MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

SIMON KUZNETS KHARKIV NATIONAL UNIVERSITY OF ECONOMICS

Guidelines
to interdisciplinary training
"ORGANIZATION AND MODELLING OF INNOVATIVE ACTIVITY"
for full-time students
of training direction
6.030601 "Management"

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Затверджено на засіданні кафедри економіки, організації та планування діяльності підприємства.

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Tasks for practical classes as well as guidelines for doing them are given. Criteria for students' knowledge assessment are provided.

Recommended for full-time students of training direction 6.030601 "Management".

Подано завдання до практичних занять, а також методичні рекомендації до їх виконання. Наведено критерії оцінювання знань студентів.

Рекомендовано для студентів напряму підготовки 6.030601 "Менеджмент" денної форми навчання.

Introduction

The purpose of the training "Organization and Modelling of Innovative Activity" is to form future managers' theoretical knowledge and practical skills in modelling the use of methods that optimize task management, organization and production planning. The task of the training is to apply modelling to testing economic theories of factual and quantitative optimal solutions.

The general knowledge and skills acquired by students in the training "Organization and Modelling of Innovative Activity" can be expanded in the process of learning academic disciplines in the speciality. Students use the knowledge when studying the academic discipline, writing the graduation paper, as well as in scientific research.

During the training students receive the necessary knowledge at practical classes, in the performance of individual tasks. Of great importance in the process of learning and consolidation of knowledge is collective students' work.

In accordance with the requirements of the educational and professional programs, students must:

know:

general principles of econometric studies;

main stages in the study of specific economic situations;

essence of system analysis;

main stages of construction of econometric models of research;

stages of building a correlation model;

performance evaluation of communication in the correlation analysis;

nature of production functions;

modelling of demand;

application of correlation methods;

autocorrelation;

performance evaluation of autocorrelation;

basic properties of economic time series;

be able to:

construct a correlation model of an economic process;

solve a pair correlation model;

evaluate the relationship between indicators using the correlation coefficient and the correlation ratio;

justify the correlation coefficients;

build a two-factor correlation model;

solve a two-factor linear correlation model;

substantiate the relationship between model parameters;

evaluate the use of models in laboratory studies;

evaluate the autocorrelation using different indicators: autocorrelation coefficients, criteria Darbina-Watson and John von Neumann;

estimate economic decisions based on econometric models;

use applications during the development-accounts on PC.

Professional competences formed in the process training "Organization and Modelling of Innovative Activity" according to the National Qualifications Framework of Ukraine are given in Table 1.

Table 1

The structure of part of professional competences formed by the training "Organization and Modelling of Innovative Activity" according to the National Qualifications Framework of Ukraine

Components of the competence which is formed under the theme	**Minimum experience**	**Knowledge**	**Skill**	**Autonomy and responsibility**	**Sociability**
1	2	3	4	5	6
Knowledge and skills in relation to methods of statistical modelling results of enterprises	The ability to use mathematical modelling techniques	The general principles of econometric studies	The main stages in the study of a specific economic situation	The essence of the system analysis	The main stages of construction of econometric models of research
The ability to use linear and nonlinear econometric models	Stages of building a correlation model	Performance evaluation of communication in the correlation analysis	The nature of production functions	Modelling of demand	Using applications during the development of accounts on a PC
The ability to determine autocorrelation models economic data	Evaluating the relationship between indicators using the correlation coefficient and correlation the ratio	Materiality to justify the correlation coefficients	Building a two-factor correlation model	Solving a two-factor linear correlation model	Making decisions under uncertainty and responsibility for the accuracy and correctness of the results

Table 1 (the end)

1	2	3	4	5	6
The ability to determine the autocorrelation patterns of economic data	Substantiating the relationship between model parameters	Evaluating the use of models in laboratory studies	Building and solving a two-factor dispersion model	Assessing the impact of factors in the two-factor dispersion models	Responsibility for the results of decisions
The ability to use the software	Lost Special package	Lost Special package: STATGRAPHICS, Excel, STATISTIKA	Possibilities of using the global Internet network to find data	Using applications during the development of accounts on a PC	Making decisions under uncertainty and responsibility for their accuracy and correctness of the results

Tasks and procedures of the training by days

Day 1

Trend models of forecasting

The basic data which a researcher has, are usually represented in the form of temporary ranks which describe changes of some characteristic in time. A time row has to reflect the studied process correctly. For this purpose it has to consist of the uniform and comparable sizes expressed in the same units of measure and calculated for the same period. A feature of a temporary row is lack of an invariance of the set and existence of three tendencies: an average level, dispersion and autocorrelation.

The dynamics of levels of a temporary row can be mathematically presented as a sum of two elements: determined $f(t)$ and casual e_t, that is $Y_t = f(t) + e_t$. The determined making $f(t)$ represents a smooth function from an argument (in most cases from t time) which keeps the values for forecast anticipation. This component is also called a trend, the level, the determined component, a basis of the process or a tendency. The casual component of it is called an error of the forecast and is necessary for determination of accuracy of the forecast.

For creation of a mathematical model of a temporary row it is necessary to execute its preliminary processing, that is to analyse the logic of the predicted process. It will allow a correct choice of the extrapolated function and definition of borders of change of its parameters.

The type of a trend (function) is established as follows. In the beginning a schedule of dynamics of an indicator is built. Then the economic analysis of the process is carried out in order to investigate:

whether the indicator is limited to any limit from above (from below);

whether the process has accurate restriction of development in time.

After that the schedule of the initial row is compared with a theoretical function graph and preliminary conclusions are drawn about their similarity, whether the function describing the process, whether it possesses the property of symmetry or not;

In the same trend, the most commonly used functions as follows:

Linear $Y = a + в\, t$

parabola $Y = a + в\, t + c\, t^2$;

sedate and $Y = a\, t^{в}$;

exponential $Y = a\, e^{bt}$;

logistic (S-shaped) curve $Y = К / (1 + в\, e^{-tc})$;

Gompertz curve $Y = К\, a^{bt}$.

On the basis of the above, one or more functions are selected to describe the trend. Then the values of functions are calculated. The calculation of the function parameters can be carried out by different methods, the most widely used one is the method of least squares, requiring compilation system of equations.

