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ДОВІРЧИЙ ІНТЕРВАЛ ДЛЯ СКЛАДАННЯ ЕКОНОМІЧНИХ ПРОГНОЗІВ

Анотація. *В статті описано роль довірчого інтервалу у прогнозуванні економічних даних. Враховуючи те, що одним із ключових чинників прийняття економічно обґрунтованих та раціональних управлінських рішень є точний прогноз, то зроблено висновок, що прогнозування з інтервалом довіри дає цінну інформацію про невизначеність точкового прогнозу та формує надійну базу для складання більш точних прогнозів. Корисність інтервальної оцінки для складання прогнозів вказана в статті. В статті роз'яснено як формування прогнозів на основі довірчого інтервалу впливає на дослідження ринку, управління ризиками та планування бюджету організації. Зазначено, що інтервальний прогноз є одним з методів, який дозволяє усунути проблему точкового оцінювання, оскільки містить два значення – верхню та нижню прогнозні межі. Основні етапи, які використовуються для побудови прогнозу з інтервалом довіри описані в статті. Доведено, що інтервальний прогноз становить цінну інформаційну основу для керівників підприємства. Практичне застосування довірчого інтервалу для складання економічних прогнозів показано в статті.*

Ключові слова: *інтервал довіри, інтервальний прогноз, точковий прогноз, економічне прогнозування, помилка прогнозу, точність прогнозу.*

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ДОВЕРИТЕЛЬНЫЙ ИНТЕРВАЛ ДЛЯ СОСТАВЛЕНИЯ ЭКОНОМИЧЕСКИХ ПРОГНОЗОВ

Аннотация. *В статье описано роль доверительного интервала в прогнозировании экономических данных. Учитывая, что одним из ключевых факторов принятия*

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экономически обоснованных и рациональных управленческих решений является точный прогноз, то сделан вывод, что прогнозирование с интервалом доверия дает ценную информацию о неопределенности точечного прогноза и формирует надежную базу для составления более точных прогнозов. Полезность интервальной оценки для составления прогнозов указана в статье. В статье разъяснено как формирование прогнозов на основе доверительного интервала влияет на исследования рынка, управления рисками и планирования бюджета организации. Указано, что интервальный прогноз является одним из методов, который позволяет устранить проблему точечного оценивания, поскольку содержит два значения – верхнюю и нижнюю прогнозные границы. Основные этапы, которые используются для построения прогноза с интервалом доверия, описаны в статье. Доказано, что интервальный прогноз составляет ценную информационную основу для руководителей предприятия. Практическое применение доверительного интервала для составления экономических прогнозов показано в статье.

Ключевые слова: *интервал доверия, интервальный прогноз, точечный прогноз, экономическое прогнозирование, ошибка прогноза, точность прогноза.*

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CONFIDENCE INTERVAL FOR ECONOMIC FORECASTING

Abstract. *This article examines the role of confidence interval for making economic forecasts. Taking into account that the most basic keys to good decision-making is accurate forecasting of the future it can be said that the confidence interval conveys valuable information regarding the uncertainty of point estimate and forms reliable base for making good forecast. Utility of interval estimation to users of business forecasts is emphasized in the article. The paper shows how the confidence interval affects business such as market research, risk management, budget planning. Range forecast as a way to counteract the problem of point estimation is explained in this article. These ranges consist of two points, representing the reasonable "best case" and "worst case" scenarios. Because no estimate can be 100 percent reliable, businesses must be able to know how confident they should be in their estimates and whether or not to act on them. The main steps used to construct the forecast with confidence interval are described in this article. It was proved that probability, measured in a confidence interval, is another piece of data that can help the end user make an informed decision. Also, the practical application of the confidence interval for making business forecast is shown in the article.*

Keywords: *confidence interval; range forecast; point estimation; business; forecast error; forecast accuracy.*

Introduction. One of the most basic keys to rational decision-making is accurate forecasting of the future. In order to bring about the best outcomes, a company must correctly anticipate the most likely future states of the economic data. Yet despite its importance, companies routinely

make basic forecasting mistakes by applying procedures that make accurate predictions harder to achieve. The future, to state the obvious, is uncertain. We may want to know precisely what the future will hold, but we realize that the best we can settle for is having some idea of the range of possible outcomes and how likely these outcomes are. Yet most companies seem to ignore this fact and ask employees to provide point predictions of what will happen – the exact price of a stock, the precise level of growth of a country's GDP next year, or the estimated return, to the dollar, on an investment.

