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Applying Econometric Modelling of Time Series for Analysis and Making Product Cost Forecasts (by the Example of NE «LRP “MOTOR”»)

In the article, we researched dynamic series of product cost using the reporting data of the NE «LRP “Motor”. We suggest applying econometric modelling inasmuch as it can help conduct the complex analysis not only in short periods, but also in the large scope dynamics. In our opinion, implementing this method will give an opportunity to make effective trend forecasts and thus, provide accurate analytical maintenance for the enterprise in the field of product costing. Article has both scientific and high practical value.

Key words: time series, econometric modelling, product costing, analytical smoothing, seasonal components, moving average.

Formulation of Scientific Problem and its Significance. Product cost calculation process is one of the key factors on the way to the attaining a successful enterprise activity, providing high level of its profitability, pricing strategy and competitiveness of goods and services enterprise produce. Taking into account this fact, arises the necessity to make cost forecasts based on the econometric modelling of time series. This method is one of the most effective among the others, because gives an opportunity to analyze the data in the dynamics and to research season components and factors of influence on the determined indices. As the example it was chosen the dynamics of the product costing on the National Enterprise «Lutsk Repair Plant “Motor”» (NE «LRP “Motor”») as one of the most successful and competitive enterprises in the sphere of high technological aircraft industry. This research describes a complex approach to the problem, has scientific and practical value, because it can help enterprises of Ukraine not to lose profit and reduce extra spending by the means of analytic forecasting, hence, this article is very actual.

Analysis of Last Researches and Publications. A problem of cost forecasting has been developed in the scientific works and publications of such Ukrainian and foreign authors, as Robert Fildes, N. Chumachenko, I. Basmanov, Napadovska L., A. Upchurch, K. Druri, S. Rollins, Y.Tsal-Tsalka, Y. Sokolov, A. Shegda, O. Oliynik and others.

Analysis of the literature indicates that the weight of previous studies of the issues related specification of trend forecasting and the peculiarities of the product costing on the repair and aircraft enterprises are been studied insufficiently. Incomplete research in the context of these aspects determines the relevance of this topic.

The Purpose and Objectives of the Article. The main purpose of the research is improving analytical maintenance of product costing on the aircraft enterprises and providing the scientific econometric background on the issue of cost forecasting. Among the most important objectives, we can determine as follows: analyzing product cost time series by the analytical smoothing method, evaluation of season components, eliminating its impact and modelling the cost trend equation and graph, this way showing the tendency of quarter fluctuations of the product cost on the NE «LRP “Motor”».

Statement of the Main Material and Substantiation Researched Results. Cost of products (works, services) – is expressed in a monetary form operating costs on its production [2, p. 365].

Cost is one of the key indicators of the company activities, which describes the essence of the resources used, the level of technical development, management excellence and, consequently, largely determines the final results of the company, such as: revenue and profitability [1, p. 81].

On the researched company NE «LRP “Motor”» among the main activities there are: capital repairs, reconstruction and maintenance of aircraft engines and its components and assemblies and other repairs; manufacture of parts and components for aircraft and other equipment for military and civil purposes. This company is a leader on the market both in Ukraine and in foreign markets; particularly an enterprise exports products and provides services for the engine overhaul to such countries as: Poland, Belarus, Kazakhstan, Azerbaijan, China, Vietnam, Malaysia, Bangladesh, Indonesia, the USA, India, Sudan, Ethiopia, Venezuela, Eritrea, Angola, Myanmar, Yemen.

NE «LRP “Motor”» uses job-order costing method for calculation of the product cost, which implies grouping the cost for making separate orders of the product. That is the subject of cost accounting in this method is a special order. Cost calculation of the completed product is made only after the full execution and completion of the orders, regardless of the duration of its implementation. Until the order will have been completed, all costs would be related to the work-in-process [6, p. 72–73].

To provide a successful operation of the enterprise arises a necessity in making cost forecasting. Currently on the NE «LRP “Motor”» is being performed simple vertical or horizontal analysis that cannot provide researching large time series in the dynamics of more than 3 periods. We suggest applying such econometric methods as time series modelling, for the large amount of data need to be analyzed. By doing this we can build cost trend showing tendency for the 5 years period and make a forecast for the analogic period in the future.

The time series models are often described by such equation:

$$y_t = f(t) + \varepsilon_t,$$

where $f(t)$ – nonrandom component (trend (T), or trend and cyclical (C) and (or) seasonal component (S), describes main tendency), ε_t – random component.