For a linear function of the form Y = *a* + *b t* it has the following form:

$$\begin{cases} \sum_1^n Y = an + b\sum_1^n t, \\ \sum_1^n Yt = a\sum_1^n t + b\sum_1^n t^2; \end{cases}$$

parabola to the second power $Y = a + b\,t + c\,t^2$:

$$\begin{cases} \sum_1^n Y = an + b\sum_1^n t + c\sum_1^n t,^2 \\ \sum_1^n Yt = a\sum_1^n t + b\sum_1^n t^2 + c\sum_1^n t^3, \\ \sum_1^n Yt^2 = a\sum_1^n t^2 + b\sum_1^n t^3 + c\sum_1^n t^4. \end{cases}$$

For the power function $Y = a\ t^{\ b}$ and after taking the logarithm $\ln Y = \ln a + b\ln t$ we have the following equation:

$$\Sigma \ln Y = \ln a\ \Sigma 1 + b\ \Sigma \ln t,$$
$$\Sigma(\ln Y \ln t) = \ln a\ \Sigma \ln t + b\ \Sigma(\ln t)^2;$$

the hyperbola $Y = a + b / t$ can be written:

$$\Sigma Y = a\ \Sigma 1 + b\ \Sigma(1/t),$$
$$\Sigma(Y / t) = a\ \Sigma(1/t) + b\ \Sigma(1/t)^2.$$

Calculation the required amounts can be carried out using the calculation formulas:

$$\Sigma\, t = \frac{n(n+1)}{2};\ \Sigma\, t^2 = \frac{n(n+1)(2n+1)}{6};\ \Sigma\, t^3 = \frac{n^2(n+1)^2}{4};$$
$$\Sigma\, t^4 = \frac{n(n+1)(2n+1)(3n^2+3n-1)}{30}.$$

In all the above formulas, the summation is over t from 1 to *n.*

To assess the closeness of the connection between these indicators, the correlation coefficient is calculated by the formula :

$$r = \frac{\sum Yt - \frac{(\sum Y)(\sum t)}{n}}{\sqrt{[\sum Y^2 - \frac{(\sum Y)^2}{n}][\sum t^2 - \frac{(\sum t)^2}{n}]}}.$$

On the basis of it the coefficient of determination of r^2, that is the square of the coefficient of correlation which defines the share of the general dispersion explained with changes of parameter t is calculated.

The importance of r and r^2 depends on the number of supervision. Smaller values of the number of supervision have to correspond with big correlation of a temporary row. Table 1 shows the threshold (lower limit) for all I and r^2 for the corresponding volumes of observations in the case of the linear regression equation (trend) in forecasting.

If the calculated value of r is much higher than the threshold, then the connection between the indices is significant.

Table 2

The threshold *r* and *r*^{2} values when using regression in forecasting (at 90 % trust level)

N	r	r^2	n	r	r^2
5	0.58	0.34	30	0.29	0.08
6	0.55	0.35	35	0.27	0.07
7	0.52	0.27	40	0.25	0.06
8	0.50	0.25	45	0.23	0.05
9	0.48	0.23	50	0.22	0.05
10	0.46	0.21	60	0.20	0.04
15	0.39	0.15	70	0.19	0.04
20	0.34	0.12	80	0.18	0.03
25	0.31	0.10	90	0.16	0.03

Now it is necessary to check the suitability of the chosen function as a trend of a number of dynamics. The final function can be chosen in two ways: through application of the dispersive analysis and the method of a minimum of errors of the forecast.

The first way implies comparison of dispersions. For calculation of a dispersion it is necessary to know a variation. The general variation of a studied row can be presented as a sum of two components: variations of the tendency of *Vf* and a casual variation of *V,* that is *V = Vf + Vres.*

The general variation is determined as

$$V = \sum_{t=1}^{n} (Y_t - \overline{Y_t})^2,$$

where $\overline{Y}_t = (\Sigma Y_t) / n$ is the average level of a number of dynamics.

The variation explained with regression is found by means of the formula:

$$V_f = V - V_{res} .$$

The residual (casual) variation which can't be explained with the influence of this factor, is calculated as follows:

$$V_{res} = \sum_{t=1}^{n} (Y_t - \hat{Y}_t)^2,$$

where $\hat{Y}_t$ is the expected value of the indicator calculated on the calculated model.

Knowing the values of variations, it is possible to calculate dispersions and the criterion of Fischer.

$S^2_{\text{™}}$ and $S^2_{\text{”}}$ are dispersions on one degree of freedom for the considered sizes.

In Table 9 tabulated boundary values of the criterion Fischer of *F* are given for the set significance value α and the number of degrees of freedom *K*. For example, if α = *0.05,* the number of degrees of freedom for a bigger dispersion *Kf = 1,* for the smaller *Kres = 10 (12 − 1 − 1 = 10 at n = 12),* F_{tab} = = *4.965. If* $F_p > F_{tab}$, the chosen function can be used as a trend.

There is another way to calculate the indicators of accuracy of the forecast: the mean square deviation or the error of the equation, average absolute percentage error of MAPE and average percentage error of MPE.

The mean square deviation is determined by the formula:

$$S_{\hat{y}_t} = \sqrt{\frac{\sum_{t=1}^{n}(Y_t - \hat{Y}_t)^2}{n-q-1}},$$

where *n* is the volume of supervision;

q is the number of parameters of the model connected with *t*;

Yt is the actual value of the indicator;

$\hat{Y}_t$ is the expected, calculated on the model, value of the indicator.

That is the function at which the mean square mistake will be the smallest and can be chosen as a forecast function. However it must be kept in mind that this method only applies in the case when functions have one and too number of parameters. If functions are compared to a different number of parameters, it is necessary to investigate them by means of indicators of errors of the forecast.

The average absolute percentage error of the forecast of MAPE characterizes the accuracy of the forecast and is calculated by the formula:

$$\text{MAPE} = \frac{1}{n}\sum_{t=1}^{n}\frac{|e_t|}{Y_t}\cdot 100,$$

where $e_t = Y_t - \hat{Y}_t$ is the error of the forecast.

If MAPE is less than 5 – 10 %, it means that the model gives high precision of the forecast.

The average percentage error of the forecast of MPE defines a shift of the forecast and can be both positive and negative size:

$$MPE = \frac{1}{n}\sum_{t=1}^{n}\frac{e_t}{Y_t}\cdot 100 .$$

If the value of MPE less than 5 % that is the boundary, it means that the forecast does not give displaced assessment.

That is the function at which the mistakes will be the smallest and will be accepted as a forecast function.

Then it is necessary to estimate the components of the expected model. Economic indicators form the non-stationary temporary ranks which make a forecast consisting of two components: the forecast on the basis of a trend (function) and the forecast on the basis of a residual component (an error of the forecast). The sum of two forecasts received thus gives a general total forecast on one temporary row.

For the definition of components of the model a method of series and a median is widely used. If deviations from a trend have a casual character and the inequalities given further are fair, selection admits casualness for 5 % of the significance value:

$$Kmax < [3.3 (\log n + 1)] \text{ and } V(n) > [\frac{n+1-1.96\sqrt{n+1}}{2}],$$

where *Kmax* is the extent of the longest series;

V (n) is the total number of series.