Recent research and publications analysis. The main task in business is to predict the movement direction of business activity so as to provide valuable decision information for top managers and investors. One way to counteract this problem of point estimation is to ask for range forecasts, or confidence intervals. Thus, many scientists, researches [2], [3], [5] and business practitioners have developed various types of forecasting methods. Of the various techniques, the forecasting with confidence interval has been found to be an effective method for the economic data prediction by business forecasters [5]. However, a problem of explaining such forecasting approach that could provide both accuracy and informativeness is not being completely covered, which determines the need for its deeper study.

The goal of this article is to explain the importance of confidence interval for economic forecasting.

Key research findings. Business, like many other fields, can benefit from the use of statistics in estimating or predicting future events. An important tool for business statistics is a confidence interval, which helps a business evaluate the reliability of a particular estimate. Because no estimate can be 100 percent reliable, businesses must be able to know how confident they should be in their estimates and whether or not to act on them [10].

One effect of confidence intervals in businesses is in determining the reliability of market research. Marketing is an important function for most firms, particularly when estimating their level of future sales. A company will want to have an idea of how many products it will sell in a given financial period, but cannot know the true number with certainty until after the end of the period. By collecting data from customers, past sales numbers and other sources, a company can statistically estimate the value of future sales. By using a confidence interval, the company can determine the range its sales are likely to fall.

Because it is impossible to predict a future event with 100 percent accuracy, confidence intervals are used by businesses to manage risk. For example, if a company is 95 percent confident that sales in the next period will be between 5 million and 6 million units, there is still a 5 percent chance that they will be above or below that number. By understanding how likely a given risk is to occur, the business can manage the risks of a non-occurrence accordingly.

When a business forecasts a budget for a fiscal period, it will need to estimate both revenues and costs. If a company is significantly off the mark on either estimation, it could get in financial trouble. By using a range of possible values for revenues and costs and finding the confidence interval of those values, a business can have the information it needs to make important financial decisions while still being able to reasonably prepare for the possibility that its estimates may be incorrect.

In statistics, a confidence interval gives the percentage probability that an estimated range of possible values in fact includes the actual value being estimated. These ranges consist of two points, representing the reasonable "best case" and "worst case" scenarios. Range forecasts are more useful than point predictions [2].

Let's take a look at forecasting with application the confidence interval. Confidence interval is a particular kind of interval estimate of an economic parameter and is used to indicate the reliability of an estimate. The confidence interval with a particular confidence level is intended to give the assurance that, if the forecasting model is correct, then taken over all the data that might have been obtained, the procedure for constructing the interval would deliver a confidence interval that included the true value of the parameter with specified confidence level. More specifically, the meaning of the term "confidence level" is that, if confidence intervals are constructed across many

separate data analyses of repeated experiments, the proportion of such intervals that contain the true forecast value of the parameter will approximately match the confidence level; this is guaranteed by the reasoning underlying the construction of confidence intervals [5].

So, a confidence interval shows the range within which the true forecast value of socio-economic parameter is likely to lie. The confidence interval is a range of values for a variable of interest constructed so that this range has a specified probability of including the true forecast value of the variable. The specified probability is called the confidence level, and the end points of the confidence interval are called the confidence limits (bounds) [5].

One of the advantages of confidence intervals over traditional forecasting methods is the additional information that they convey. The upper and lower bounds of the interval give us information on how big or small the true forecast value might plausibly be, and the width of the confidence interval also conveys some useful information [8].

The following steps are used to construct the forecast with confidence interval:

1-st step. Point forecast calculation is a process of defining the quantitative forecast value. To find the point forecast we can use the simple regression model in the case of one independent variable and one dependent variable or multiple regression in the case of several independent variables and single dependent variable.

2-d step. Confidence level selection is a process of determining the probability that the confidence interval will contain the true forecast value. A confidence level is statistical measure of the number of times out of 100% that test results can be expected to be within a specified range. The confidence level ranges from 0% to 100%. The higher confidence level, the forecast is accurate. If confidence level is 95%, we are 95% sure that the forecast is accurate with the probability of 95%.

3-d step. Making interval forecast is a process of defining the upper and lower bounds of the confidence interval.

The upper bound of the confidence interval is calculated by adding the point forecast and the permissible forecast error by the formula (1):

$$UB = PF + PFE, \tag{1}$$

where $UB -$ is the upper bound of the confidence interval;

$PF -$ is the point forecast made with application the regression model;

$PFE -$ is the permissible forecast error.