This method supposes analytical smoothing of the time series. Time series smoothing implies the selection random component that characterizes the basic trend of studied process, and the selection of this function.

The concept «analytical time series smoothing» implies the allocation of non-random component $f(t)$, which describes the basic trend of studied process, and the selection of this function that characterizes a dependence of levels series from the time or trend. As dependence on time can take many forms, for its formalization can use different types of functions. In our research, we will build a linear function $T = a_0 + a_1t$.

There are several approaches to the analysis of time series structure containing seasonal or cyclical fluctuations [4, p. 239]. The simplest approach – Calculation of seasonal components by the sliding average. We will build additive model trend of seasonal time series. The process of building model includes the following steps.

Aligning the initial series by moving average (table 1) according to the quarterly data.

Table 1

Calculation of Seasonal Components Estimates

Years	№ of quarter, t	Cost, y_t	Moving average of 4 quarters	Centered moving average	Estimate of seasonal component
2011	1	9514,00	-	-	-
	2	16325,00	18715,50	-	-
	3	23074,00	18944,00	18829,75	-8401,75
	4	25949,00	22413,00	20678,50	9522,50
2012	5	10428,00	22431,25	22422,13	724,88
	6	30201,00	37255,25	29843,25	55401,75
	7	23147,00	40950,50	39102,88	-13893,90
	8	85245,00	36646,25	38798,38	-25814,40
2013	9	25209,00	37321,25	36983,75	-11136,80
	10	12984,00	24984,75	31153,00	4746,00
	11	25847,00	26888,00	25936,38	6885,63
	12	35899,00	28184,00	27536,00	-9368,00
2014	13	32822,00	30621,25	29402,63	6193,38
	14	18168,00	43891,50	37256,38	51723,63
	15	35596,00	40508,25	42199,88	-22910,90
	16	88980,00	45284,75	42896,50	-5622,50
2015	17	19289,00	53817,00	49550,88	20174,13
	18	37274,00	45051,25	49434,13	4482,88
	19	69725,00	-	-	-
	20	53917,00	-	-	-

Source. Developed by the authors according to the data [5].

Estimating seasonal component values (table 2).

Table 2

Calculation of Seasonal Components in the Additive Model

№	Index	Year	№ of quarter, <i>i</i>			
			I	II	III	IV
1	-	1			-8401,75	9522,50
2	-	2	724,88	55401,75	-13893,90	-25814,40
3	-	3	-11136,80	4746,00	6885,63	-9368,00
4	-	4	6193,38	51723,63	-22910,90	-5622,50
5	-	5	20174,13	4482,88	-	-
6	In total by <i>i</i> -quarter (the sum of all the years)	x	15955,59	116354,26	-38320,92	-31282,40
7	Mean estimator of seasonal component by <i>i</i> -quarter	x	3988,90	29088,57	-9580,23	-7820,60
8	Adjusted seasonal component, S_{ci}	x	69,74	25169,41	-13499,39	-11739,76

Source. Developed by the authors according to the data [5].

The adjustment coefficient equals:

$$k = 3919,16.$$

And calculated values of seasonal components are:

I quarter: $S_1=69,74$;

II quarter: $S_2= 25169,41$;

III quarter: $S_3=-13499,39$;

IV quarter: $S_4=-11739,76$.

The sum of the seasonal components values equals zero: $\sum S_{ci} = 0$.

The obtained values S_{ci} for the corresponding quarters of each year are shown in the table 2.

Eliminating the impact of seasonal components of the input number of levels and retaining aligned data ($T + \varepsilon$) in additive model (table 3).