If at least one inequality is broken, the hypothesis of the casual character of deviations of levels of a temporary row from a trend is rejected, and the forecast becomes a two-component: determined and casual. For the latter it is necessary to repeat and find all calculations model *e (t) = f (t).* If inequalities aren't broken, the forecast is only based on the determined component (on a trend).

Then it is necessary to check whether there is an autocorrelation in the basic data. There are three ways of establishment of existence of autocor-relation: calculation of criteria of John von Neumann and Darbin – Watson, and also calculation of coefficients based on autocorrelation.

John von Neumann's criterion pays off on the formula:

$$K_H = \left(\frac{\sum_{t=2}^{n}(e_t - e_{t-1})^2}{n-1}\right) / \left(\sum_{t=1}^{n}\frac{e_t^2}{n}\right),$$

where *n* is the number of supervision;

e_t – e_{t-1} is the difference of the subsequent and previous values of residual sizes.

An inspection by this criterion is carried out as follows. By Table 11 criterion *K′n* (if the correlation coefficient is positive) and *K″n* (if it is negative) is determined for the set number of supervision of n and the chosen significance value α. Then the estimated value of the criterion is compared with these values: if the calculated value of Kn misses the feasible region K′n < Kn < K″n at 5 % significance level the hypothesis no autocorrelation residues, otherwise there – autocorrelation.

Darbin – Watson criterion is used if there is a free member in the model. This criterion demands that the number of supervision in the studied file was more than 15. The values of the lower and upper *d1 d2* criterion are tabulated in Table 10. The payment criterion is conducted by the following formula:

$$d = \frac{\sum_{t=1}^{n}(e_t - e_{t-1})^2}{\sum_{t=1}^{n} e_t^2}.$$

If *d = 2,* there is no autocorrelation; if *d < d1,* then the series contains a positive autocorrelation; when *d > 4 d1,* it contains a number of negative autocorrelations. Finally, if *d1 < d2,< d,* more research is needed.

In practice, to assess the residual autocorrelation coefficients, cyclic and non-cyclic auto-correlations which reflect the degree of closeness of relationships e_t and e_{t-1} are also applied.

The coefficient of cyclic autocorrelation is calculated by the formula:

$$r_a = \frac{\sum_{t=1}^{n} e_t e_{t-1}}{\sum_{t=1}^{n} e_t^2}.$$

The size r_a is compared to 12 sizes specified in Table 12 for five- and one-percentage significance values. If the settlement criterion r_a coefficient $r_a < r_{5\,\%}$ significance value, a hypothesis of no autocorrelation of deviations is confirmed. If the coefficient of autocorrelation was essential, autocorrelation is available and the model cannot be used. We will assume that autocorrelation coefficient $r_a = -\ 0.403$. From Table 12 for n = 9 we have $r_{5\,\%} = -\ 0.593$. We value ra absolute value less than $r_{5\,\%} = -\ 0.593$ then the hypothesis is rejected autocorrelation deviations.

Forecasting the future values of an indicator is carried out by substitution of the value $t = n + \tau$, where τ is the anticipation period (the period of time in the future when the forecast comes true).

The confidential interval has to consider the anticipation time, therefore for its calculation a standard error of the forecast is used:

$$S_{t+\tau} = S_{\hat{y}} \sqrt{1 + \frac{1}{n} + \frac{3(n+2\tau-1)^2}{n(n^2-1)}},$$

where $S_{\hat{Y}} = \sqrt{\frac{\sum_{t=1}^{n}(Y_t - \hat{Y}_t)^2}{n-q-1}}$ is a standard error of the equation;

τ is the anticipation period,

n is the volume of supervision,

q is the number of parameters of the model connected with t.

For a linear function of the type $Y_t = a + b\ t$ a standard error of the equation is equal to $b\ t$.

$$S_{\hat{Y}} = \sqrt{\frac{\sum(Y_t - \hat{Y}_t)^2}{n-2}}.$$

The confidential interval is calculated for different probabilities:

for probability 99.74 % the interval is $\hat{Y}_{t+\tau} \pm 3S_{t+\tau}$;

for probability 95.45 % the interval is $\hat{Y}_{t+\tau} \pm 2S_{t+\tau}$;

for probability 68.3 % the interval is $\hat{Y}_{t+\tau} \pm S_{t+\tau}$.

Day 2
Trend models of forecasting
The content of the task

Prove the expected model of demand for production. Basic data (15 values of demand for enterprise production) are given in Table 2. Calculate the forecast demand and confidence intervals for the next 16 period.

The order of doing the task

1. Plot the values of 15 respondents' demand for products and selected as a linear trend function $Y = a + bt$ and parabola $Y = a + Bt + c\ t2.$

2. Solve the model by least squares.

3. Determine the force effect of time (t) on demand via the correlation coefficient test of its materiality.

4. The variance analysis and calculation of the indicators of quality of predictive models MAPE, MPE, select the standard deviation of demand for a forecast model.

5. Prove that prediction is possible (impossible) to implement a deterministic component by using the series and the median.

6. Prove the existence (lack) of autocorrelation by means of calculation and an assessment of coefficients of cyclic autocorrelation using John von Neumann and Darbin – Watson criteria.

7. Make a payment forecast and confidence intervals on the model chosen for a period of pre-emption. Apply the forecasts and the confidence intervals to the schedule of dynamics.

As the basic data, the demand for the firm production for 15 periods is used. 10 options of tasks are given in work (from 0 to 9). The choice of the option is carried out depending on the last figure of the record book. If it comes to an end, for example, at 3, from Table 3 it is necessary to take the demand with 3 of 17 supervision; if it is 0, take 10 of 24 supervision.

Table 3

The basic data for the task. The demand for production in pieces

The number of observation	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Demand in pieces	40	45	46	50	46	48	50	46	42
The number of observation	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Demand in pieces	44	47	50	55	53	58	55	58	54
The number of observation	**19**	**20**	**21**	**22**	**23**	**24**			
Demand in pieces	58	55	60	59	61	58			

Methodical recommendations

1. Build the dynamics diagram (axis *U* represents the delay of the actual demand (from *Umin* until *Umax* + 20), and axis *X* is the periods of time of *t* (from 1 to 18).

2. Calculate the parameters of the functions of the trend for 15 supervisions.

Calculation of the parameters of the function of the trend is done by means of the method of the smallest squares (MSS).

2.1. The linear function $Y = a + b\,t$.

On the basis of MNK make a system of equations to determine the parameters *a* and *v* of the models:

$$\begin{cases} \sum_1^n Y = an + b\sum_1^n t, \\ \sum_1^n Yt = a\sum_1^n t + b\sum_1^n t^2. \end{cases}$$

Calculation of the parameters *a* and *b* is conducted by the following formula:

$$b = \frac{\sum_1^n Yt - \frac{\sum_1^n Y \sum_1^n t}{n}}{\sum_1^n t^2 - \frac{\left(\sum_1^n t\right)^2}{n}}, \quad a = \frac{\sum_1^n Y - b\sum_1^n t}{n}.$$

Calculation of the sums is carried out based on Table 4, where $Y_t = (1/n)\sum Y_t$.