The lower bound of the confidence interval is defined by subtracting the permissible forecast error from the point forecast by the formula (2):

$$LB = PF - PFE, \tag{2}$$

where $LB -$ is the lower bound of the confidence interval.

Permissible error is the amount of error that we can tolerate in the forecast. It is calculated by multiplying the critical *t*-score by the standard forecast error (3):

$$PFE = C_{t-score} \cdot SFE, \tag{3}$$

where $PFE -$ is the permissible forecast error;

$C_{t-score} -$ is the critical *t*-score;

Critical *t*-score allows to calculate various statistics within a specific sample and to test various hypotheses about samples. It can be defined using Data Analysis or specific statistical tables.

$SFE -$ is the standard forecast error.

Standard forecast error is a standard deviation of the interval estimate of a dependent variable for a given value of an independent variable.

The standard forecast error (SFM) is defined by the formula (4):

$$SFM = s_e \cdot \sqrt{1 + \frac{1}{n} + \frac{(\hat{x} - \bar{x})^2}{\sum (x_i - \bar{x})^2}}, \quad (4)$$

where S_e - is the standard regression error is a measure of error in the regression model;

x_i - is the quantitative values of independent variable *x*;

$\hat{x}$ - is the forecast of independent variable (*x*);

$\bar{x}$ - is the average value of independent variable *x*;

n – is the number of observations (periods).

Let's take a look at application the confidence interval for making retail sales forecast. A company must develop interval forecast for the next month. It has collected data on retail sales and advertising costs for 10 months (table 1).

Table 1

Statistics on retail sales and advertising costs

Months	Retail sales, thousand dollars	Advertising costs, thousand dollars
Mart	125	12,5
April	126	12,7
May	128	12,8
June	130	13,0
July	131	13,2
August	133	13,5
September	139	13,7
October	142	13,8
November	145	14,0
December	150	14,4

To find the retail sales forecast (point forecast) with regression model for January we can use the simple regression model (5):

$$Y = b_0 + b_1 \cdot X_{1t}, \quad (5)$$

where $Y -$ is the forecast of retail sales, thousand dollars;

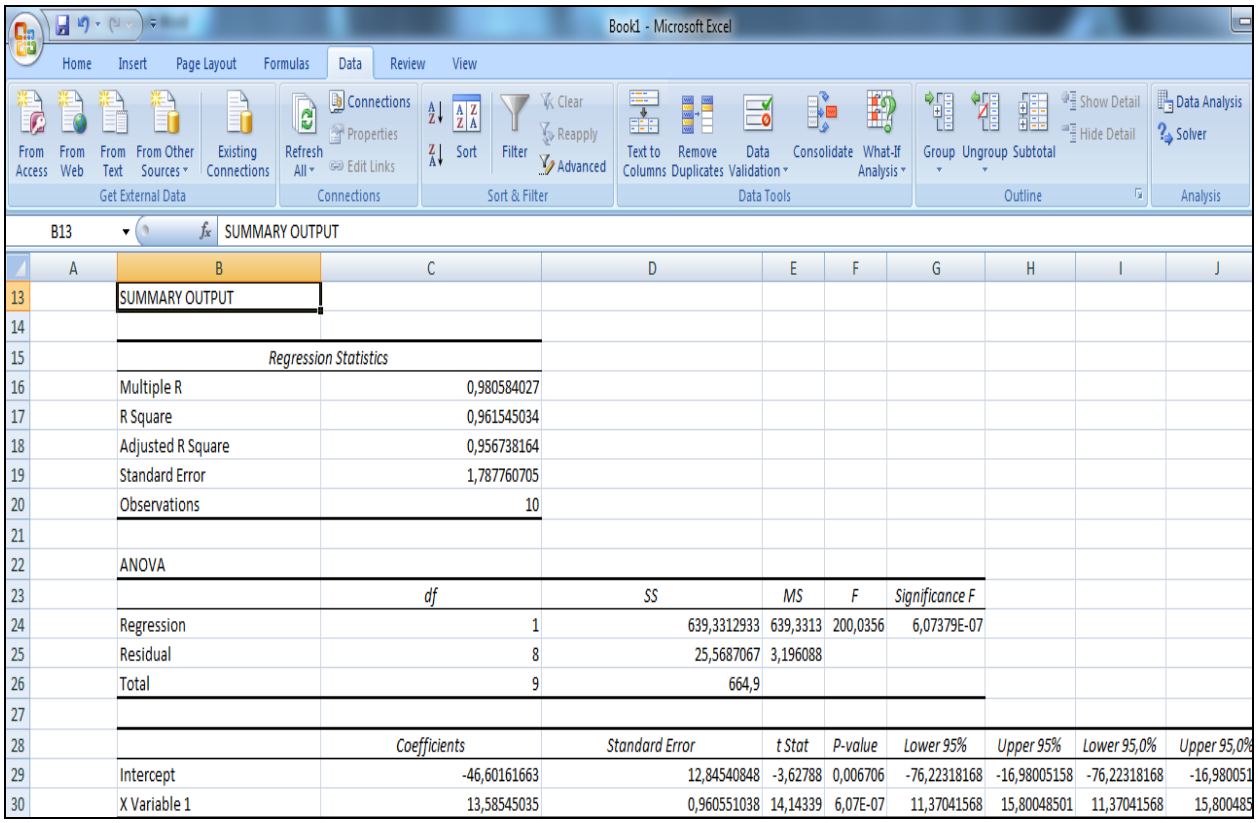
X_{1t} – is the forecast of advertising costs for the next period *t*, thousand dollars;