Table 3

Calculation of Aligned T Values and ε Errors in the Additive Model

№ of quarter, <i>t</i>	Cost, <i>y_t</i>	S_{ci}	$y_t - S_{ci} = T + \varepsilon$	T	$T + S_{ci}$	$\varepsilon = y_t - (T + S_{ci})$	ε^2
1	2	3	4	5	6	7	8
1	9514,00	69,74	9444,26	15847,60	15917,34	-6403,34	41002763,16
2	16325,00	25169,41	-8844,41	17756,20	42925,61	-26600,61	707592452,37
3	23074,00	-13499,39	36573,39	19664,80	6165,41	16908,59	285900415,79
4	25949,00	-11739,76	37688,76	21573,40	9833,64	16115,36	259704827,93
5	10428,00	69,74	10358,26	23482,00	23551,74	-13123,74	172232551,59
6	30201,00	25169,41	5031,59	25390,60	50560,01	-20359,01	414489288,18
7	23147,00	-13499,39	36646,39	27299,20	13799,81	9347,19	87369960,90
8	85245,00	-11739,76	96984,76	29207,80	17468,04	67776,96	4593716306,84
9	25209,00	69,74	25139,26	31116,40	31186,14	-5977,14	35726202,58
10	12984,00	25169,41	-12185,41	33025,00	58194,41	-45210,41	2043981172,37
11	25847,00	-13499,39	39346,39	34933,60	21434,21	4412,79	19472715,58

End of table 3

1	2	3	4	5	6	7	8
12	35899,00	-11739,76	47638,76	36842,20	25102,44	10796,56	116565707,83
13	32822,00	69,74	32752,26	38750,80	38820,54	-5998,54	35982482,13
14	18168,00	25169,41	-7001,41	40659,40	65828,81	-47660,81	2271552809,86
15	35596,00	-13499,39	49095,39	42568,00	29068,61	6527,39	42606820,21
16	88980,00	-11739,76	100719,76	44476,60	32736,84	56243,16	3163293046,79
17	19289,00	69,74	19219,26	46385,20	46454,94	-27165,94	737988296,08
18	37274,00	25169,41	12104,59	48293,80	73463,21	-36189,21	1309658920,42
19	69725,00	-13499,39	83224,39	50202,40	36703,01	33021,99	1090451823,56
20	53917,00	-11739,76	65656,76	52111,00	40371,24	13545,76	183487613,98

Source. Developed by the authors according to the data [5].

Then we accomplish analytical smoothing of $(T + \varepsilon)$ levels and calculate values T using the equation trend.

$$T = a_0 + a_1 t.$$

Thus, to determine the parameters of a linear trend we should solve a system of equations:

$$\begin{cases} na_0 + a_1 \sum t = \sum y \\ a_0 \sum t + a_1 \sum t^2 = \sum ty. \end{cases}$$

From which determine:

$$a_1 = \frac{\overline{ty} - \bar{t} \cdot \bar{y}}{\overline{t^2} - \bar{t}^2}; a_0 = \bar{y} - a_1 \cdot \bar{t}.$$

To simplify the calculations we compile the table 4.

Table 4

Initial Data for Calculating the Linear Trend

№ i/o	№ of quarter, t	$y_t - S_{ci} = T + \varepsilon$	t^2	$(T + \varepsilon)^2$	$(T + \varepsilon) \cdot t$	T
1	2	3	4	5	6	7
1	1	9444,26	1	89194046,95	9444,26	15847,60
2	2	-8844,41	4	78223588,25	-17688,82	17756,20
3	3	36573,39	9	1337612856,09	109720,17	19664,80
4	4	37688,76	16	1420442630,34	150755,04	21573,40
5	5	10358,26	25	107293550,23	51791,3	23482,00
6	6	5031,59	36	25316897,93	30189,54	25390,60
7	7	36646,39	49	1342957900,03	256524,73	27299,20
8	8	96984,76	64	9406043672,26	775878,08	29207,80
9	9	25139,26	81	631982393,35	226253,34	31116,40
10	10	-12185,41	100	148484216,87	-121854,1	33025,00
11	11	39346,39	121	1548138406,03	432810,29	34933,60
12	12	47638,76	144	2269451454,34	571665,12	36842,20
13	13	32752,26	169	1072710535,11	425779,38	38750,80
14	14	-7001,41	196	49019741,99	-98019,74	40659,40
15	15	49095,39	225	2410357319,25	736430,85	42568,00

End of table 3

1	2	3	4	5	6	7
16	16	100719,76	256	10144470054,46	1611516,16	44476,60
17	17	19219,26	289	369379954,95	326727,42	46385,20
18	18	12104,59	324	146521099,07	217882,62	48293,80
19	19	83224,39	361	6926299090,87	1581263,41	50202,40
20	20	65656,76	400	4310810133,70	1313135,2	52111,00
Total	210	679593,00	2870	43834709542,00	8590204,25	679586,00

Source. Developed by the authors according to the data [5].