Table 4

Calculation of the necessary sums for calculation of parameters of the model

t	$У_t$	$Y_t\,t$	$Y_t^{\,2}$	$\hat{Y}_t$	$e_t = Y_t - \hat{Y}_t$	$e_t^{\,2}$	$(e_t / Y_t)100$	$(Y_t - \bar{Y})^2$
1	2	3	4	5	6	7	8	9
1	3	3	9	3.6	– 0.6	0.36	– 0.2	1.6
…				–	–	–	–	–
15								
	$\sum$	$\sum$	$\sum$	$\sum$	–	$\sum$	$\sum 1$; $\sum 2$	$\sum$

In column 8 it is necessary to find two sums in this table:

$$\sum 1 = \sum_{t=1}^{n} \frac{|e_t|}{Y_t} \cdot 100 \; ; \; \sum 2 = \sum_{t=1}^{n} \frac{e_t}{Y_t} \cdot 100 \, .$$

The first sum is used for MAPE calculation, the second one is used for MPE calculation.

2.2. The parabola form $Y_t = a + b\,t + c\,t^2$.

For convenience of calculations we pass to conditional variables $t = t' - 8$ (subtract 8, as it is the middle of the time series sequence number), and then the model is:

$$Y'_t = a' + b'\,t' + c'\,(t')^2.$$

Parameters and ,′, b ′ with ′ define MNK:

$$\begin{cases} \sum_1^n Y = a'n + b'\sum_1^n t' + c'\sum_1^n (t'),^2 \\ \sum_1^n Yt' = a'\sum_1^n t' + b'\sum_1^n (t')^2 + c'\sum_1^n (t'),^3 \\ \sum_1^n Y(t')^2 = a'\sum_1^n (t')^2 + b'\sum_1^n (t')^3 + c'\sum_1^n (t')^4. \end{cases}$$

As $\sum_1^n t' = 0, \sum_1^n (t')^3 = 0$, then from the second equation find

$$\text{parameter } b' = \frac{\sum_1^n Yt'}{\sum_1^n (t')^2}.$$

Make a system of equations of the first and third equations:

$$\begin{cases} \sum_1^n Y = a'n + c'\sum_1^n (t'),^2 \\ \sum_1^n Y(t')^2 = a'\sum_1^n (t')^2 + c'\sum_1^n (t')^4. \end{cases}$$

Solve it concerning the *c′* and *a′* parameters and receive

$$c^{\copyright} = \frac{\sum_1^n Y(t')^2 - \frac{\sum_1^n Yt' \sum_1^n (t')^2}{n}}{\sum_1^n (t')^4 - \frac{\left[\sum_1^n (t')^2\right]^2}{n}.}; \quad a^{\copyright} = \frac{\sum_1^n Y - c^{\copyright} \sum_1^n (t')^2}{n}.$$

Calculation of the necessary sums is given in Table 5.

Transition to the initial variables is carried out by the following formulas:

$t = t' + 8$; $c' = c$; $a = a' - 8\,b' + 64\,c'$; $b = b' - 16\,c'$.

3. Calculation of the coefficient of pair correlation:

$$r = \frac{\sum Yt - \frac{(\sum Y)(\sum t)}{n}}{\sqrt{[\sum Y^2 - \frac{(\sum Y)^2}{n}][\sum t^2 - \frac{(\sum t)^2}{n}]}}.$$

Table 5

Calculation of the necessary sums for calculation of parameters of the parabola

t	Y_t	t'	$Y_t t'$	$(t')^2$	$(t')^4$	$Y_t(t')^2$	$\hat{Y}_t$	$e_t = Y_t - \hat{Y}_t$	e^2_t	$\frac{e_t}{Y_t}100$
1	2	3	4	5	6	7	8	9	10	11
1	3	– 7	-21	49	2 401	147	3.3	– 0.3	0.1	– 10
2		– 6								
...		...								
15		7								
		0	$\sum$	$\sum$	$\sum$	$\sum$	$\sum$		$\sum$	$\sum 1$, $\sum 2$

The tabular value of the coefficient of correlation for 15 supervisions and 90 % of probability is equal to *r* = 0.39 (Table 1). If the calculated value of the coefficient of correlation is more than the tabular one, than there is an essential connection between the considered indicator and the time.

4. The final choice of the function of the trend.

The first way is based on the analysis of indicators of accuracy of the forecast. Table 6 in which the values of indicators of accuracy of the forecast are entered is formed and that function to which the minimum values of mistakes correspond is accepted as a trend.

Table 6

Indicators of accuracy of the forecast

Indicators of accuracy of the forecast	Type of function	
	$Y_t = a + b\,t$	$Y_t = a + b\,t + c\,t^2$
1. The mean square deviation		
2. The average absolute percentage error of MARE		
3. The average percentage error of MRE		

The second method is based on the analysis of variance.

Calculate

$$F_r = S^2_f / S^2res,$$

where $S^2_f = V_f / g = (V - Vост) / g$;

$S^2res = V_{res} / (n - (g+1)) = (\sum(Y - \hat{Y})^2 / (n - (g + 1))$;

$V = \sum(Y - \bar{Y})^2$; the linear dependence of g = 1 to g = 2 parabola.

If $Fp > F_{tab}$, then the model can be used and the time factor *(t)* affects the demand (Table 9).

5. The method of series and the median for determining the components of a predictive model.

Table 7 in which the values of errors (e_t) for the chosen function of a trend are entered, is formed. From these mistakes a variation row, that is the values of the previous column (e_t) is formed which is registered in the ascending order. In a variation row we choose its median $e_м$ value to which an initial row (a column) is compared. If the number in the initial row is higher, we put a plus in the column.

6. From data column 4 we determine *Kmax,* the maximum extent of a series (the number of minuses or pluses) and *V (n)* of the total number of the series (zero is not considered).

The selection is considered to be casual if for 5 % of a significance value

$$K_{max} < [3.3 \ (\log n + 1)],$$
$$V(n) > [1/2 \ (n + 1 - 1.96\sqrt{n - 1})].$$

Brackets [ ] mean that the whole part is taken. If at least one inequality is broken, the hypothesis of the casual character of deviations of the levels of a temporary row from a trend is rejected. The forecast is based on two components: determined and casual. If inequalities aren't broken, the forecast is only based on the determined component.

