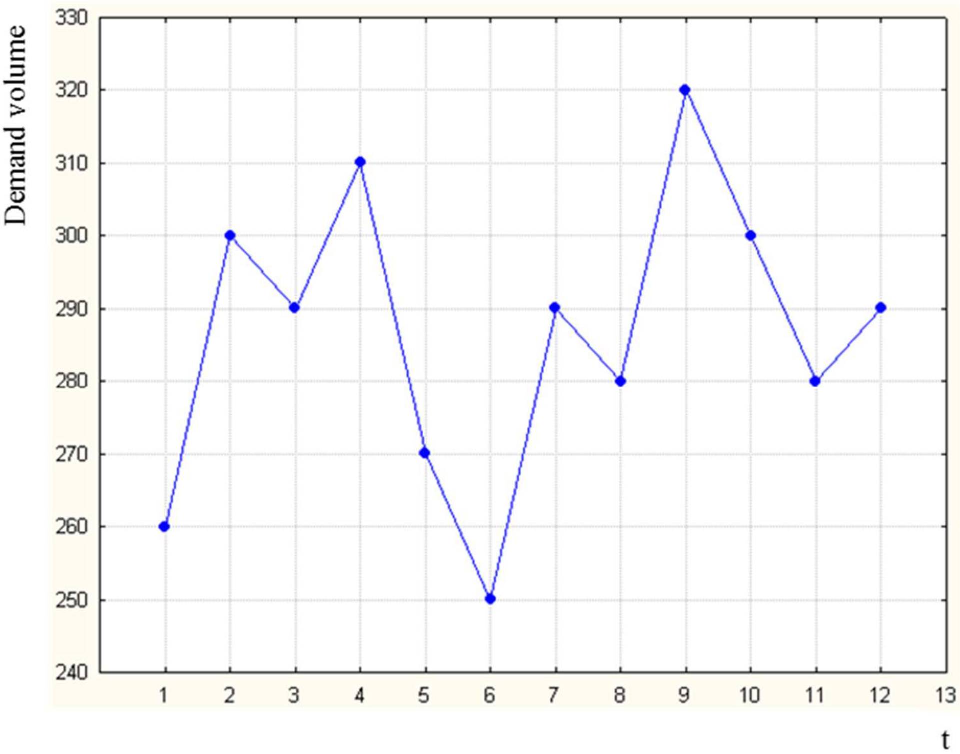

Figure 2 The demand volume for the products of the regional enterprise belonging to the industrial cluster in the Udmurt Republic

The chart shows that the time series doesn't have upward trend or down trend, or seasonality, therefore for our prediction we will use exponential smoothing without consideration of trend or seasonality factors.

There are following results made by the program after data entry and doing calculations (Figures 3 and Table 2).

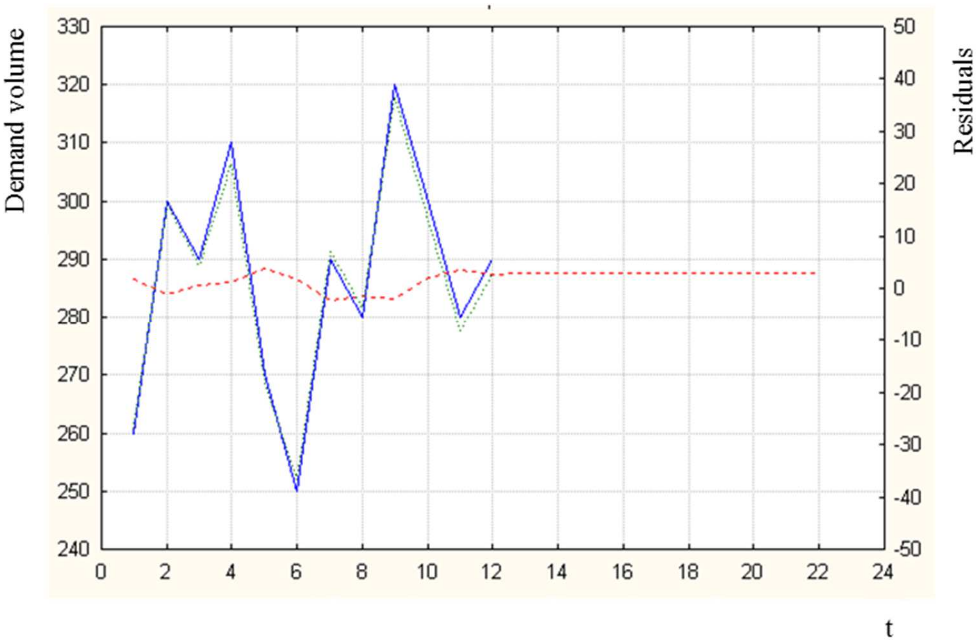

Figure 3 Exponential smoothing of the dynamic demand relations from a time series

Table 2 Values of the smoothed and residuals series

Observations	Y	Smoothed series	Residuals series
1	260	286,6667	-26,6667
2	300	284,0000	16,0000
3	290	285,6000	4,4000
4	310	286,0400	23,9600
5	270	288,4360	-18,4360
6	250	286,5924	-36,5924
7	290	282,9332	7,0668
8	280	283,6398	-3,6398
9	320	283,2759	36,7241
10	300	286,9483	13,0517
11	280	288,2543	-8,2543
12	290	287,4281	2,5719
		287,6853	

According to the results, a number of past observations is more significant for the prediction than the current value of the indicator (α = 0.1). And the most important thing in these results is the predicted value of the demand equal to 287.6853.