Using data from the Table 4, obtain the following figures:

$$\bar{t} = 10,50 \quad \overline{(t)^2} = 143,50 \quad \overline{t^2} = 143,50$$

$$\overline{(T + \varepsilon)} = 33979,65 \quad \overline{(T + \varepsilon)^2} = 461846645649,00 \quad \overline{(T + \varepsilon)^2} = 2191735477,10.$$

$$t(\overline{T + \varepsilon}) = 429510,21 \quad \overline{t \cdot (T + \varepsilon)} = 356786,33.$$

Hence, calculate values of a_1 and a_0 parameters:

$$a_1 = 1908,623; \quad a_0 = 13939,105.$$

Parameters of linear trend can be interpreted as follows: a_0 – initial level time series at $t = 0$, i.e. product cost in the first quarter in 2011; a_1 – period average absolute increase of levels series (i.e. cost).

Then we have a linear trend as follows:

$$y = 13939,105 + 1908,623 t.$$

Substituting values $t = 1, \dots, 20$ into the equation, we find the T-levels for each time moment and inscribe the data to the appropriate column in table 4.

The graph of trend equation shown in figure 1. Analyzing the tendency of cost we see that function extremum takes place in the 16th quarter at the end of 2014 year. This fact was resulted from the price increasing and growth in production volumes on the NE «LRP “Motor”». In 2014 the enterprise obtained a big amount of orders from such countries, as Poland, Belarus, Kazakhstan, and Indonesia and made capital engine repairs for them. Considering this fact, we can sum up that all expenses grew significantly: for remuneration of labor, payments for electricity, purchasing of raw materials and semi-finished products etc.

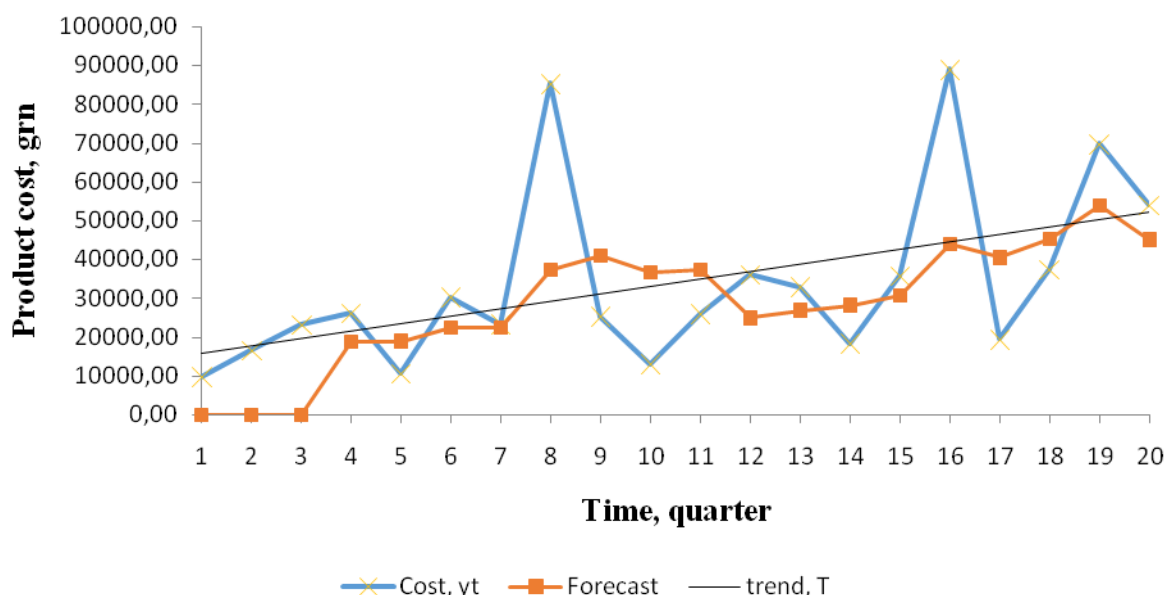


Fig. 1. Actual Aligned and Received by the Additive Value Model Numbers of Levels (the Dynamics of Product Cost on the NE «LRP “Motor”» During 2011-2015 Years by the Quarters)
Source. Developed by the authors according to the data [5].

Calculated values obtained by the model (T + S) and a number of levels T + Ss are set in the table 4.

Finally, we determine absolute or relative errors by the formula: $\varepsilon = Y_t - (T + S)$. Received data are written down into the table 3.