b_0, b_1 – are the regression coefficients.

To calculate the coefficients b_0, b_1 is imperative to use computer software (Data Analysis) to the prediction equation. Corresponding to the regression equation, software finds a forecast equation by estimating the model parameters using sample data.

The regression output has three components: Regression statistics table, ANOVA table, Regression coefficients table. Figure 1 contains the information that can be used for the simple regression model building. Quantitative values of the coefficients are given on Regression

coefficients table: b_0 is opposite "Intercept" (b_0= – 46,6); b_1 is opposite "X Variable 1" (b_1= 13,585).



13	SUMMARY OUTPUT								
14									
15	*Regression Statistics*								
16	Multiple R	0,980584027							
17	R Square	0,961545034							
18	Adjusted R Square	0,956738164							
19	Standard Error	1,787760705							
20	Observations	10							
21									
22	ANOVA								
23		*df*	*SS*	*MS*	*F*	*Significance F*			
24	Regression	1	639,3312933	639,3313	200,0356	6,07379E-07			
25	Residual	8	25,5687067	3,196088					
26	Total	9	664,9						
27									
28		*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
29	Intercept	-46,60161663	12,84540848	-3,62788	0,006706	-76,22318168	-16,98005158	-76,22318168	-16,980051
30	X Variable 1	13,58545035	0,960551038	14,14339	6,07E-07	11,37041568	15,80048501	11,37041568	15,800485

Fig. 1. Forecast output

The simple regression model that estimates the retail sales for the next month (Y) looks like:

$$Y = -46{,}602 + 13{,}585 \cdot X_{1t}. \quad (6)$$

The simple regression model (6) is a basis to make the retail sales forecast, but quantitative value of the forecast using Data Analysis we can not find.

To check the simple regression model on the goodness of fit we can use the information on Regression statistics table (Figure 1). Correlation coefficient (r=0,98) means approximately 98% (0,98*100%) of the variation in the dependent variable (retail sales) can be explained by the simple regression model (6).

Coefficient of determination (R^2=0,961) means approximately 96,1% (0,961*100%) of the variation in the dependent variable (retail sales) can be explained by the independent variable (the advertising costs).

Adjusted coefficient of determination (adjusted R^2=0,956) means approximately 95,6% (0,956*100%) of the variation in the dependent variable (retail sales) caused by the independent variable (the advertising costs).

To validate the simple regression model on the statistical significance we can use the information on ANOVA table (Figure 1). In this case, the value of "Significance F" is lower than 0,05, the simple regression model (6) is acceptable and statistically significant to make the retail sales forecast ($6{,}073*10^{-7}$ <0,05).