Table 7

Definition of signs of series

Mistake e_t	A variation row (on themistake increase e_t)	The series sign (comparison of e_t with a median e_M)
– 0.3	– 56	+
4.1	– 23.8	–

7. Assessment of existence of autocorrelation.

7.1. The coefficient of autocorrelation is calculated by the formula

$$r_a = \frac{\sum_{t=1}^{n} e_t e_{t-1}}{\sum_{t=1}^{n} e_t^2}.$$

Compare r_a with the table $r_{5\,\%}$ for 5 % level of significance (Table 12). If $r_a > r_{5\,\%}$, it is necessary to build an autocorrelation autoregressive model $\hat{Y}_t = b_1 Y_{t-1} + b_2 Y_{t-2} + \ldots + b_k Y_{t-k}$.

Calculation of the autocorrelation coefficients (for k = 4 shifts) is done with the necessary sums in Table 7.

7.2. Darbin – Watson criterion $d = \frac{\sum_{t=1}^{n} (e_t - e_{t-1})^2}{\sum_{t=1}^{n} e_t^2}$.

Table 8

Calculation of the autocorrelation coefficient r_a

t	e_t	e_{t-1}	$e_t\,e_{t-1}$	e_t^2	e_{t-2}	$e_t\,e_{t-2}$	Etc.
1	2	3	4	5	6	7	8
1	23	– 4.5	– 103.5	529	0.4	9.2	
2	56	23	1288	3136	– 4.5	– 252	
3	– 12	56	– 672	224	23	276	
...	...	...	...	...	56	...	
13	– 12	...	...	...	...	...	
14	0.4	– 12	– 4.8	0.16	...	...	
15	– 4.5	0.4	– 1.8	– 20.25	– 12	54	
			$\sum$	$\sum$		$\sum$	

Payment of the required amounts is shown in Table 8.

If $d = 2$, there is no autocorrelation;

$d < -d1$ series contains apositive autocorrelation;

$d1 < d < -d2$ means uncertainty;

$d2$ contains no autocorrelation;

$d > 4 - d2$ there is a negative autocorrelation.

D1 and *d2* are tabulated (Table 10) for different numbers of observations, starting with 15, and a different number of parameters of the model forecast. If the model does not have a free member, the Darbin – Watson is not used.

7.3. John von Neumann criterion:

$$Kn = \frac{\dfrac{\sum_{2}^{n}(e_t - e_{t-1})^2}{n-1}}{\dfrac{\sum_{1}^{n} e_t^2}{n}}.$$

In this formula, the numerator is the sum of the squared differences between subsequent (e_t) and previous (e_{t-1}) errors. The payment of the required amounts is shown in Table 8.

Table 9

Payment criterion of John von Neumann *Kn*

t	e_t	e_t^2	$e_t - e_{t-1}$	$(e_t - e_{t-1})^2$
1	2	3	4	5
1	–23	529	–	–
2	+56	3 136	56–(–23)=79	6 241
...	...	...	...	...
15	...	...	...	...
	–	$\sum$	–	$\sum$

The estimated criterion *Kn* if compared with the data in Table 11, calculated for the positive $(Kn)'$ and negative $(Kn)'$ correlation.

If the settlement falls within the range criterion $Kn < ' < Kn\ Kn\ ,' '$ then there is no autocorrelation. If $Kn\ Kn\ ,'$ then there is a positive in the time series autocorrelation if $Kn > Kn\ -\ ' '$ is negative.

8. Calculation of forecast and confidence intervals.

Substitute in model $t = n + \tau$, where τ is the period of pre-emption *(at* $= \tau$ *1*, we obtain t = 15 +1 = 16), and determine the point forecast $\hat{Y}_{t\,t+\tau}$.

To calculate the confidence intervals it is necessary to know the standard error of prediction:

$$S_{t+\tau} = S_{\hat{y}} \sqrt{1 + \frac{1}{n} + \frac{3(n + 2\tau - 1^2}{n(n^2 - 1)}}.$$

For a given (τ = 1) the period of pre-emption is calculated. Knowing the standard error of prediction and point forecast, determine the confidence intervals of the expected size of demand for products for the 95 % probability by the formula:

$$\hat{Y}_{t+\tau} \pm 2S_{t+\tau}.$$

Put the received value of the forecast and its confidential intervals on the dynamics diagram.

Table 10

Values of criterion of Fischer F for 0.95 probability

K_{res}	The number of degrees of freedom of a variation for bigger dispersion (K_f)								
	1	2	3	4	5	6	7	8	9
1	161	199.5	215.71	224.58	230.16	233.9	236.7	238.8	240.54
2	18.51	19.00	19.164	19.240	19.296	19.33	19.35	19.37	19.385
3	10.12	9.552	9.277	9.117	9.014	8.941	8.887	8.845	8.812
4	7.709	6.944	6.591	6.388	6.256	6.163	6.094	6.041	5.999
5	6.608	5.786	5.410	5.192	5.050	4.950	4.876	4.818	4.099
6	5.987	5.143	4.757	4.534	4.387	4.287	4.207	4.147	4.099
7	5.591	4.737	4.347	4.120	3.972	3.866	3.787	3.726	3.677
8	5.318	4.459	4.066	3.838	3.688	3.581	3.501	3.438	3.388
9	5.117	4.257	3.863	3.633	3.482	3.374	3.293	3.230	3.179
10	4.965	4.103	3.708	3.478	3.326	3.217	3.136	3.072	3.020
11	4.844	3.982	3.587	3.357	3.204	3.095	3.012	2.948	2.896
12	4.747	3.885	3.490	3.259	3.106	2.996	2.913	2.849	2.796
13	4.667	3.806	3.411	3.179	3.025	2.915	2.832	2.767	2.714
14	4.600	3.739	3.344	3.112	2.958	2.848	2.764	2.699	2.646
15	4.543	3.682	3.287	3.056	2.901	2.791	2.707	2.641	2.588
16	4.494	3.634	3.239	3.007	2.852	2.741	2.657	2.591	2.538
17	4.451	3.592	3.197	2.965	2.810	2.699	2.614	2.548	2.494
18	4.414	3.555	3.160	2.928	2.773	2.661	2.577	2.510	2.456
19	4.381	3.522	3.127	2.895	2.74	2.628	2.544	2.477	2.423
20	4.351	3.493	3.098	2.866	2.711	2.599	2.514	2.447	2.393
25	4.242	3.385	2.991	2.759	2.603	2.490	2.405	2.337	2.282
30	4.171	3.316	2.922	2.690	2.534	2.421	2.334	2.266	2.211