In this case, it is about the number of ordered items, and it cannot be a fractional value, therefore, the number 287.6853 needs to be rounded to the whole, thus, the predicted demand value is 288 units. However, this number cannot satisfy us either, since there's a 50% chance that the demand value will exceed 287.6853 and the same chance that it will not.

To fill this knowledge gap we have to produce a confidence interval for the prediction. We will use the 95% confidence interval. This means that there is a 95% probability that the demand value in a future period lies within the interval.

According to the residuals chart data (Figure 4), it can be concluded that the residuals are normally distributed, which allows us to apply «Student's t-Distribution Table» for confidence limit calculating.

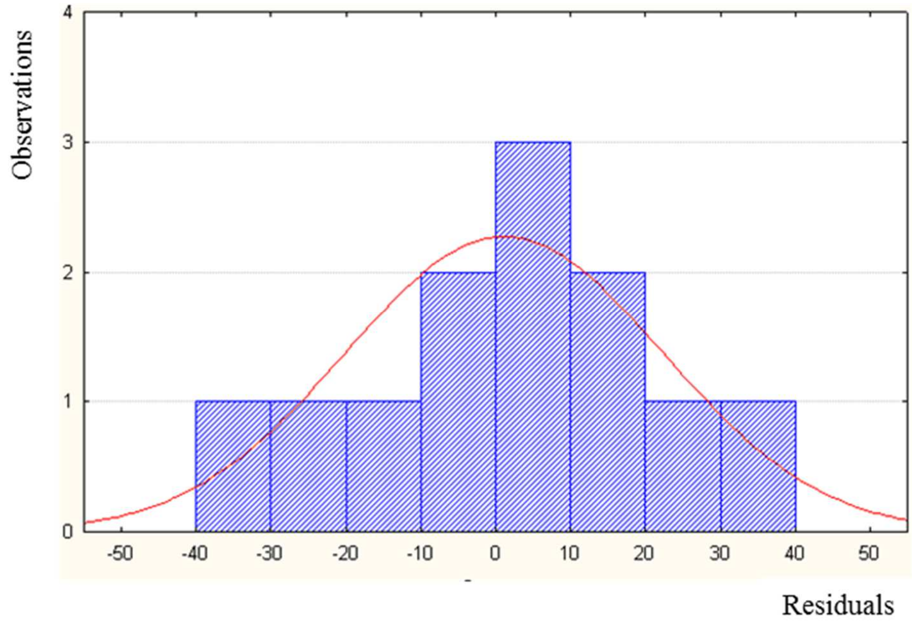

Figure 4 The residuals chart data

The confidence interval for the prediction is calculated as follows (3):

$$S_{t+1} = S_t \pm t_{\beta,p} S \sqrt{1 + \frac{\alpha}{2-\alpha}} \quad (3)$$

where:
S_{i+1} - predicted value,
S_i - latest calculated value,
$t_{\beta,p}$ - value from the Student's table at significance level β and p degrees of freedom,
p = n– 1, n–number of observations,
S – standard deviation (4),
α – smoothing constant.

$$S = \sqrt{\frac{\sum_{t=1}^{n}(X_t - S_t)}{n-1}} \quad (4)$$

where:
X_t - observing value.

Calculation data for 12 observations are as follows:

S_t = 287;
t = 12;
β = 0,05;
p = 11;
$t_{\beta,p}$ = 2,201;
S = 21,1.

The confidence interval for the prediction:

$$S_{13} = 287 \pm 2{,}201 \cdot 21{,}1 \cdot \sqrt{1 + \frac{0{,}05}{2 - 0{,}05}} = 287 \pm 46{,}9$$

But since the quantity of products must be a whole number:

$$S_{13} = 287 \pm 47$$

For studying application, the model, we will use the data on demand for products in 2017-2018. Provided that 1 billet is needed for every product manufacturing, we can use data of the Table 1 as the level of raw materials costs needed for every product manufacturing in 2017-2018.

Let us calculate the level of raw materials which are required for other months in 2018. The results are shown in Table 3.

Table 3 Calculated level of required raw materials

Date	01.2018	02.2018	03.2018	04.2018	05.2018	06.2018
Raw materials, pcs.	305	304	303	304	306	305
Date	07.2018	08.2018	09.2018	10.2018	11.2018	12.2018
Raw materials, pcs.	306	305	304	304	305	305

Now, when we have the data on the required volume of raw materials stocks, as well as actual data on the volume of raw materials in the enterprise (Table 4), we can assess the effectiveness of the models under consideration.