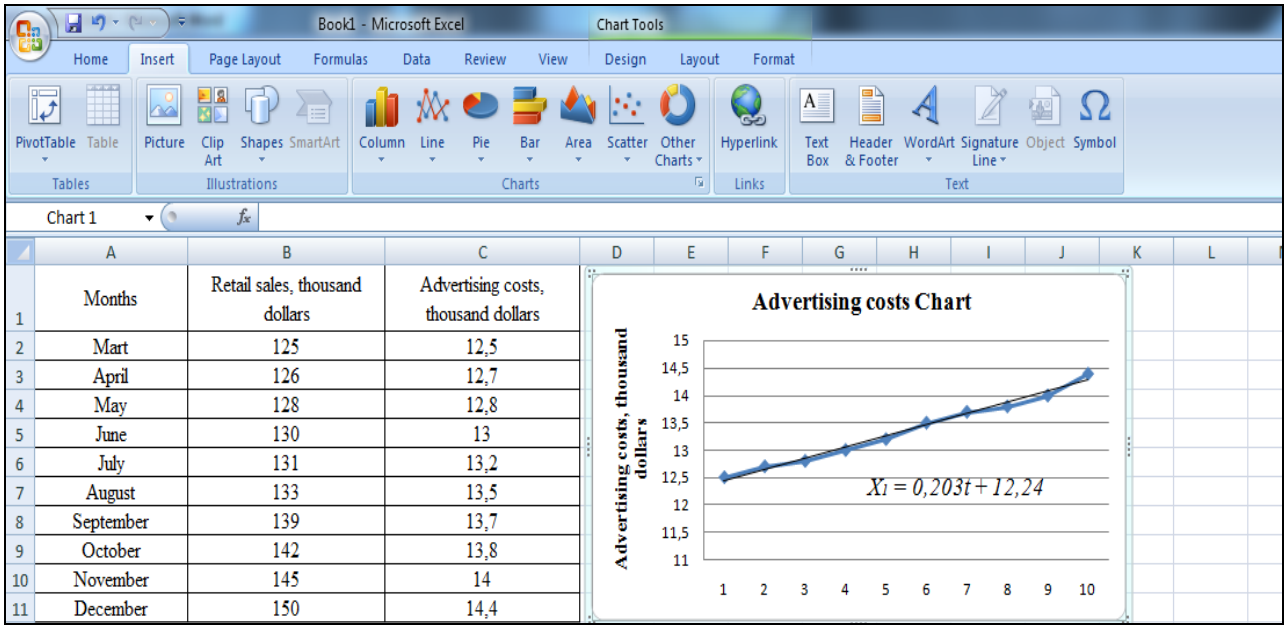
To estimate each coefficient on the statistical significance we can use Regression coefficients table (Figure 1). In this case, "P-value" for coefficient b_0 is 0,006 (lower than 0,05), "P-value" for coefficient b_1 is $6{,}07*10^{-7}$ <0,05 (lower than 0,05); the simple regression model (6) is statistically significant and reliable to make the retail sales forecast.

To find the point retail sales forecast for January we need to calculate the quantitative forecast of advertising costs for January.

Trend equation that estimates the advertising costs is given below (7):

$$x_t = a + b \cdot t, \tag{7}$$

where x_t – is the forecast of advertising costs;
a and b – are the linear coefficients;
t – is the time unit.
Trend equation is shown on Figure 2.



	A	B	C
1	Months	Retail sales, thousand dollars	Advertising costs, thousand dollars
2	Mart	125	12,5
3	April	126	12,7
4	May	128	12,8
5	June	130	13
6	July	131	13,2
7	August	133	13,5
8	September	139	13,7
9	October	142	13,8
10	November	145	14
11	December	150	14,4

Fig. 2. Trend equation

Forecast of advertising costs for January based on trend equation equals:

$$x_{1t} = 12{,}24 + 0{,}203 \cdot 11 = 14{,}473 \text{ thousand dollars.}$$

Point retail sales forecast for January with application the simple regression model equals:

$$Y = -46{,}602 + 13{,}585 \cdot 14{,}473 = 150{,}014 \text{ thousand dollars.}$$

To calculate the retail sales forecast for January with confidence interval we need to find the standard forecast error by the formula (4):

$$SFE = 1{,}78 \cdot \sqrt{1 + \frac{1}{10} + \frac{(14{,}47 - 13{,}36)^2}{3{,}46}} \approx 2{,}158.$$

The permissible error by the formula (3) equals:

$$PFE = 2{,}306 \cdot 2{,}158 \approx 4{,}98.$$

The upper bound of the confidence interval (the retail sales forecast plus permissible error) by the formula (1):

$$UB = 150{,}014 + 4{,}98 = 154{,}99 \text{ thousand dollars.}$$

The lower bound of the confidence interval (the retail sales forecast minus permissible error) by the formula (2):

$$LB = 150{,}014 - 4{,}98 = 145{,}03 \text{ thousand dollars.}$$

Conclusion is that the retail sales forecast for January ranges from 145,03 to 154,99 thousand dollars with probability of 95%.

Conclusions. Based on the mentioned above it can be said that the confidence interval can help the end user make an informed decision valuable information regarding the uncertainty of point estimate and forms reliable base for making accurate forecast. It was proved that the range forecast is a good tool to counteract the problem of point estimation. Thus, the range forecasts are more useful than point predictions in providing the valuable decision information for managers and business practitioners.

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