Table 11

Darbin – Watson criterion (a five-percent significance value)

n	The number of variables in the equation connected with t									
	1		2		3		4		5	
	d_1	d_2	d_1	d_2	d_1	D_2	d_1	d_2	d_1	d_2
1	2	3	4	5	6	7	8	9	10	11
15	1.08	1.36	0.95	1.54	0.82	1.75	0.69	1.97	0.56	2.21
16	1.10	1.37	0.98	1.54	0.86	1.73	0.74	1.93	0.62	2.15
17	1.13	1.38	1.02	1.54	0.90	1.71	0.78	1.90	0.67	2.10
19	1.18	1.40	1.08	1.53	0.97	1.68	0.86	1.85	0.75	2.02

Table 11 (the end)

1	2	3	4	5	6	7	8	9	10	11
20	1.20	1.41	1.10	1.54	1.00	1.68	0.90	1.83	0.79	1.99
21	1.22	1.42	1.13	1.54	1.03	1.67	0.93	1.81	0.83	1.96
22	1.24	1.43	1.15	1.54	1.05	1.66	0.96	1.80	0.86	1.94
23	1.26	1.44	1.17	1.54	1.08	1.66	0.99	1.79	0.90	1.92
24	1.27	1.45	1.19	1.55	1.10	1.66	1.01	1.78	0.93	1.90
25	1.29	1.45	1.21	1.55	1.12	1.66	1.04	1.77	0.95	1.89
26	1.30	1.46	1.22	1.55	1.45	1.65	1.65	1.76	0.98	1.88
27	1.32	1.47	1.24	1.56	1.16	1.65	1.08	1.76	1.01	1.86
28	1.33	1.48	1.26	1.56	1.18	1.65	1.10	1.75	1.03	1.85
29	1.34	1.48	1.27	1.56	1.20	1.65	1.12	1.74	1.05	1.84
30	1.35	1.49	1.28	1.57	1.21	1.65	1.14	1.74	1.07	1.83

Table 12

Five- and one-percentage levels of importance of the relation to dispersion of an average square of consecutive differences (John von Neumann's criterion)

The number of selection	value $r > 0$		value $r < 0$	
	$\alpha = 0.01$	$\alpha = 0.05$	$\alpha = 0.05$	$\alpha = 0.01$
4	0.8341	1.0406	4.2927	4.4992
5	0.6724	1.0255	3.9745	4.3276
6	0.6738	1.0682	3.7318	4.1262
7	0.7163	1.0919	3.5748	3.9504
8	0.7575	1.1228	3.4486	3.8139
9	0.7974	1.1524	3.3476	3.7025
10	0.8353	1.1803	3.2642	3.6091
11	0.8706	1.2062	3.1938	3.5294
12	0.9033	1.2301	3.1335	3.4603
13	0.9336	1.2521	3.0812	3.3996
14	0.9618	1.2725	3.0352	3.3458
15	0.9880	1.2914	2.9943	3.2977
16	1.0124	1.3090	2.9577	3.2543
17	1.0352	1.3253	2.2947	3.2148
18	1.0566	1.3405	2.8948	3.1787
19	1.0766	1.3547	2.8675	3.1456
20	1.0954	1.3680	2.8425	3.1151
21	1.1131	1.3805	2.8195	3.0869
25	1.1748	1.4241	2.7426	2.9919
30	1.2363	1.4672	2.6707	2.9016
35	1.2852	1.5014	2.6163	2.8324

Table 13

Autocorrelation coefficients at 5 and 1 percentage significance values

Size selections	Values of levels of coefficients of correlation			
	The positive		The negative	
	α = 0.05	**α = 0.01**	**α = 0.05**	**α = 0.01**
5	0.253	0.297	– 0.753	– 0.798
6	0.345	0.447	– 0.708	– 0.863
7	0.370	0.510	– 0.674	– 0.799
8	0.371	0.531	– 0.625	– 0.764
9	0.366	0.533	– 0.593	– 0.737
10	0.360	0.525	– 0.564	– 0.705
11	0.353	0.515	– 0.539	– 0.679
12	0.348	0.505	– 0.516	– 0.655
13	0.341	0.495	– 0.497	– 0.634
14	0.335	0.485	– 0.479	– 0.615
15	0.328	0.475	–0.462	– 0.597
20	0.299	0.432	– 0.399	– 0.524
25	0.276	0.398	– 0.356	– 0.473
30	0.257	0.370	– 0.324	– 0.433
35	0.242	0.347	– 0.300	– 0.401
40	0.229	0.329	– 0.279	– 0.376

Day 3
Types of Innovations

Disruptive Innovation. This innovation appears from nowhere, creating a massive new source of wealth from certain technological discontinuities (e.g., Motorola's first generation cell phones; Sony's PlayStation One, Two and Plus; Apple's iPod and iTunes; the collector card game Pokémon, and the like).

Application Innovation. This innovation takes existing technology into new markets to serve new purposes (e.g., Tandem applied its fault-tolerant computers to the banking market to create ATMs; OnStar took Global Positioning Systems into the automobile market for roadside assistance).

Product Innovation. This innovation takes established market offerings in established markets to the next level focusing on the product performance increase (e.g., Intel releases its new microprocessor, Toyota releases its new hybrid Toyota Prius; Titleist Pro VI golf balls) or cost reduction (e.g., HP inkjet printers; Dell's personal computers or laptops), usability improvement (e.g., Palm handhelds, Blackberry) or any other product enhancement (e.g., various cell phones; iPod to iTunes).

Process Innovation. This innovation makes production processes of established products more efficient and effective (e.g., Wal-Mart's refinement of vendor-managed inventory process; Charles Schwab's migration to online trading; Dell's PC supply chain and order fulfillment systems; Fedex's package tracking).

Experiential Innovation. This innovation makes surface or cosmetic modifications to improve customer experience of established products or processes (e.g., Disneyland, Avis Rental, American Place, Hard Rock Café, MGM Casino).

Marketing Innovation. This innovation significantly improves customer-interfacing processes by such things as marketing communications (e.g., Web-based marketing; viral marketing), consumer transactions (e.g., Amazon's e-commerce mechanisms; eBay's online auctions).

Business Model Innovation. This innovation reframes an established value-proposition to the customer or a company's established role in the value chain or both (Gillette's move from razors to razor blades; IBM's shift to on-demand computing, and Apple's expansion into consumer retailing).

Structural Innovation. This innovation capitalizes on disruption to restructure industry relationships. For instance, Fidelity and Citigroup used the deregulation of financial services to offer broader arrays of products and services to consumers under one umbrella, thus becoming fierce competitors to traditional banks and insurance companies; Fannie May and Freddie Mac exploited credit deregulations to offer easy mortgage loans to homeowners who could scarcely afford them).

As an executive, what type of innovation would you focus on, when, and to what competitive advantage? Once we invoked the theory of core competencies to solve this problem: select the processes and products you are best at and focus your resources accordingly. But companies have discovered that being the best at something does not guarantee sustainable competitive advantage. A distinctive competence is valuable only if its drives or converts to purchase preferences. Customers ignore a company's core competencies in favor of products that are good enough and cheaper (Moore 2004: 88).