We estimate the quality of the models using mean square error of approximation:

$$\bar{A} = 100 \cdot \sqrt{\frac{1}{n} \sum \frac{\varepsilon^2}{y_t}}$$

Mean square error of approximation for additive model is 4,8 %. Hence, the additive model is qualitative inasmuch as mean-square error of approximation is less than 15 %.

On the graph (Fig.1) we can see is rising uptrend, showing ascending dynamics of product cost. Modelled forecast, built by the method of analytical smoothing shows that in the analogic period in perspective during 2016–2020 years enterprise would have less abrupt changes in cost dynamics.

Conclusions and Perspectives for Future Research. Summing up our scientific research we can determine that time series econometric modelling has significant benefits. Among them there are: making long term forecasts, researching trend in dynamics, determination the key extremums and lowest points of function, visually describing information in graphical form providing better and clear understanding of factor interaction. Implementation of this method on the NE «LRP «Motor»» guaranteeto make accurate long-sighted prognosisof the cost and this way prevent failure in plan performance, helps to follow determined strategy, thus avoid profit loss and overestimation the expenses. Hence, the above named method has significant scientific and practical value.

References

1. Begun S. I. Calculation of product cost: a comparative analysis of approaches to the definition of economic content / S. I. Begun, N. V. Kovtun // Young scientist (Economic Sciences). – 2014. – № 6 (09). – 398 p.
2. Blai A. N. Forecasting construction cost escalation / Andrew N. Blair, Leonard M. Lye, W. J. Campbell: Revised manuscript [Internet resource]. – Mode of access : https://www.researchgate.net/publication/237190720_Forecasting_construction_cost_escalation
3. FildesR. Cost and benefits of the forecasting methods / R. Fildes // Long-range forecasting [Internet resource]. – Mode of access : <http://www.forecastingprinciples.com/files/LRF-Ch14b.pdf>
4. Eliseeva I. I. Econometrics: Tutorial / I. I. Eliseeva. – Moscow : Finance and Statistics, 2003. – 344 p.
5. Report on financial resultsfor 2011–2015 years // Reporting statistic documentation of NE «LRP «Motor»»
6. Sliepenchenko K. O. Peculiarities of product cost calculation by the job-order costing method and identification of reserves to reduce it (on the NE «LRP «Motor»») / N. A. Bukalo, K. O. Sliepenchenko // Economic Sciences Series «Accounting and Finance» / Scientific works of Lutsk National Technical University. – Lutsk, 2014. – 432 p.

Бегун Світлана, Слепченко Катерина. Застосування економетричного моделювання часових рядів для аналізу та прогнозування собівартості продукції (на прикладі ДП «ЛРЗ «Мотор»»). У статті досліджено динаміку собівартості продукції ДП «ЛРЗ «Мотор»» на основі адитивної моделі часового ряду. Запропоновано її застосування на підприємстві для забезпечення комплексного аналізу й прогнозування показників не лише в короткостроковій перспективі, а й у довготермінових періодах. Проведено моделювання сезонних коливань собівартості продукції підприємства. Здійснено аналітичне вирівнювання ряду динаміки собівартості на основі лінійного тренду. Обґрунтовано застосування на практиці методу прогнозного моделювання часових рядів собівартості продукції.

Ключові слова: ряди динаміки, економетричне моделювання, собівартість продукції, аналітичне вирівнювання, сезонні компоненти, ковзкі середні, тренд.

Бегун Светлана, Слепченко Екатерина. Применение эконометрического моделирования временных рядов для анализа и прогнозирования себестоимости продукции (на примере ГП «ЛРЗ «Мотор»»). В статье исследуется динамика себестоимости продукции ГП «ЛРЗ «Мотор»» на основе аддитивной модели временного ряда. Предлагается ее применение на предприятии для обеспечения комплексного анализа и прогнозирования показателей не только в краткосрочной перспективе, но и в долгосрочных периодах. Проведено моделирование сезонных колебаний себестоимости продукции предприятия. Осуществляется аналитическое выравнивание ряда динамики себестоимости на основе линейного тренда. Обосновывается применение на практике метода прогнозного моделирования временных рядов себестоимости продукции.

Ключевые слова: ряды динамики, эконометрическое моделирование, себестоимость продукции, аналитическое выравнивание, сезонные компоненты, скользящие средние, тренд.