Table 4 The level of raw materials stocks at the beginning of the month (actual data)

Date	01.2018	02.2018	03.2018	04.2018	05.2018	06.2018
Amount of stock	740	850	1090	790	480	950
Date	07.2018	08.2018	09.2018	10.2018	11.2018	12.2018
Amount of stock	870	780	720	990	980	900

Table 5 shows actual data on the raw materials stocks replenishment at the enterprise in 2018.

On the whole, in 2018 the company purchased 3,330 units of raw materials.

Let us consider how would the structure of the replenishment of raw materials stocks look like, if the enterprise applied cost prediction model on the basis of exponential smoothing (Table 6).

If the enterprise applied this model, then in 2018 they would have purchased 2758 units of raw materials, and the demand would be satisfied. And finally, Table 7 shows the data on the structure of the raw materials stocks replenishment when using Brown's Exponential Smoothing model.

Negative values in the "Residuals" column indicate the level of unmet need for raw materials.

If the enterprise used this model, then 2723 units of raw materials would have been purchased in 2018, while in April and October the company would not have been able to meet the demand due to the fact that the predicted level of the demand for the products (raw materials costs) happened to be less than the actual.

Table 5 The structure of the raw materials stocks replenishment

Date	Inventory at the beginning of the month	Purchase	Actual expenses	Residuals
01.2018	740	380	270	850
02.2018	850	520	280	1090
03.2018	1090	0	300	790
04.2018	790	0	310	480
05.2018	480	750	280	950
06.2018	950	220	300	870
07.2018	870	180	270	780
08.2018	780	200	260	720
09.2018	720	560	290	990
10.2018	990	300	310	980
11.2018	980	220	300	900
12.2018	900	0	290	690

Table 6 The results of applying cost prediction model on the basis of exponential smoothing

Date	Inventory at the beginning of the month	Cost prediction	Purchase	Actual expenses	Residuals
01.2018	740	334	0	270	470
02.2018	470	333	0	280	190
03.2018	190	329	139	300	29
04.2018	29	328	299	310	18
05.2018	18	330	312	280	50
06.2018	50	331	281	300	31
07.2018	31	329	298	270	59
08.2018	59	330	271	260	70
09.2018	70	330	260	290	40
10.2018	40	326	286	310	16
11.2018	16	326	310	300	26
12.2018	26	328	302	290	38

Table 7 The data on the structure of the raw materials stocks replenishment when using Brown's Exponential Smoothing model

Date	Inventory at the beginning of the month	Cost prediction	Purchase	Actual expenses	Residuals
01.2018	740	305	0	270	470
02.2018	470	304	0	280	190
03.2018	190	303	113	300	3
04.2018	3	304	301	310	-6
05.2018	0	306	306	280	26
06.2018	26	305	279	300	5
07.2018	5	306	301	270	36
08.2018	36	305	269	260	45
09.2018	45	304	259	290	14
10.2018	14	304	290	310	-6
11.2018	0	305	305	300	5
12.2018	5	305	300	290	15

3 Conclusion

According to the results of calculations, the model developed on the basis of logistic approaches leads to cost reduction, prevents the possibility of unmet demand, which in the future can lead to a decrease in the number of customers, and that will reduce the profit of the regional industrial cluster in the Udmurt Republic.

Therefore, when developing the inventory control structure in the production of innovative products by enterprises of the regional industrial cluster in the Udmurt Republic, we should use the model which is based on predictions with the applying of exponential smoothing and confidence intervals.

References

[1] LOBANOVA, G.A.: *Formation and development of clusters in the economy*, Vestnik IZHGTU – Izhevsk, pp. 71-75, 2014. (Original in Russian)

[2] LOBANOVA, G.A., GAMBURG, K.A.: *Analysis of Economical Clusters Formation in Russia,* Third Forum of Young Researchers in the framework of International Forum "Education Quality - 2012", Izhevsk: Publishing House of ISTU, pp. 444, 2012.

[3] PERMINOVA, O., PRAJOVA, V., FAIZULLIN, R.: Principles of organizations' interaction while forming mechatronics specialists' professional competences in a regional industry cluster, *Procedia Engineering,* Vol. 96, pp. 370-373, 2014.

[4] PERMINOVA, O.M., LOBANOVA, G.A: A logistic approach to establishing balanced scorecard of Russian oil-producing service organizations, *Acta logistica,* Vol. 5, No. 1, pp. 1-6, 2018. doi:10.22306/al.v5i1.83

[5] PERMINOVA, O.M.: *Personality innovation and educational potential is the basis of regional labour potential*, Vestnik IZHGTU – Izhevsk, pp. 101-103. 2018. (Original in Russian)

[6] ZAKHARCHENKO, N.I.: Biznes-statistika I prognozirovanie v MS Excel, Business statistics and forecasting in MS Excel, N. I. Zakharchenko, Moscow, pp. 208, 2004. (Original in Russian)

Review process

Single-blind peer review process.