Each of these innovation types should respond to a given stage in the product or technology adoption life cycle as follows:

Early market of enthusiastic adopters and innovators and lifestyle setters; the media comes with glowing reports about your sensational product. Capitalize on the disruptive innovation your product implies.

The Chasm. The market stalls adoption; needs more time to understand and prefer your product over existing brands; the media watches for further market reaction; the market-response chasm could deepen and widen. Robust technologies withstand the chasm.

The Bowling Alley. The market regains confidence in your product; speaks well about your product; the late adopters or pragmatists now risk your product and embrace it; targeting one market influences and touches the other as in bowling when one pin hits the others. Work on application innovation to target multiple markets.

Tornado. The technology has passed the test of usefulness, safety and customer delight. It hits the market. Your product becomes the market format, standard or benchmark. Customers of all stripes flood the market and do not wish to be left behind. Maximize and energize product innovation to meet this burst of market enthusiasm.

Early Main Street. The era of hyper-growth has subsided, but the market is still growing nicely amidst early competition (oligopoly). Hit the market with exciting *process innovation* as customers are looking for systematic product improvements.

Mature Main Street. Your product/service has been highly commoditized and there is strong competition; the growth flattens; your sales revenues are stagnant; your profits are still improving since fixed costs are recovered. It is an indefinite elastic market period. If you want to survive the tough competition then you must heighten your experiential innovation to enrich customer experience and double up marketing innovation to increase differentiation.

Main Street Decline. Your technology is obsolete; your product is not responding to current market needs; customers are bored and withdraw to better competing brands. At this juncture, you must pull your remaining levers to fight the declining market: business model innovation and structural innovation.

The Fault Line. Technology obsolescence has struck like an earthquake, exposing the gaping and slippery fault line between what you can sell and what the market desires. Your *survival innovation* strategies will be to buy your competitors (leveraged buy out) or merge with them. With the market nearing the fault line, reinventing the product or radical restructuring of your enterprise may be an option.

The End of Life. Your market has vanished or is quickly vanishing. Hang to your old loyal customers for some solace. Spark fire by some revival innovation tactics; if none works, withdraw from the market, and focus your resources on new opportunities.

Day 4
A decision tree

A decision tree is a decision support tool that uses a tree-like graph or model of decisions and their possible consequences, including chance event outcomes, resource costs, and utility. It is one way to display an algorithm.

Decision trees are commonly used in operations research, specifically in decision analysis, to help identify a strategy most likely to reach a goal.

A decision tree is a flowchart-like structure in which internal node represents a test on an attribute, each branch represents an outcome of a test and each leaf node represents a class label (a decision taken after computing all attributes). A path from root to leaf represents classification rules.

In decision analysis a decision tree and the closely related influence diagram is used as a visual and analytical decision support tool, where the expected values (or expected utility) of competing alternatives are calculated.

A decision tree consists of 3 types of nodes:

decision nodes commonly represented by squares,

chance nodes represented by circles,

end nodes represented by triangles.

Decision trees are commonly used in operations research, specifically in decision analysis, to help identify a strategy most likely to reach a goal. If in practice decisions have to be taken online with no recall under incomplete knowledge, a decision tree should be paralleled by a probability model as a best choice model or online selection model algorithm. Another use of decision trees is as a descriptive means for calculating conditional probabilities.

Decision trees, influence diagrams, utility functions, and other decision analysis tools and methods are taught to undergraduate students in schools of business, health economics, and public health, and are examples of operations research or management science methods.

The decision-making process is considered by a manager as a method of the help of the strategic and operative purposes. The decision tree is used in decision-making under the conditions of risk, uncertainty, in designing an operating system, the process goods.

The content of the task

A businessman wants to open production. If the market is favorable, he will get a profit of 150 000 UAH. If the market is adverse, his loss will constitute 60 000 UAH. He can also conduct marketing research, which will cost him 75 000 UAH. The results of the research can be successful and unsuccessful.

The content of the task

An enterprise has decided to carry out capital or current reconstruction of the enterprise. There is an option – not to carry out reconstruction in general. With the favorable market the reconstruction will make a profit of 80 000 UAH. If the market is adverse, the costs will be 40 000 UAH. Current reconstruction will bring 60 000 UAH net profits with the favorable market and 30 000 UAH losses with the adverse market. The probability of decision-making is 0.5.

The content of the task

An enterprise has implemented a new line of production of parts. The sale during the life cycle is predicted at a rate of 100 000 pieces. The management considers 2 variants of decision on the release of these parts.

Decision A has a probability of 0.9 of production of 59 qualitative parts out of 100 and a probability of 0.1 of production of 64 qualitative parts out of 100. This decision requires costs of 1 000 000 UAH.

Decision B would have a probability of 0.8 of production of 64 qualitative parts out of 100 and a probability of 0.2 of production of 59 qualitative parts out of 100. This decision requires costs of 1 350 000 UAH.

The cost value of parts is 75 UAH, the payment price is 150 UAH. Bad payments are not considered.

The content of the task

An industrial organization receives relays from two suppliers (A and B). The quality of relays from these suppliers is presented in Table 14.

A standard set is 10 000 pieces. The rejected relays can be repaired at 0.5 UAH/unit. Though the quality of relays from supplier B is lower, the price he asks for 10 000 relays is 37 UAH less, than that from supplier A.

Construct a decision tree and specify a supplier, proceeding from the criterion of minimization of expenses.

Table 14

The quality of relays

Defect %	Probability of supplier A	Probability of supplier B
1	0.7	0.3
3	0.2	0.4
5	0.1	0.3

The content of the task

The university management contemplates a problem of building a restaurant with a bar for students. One of the options includes opening a bar for beer sale, and another one doesn't. The chances of success make 0.6, those of a failure are 0.4. The success of the plan which includes a bar, is estimated at 325 000 UAH of profit, and that without a bar may bring in 250 000 UAH. The losses of the plan with a bar make 70 000 UAH, without a bar they amount to only 20 000 UAH. Build a decision tree.

Day 5
Methodological basis for the formation of innovative potential of an enterprise

Few enterprises have a strong innovative potential, but still less can use it effectively. The problem stems from the lack of comprehensive research, methodological development and conceptual approaches to the management of the innovative potential of an industrial enterprise and its efficient use. For these reasons, the research potential of a company is an urgent task.

The difficulty in defining the innovation potential results from different understandings of the term "scientists" and the lack of comprehensive methodological research in this area. The disclosure of the concept "innovation potential" is advantageously carried out through the definition of its constituent categories, such as "potential" and "innovation".

The concept of capacity in relation to the individual employee, company, society, expresses a real ability to use the available resources to achieve the intended purpose. The concept of potency reflects only the theoretical aspect, not taking into account the real reproducing conditions, the ability of an individual employee, enterprise, society to use resources and create goods and services. Hence, for example, the production capacity of a company reflects the real, the actual ability to create a certain amount of wealth within specific resource constraints. In particular, the modern dictionary Macmillan provides the following definition: "... *potential output* is the maximum possible production a firm, industry, sector of the economy as a whole can achieve, defined security factors of production". That is, for the characterization of promising potential development parameters it is necessary to use such concepts as "the potential", "the potential level", etc. In the case of the description of the levels achieved, it is necessary to use the term "potential".

Also the concept of "capacity" in relation to the socio-economic system activity includes two components:

1) objective, implying a collection of various kinds of resources with a real opportunity to participate in any activities (production, innovation, etc.);

2) subjective which is the ability of workers (labor groups) to use resources and create certain material goods and services, as well as the ability of the administrative apparatus of an enterprise, industry, economic system as a whole to make optimum use of available resources.

After clarifying the methodological essence of the concept "potential" let's turn to the analysis of the theoretical aspects of the innovation potential.

It is known that innovation in accordance with International Standards is the end result of innovation, embodied in the form of new or improved product, launched in the market, new or improved technological process used in practice, or a new approach to social services. This definition is the basis for justification of the essence of the concept "innovation potential".

Taking into account the above, it should be emphasized that the potential of an enterprise is a fundamental principle of innovation. This methodological base essence of innovative potential is the concept of "potential" that has specific features based on targeting, i.e. providing a given (desired) level of innovation activity of an enterprise.

The concept of "innovation potential" was a reflection of the phenomenon of conceptual innovation. It was justified and clarified during the methodological, theoretical and empirical research, and more recently introduced in the number of concepts of economic science as an economic category. However, the scientific community has not yet developed a sufficiently precise definition of "innovation potential" of its component parts, the mechanism of formation.

Often perceived as innovative potential, technological advance in the form of discoveries, inventions, research, as well as scientific and technological level of development that allows solving new problems or that its essentially the same, the innovative potential is the economic opportunities of an enterprise to effectively engage new technologies into the economy.

However, one can agree only partially with this option, because the innovative potential implies a deeper concept, which is based on a comprehensive resource provision. Hence, the following definition is put forward: innovative potential contains unused latent potential accumulated resources that can be brought into action to achieve the goals of economic subjects.

In many studies, the authors focus their efforts on the analysis of individual aspects of innovation capacity, so often the definition is quite consistent and not focused on the methodological essence of the concept.

To analyze the concept of "innovation potential" domestic scientists use different scientific approaches:

A structural and institutional approach which isolates the structure of innovation in terms of institutional players engaged in innovation activities, as well as economic relations with the outside for its spheres – science and industry;

A functional approach which identifies temporal patterns in the innovation process: the production of an innovative product, its metabolism, distribution, consumption and a renewal cycle of the innovation process;

A resource-based approach which is based on the possibility to use each unit of the economic resource in the innovation process.

Evaluation criteria of the training

Control measures are components of the goal of education which is mastering a specific set of subject knowledge, development of skills and abilities that are the basis of an appropriate level of competence of the student.

Organization of control measures during training sessions involves checking:

which groups of competencies, skills, abilities of the future specialists have been formed in the course of study;

the nodal elements of the knowledge base of students who meet the level of educational qualifications;

forms and methods used for objective testing;

the scale used to evaluate the results of control.

The results of the training of each student are evaluated on a 100-point scale.

The criteria for evaluating the skills that a student has formed in the process of training are given in the Table 15.

Table 15

Evaluation criteria of the training

Evaluation criteria					
Formation of competences	Using the Internet	Using basic knowledge	Using the knowledge in practice	Creative problem solving	Total
30	10	15	20	25	100

Task 3. Assessment of impact factors using analysis of variance

The content of the task

A large company has a network of shops, and is interested in increasing the sales revenue, which depends on many factors: products quality, customer habits, location of stores, the presence of a number of competitors, as well as a properly designed and conducted marketing policy.

Fluctuations in the size of sales of certain goods depending on the day of the week and the shops location are given in Table 16. In this setting we study a two-factor model: one factor (A) is the day of the week, the second (B) is the location of the store.

The purpose of the task

Assess the effect of the location of the store and the day of the week on the fluctuations in the revenue from the sale of specific products using the analysis of variance.

Tables 16 and 17 show the initial data and the choice of the variant of the task.

The order of doing the task

1. Calculate the variation of the total sales revenue and the factors.

2. Determine the variance of the factors to assess materiality variance using the Fisher F-test (Table 18).

3. Calculate the net variance of the factors and provide an economic analysis of the results of the problem solution.

Guidelines for Task 3

The overall process variability (*V*) for the two-factor analysis (factors *A* and *B*) can be decomposed into variability of reasons:

$$V = V_A + V_B + Verr,$$

where V_A is variability by factor A (day);

V_B is variability due to factor V (store location);

Verr is residual variability due to other factors.

Variability is determined by the following formulas:

total:

$$V = \sum_{I=1}^{n}\sum_{J=1}^{P} X^2_{ij} - \frac{T^2}{N};$$

variability by factor *A*:

$$V_A = \frac{\sum_{J=1}^{P} A_J^{\ 2}}{n} - \frac{T^2}{N};$$

variability by factor *B*:

$$V_B = \frac{\sum_{1}^{n} B_i^2}{P} - \frac{T^2}{N};$$

residual variability:

$$V_{OC} = V - (V_A + V_B),$$

where $T = \sum A_j = \sum B_i$;

n is options factor *A* (the number of columns);

p is variations in the factors (number of lines of the source data).

Dispersion of factors is determined by the following formulas:
the total variance:

$$S^2 = \frac{V}{np-1};$$

dispersion factor *A*:

$$S^2{}_A = \frac{V_A}{p-1};$$

dispersion factor *B*:

$$S^2{}_B = \frac{v_B}{n-1};$$

the residual variance:

$$S^2{}_{err} = \frac{V_{err}}{(n-1)(p-1)};$$

the net variance of factor *A* is equal to:

$$\sigma^2{}_A = (S^2_A - S^2_{err})\frac{1}{p-1};$$

the net variance of factor *B* is equal to:

$$\sigma^2{}_B = (S^2_B - S^2_{err})\frac{1}{n-1};$$

the residual variance:

$$\sigma^2{}_{err} = S^2{}_{err};$$

the total net variance:

$$\sigma^2 = \sigma^2{}_A + \sigma^2{}_B + \sigma^2{}_{err}.$$

Table 16

The deviations of the actual revenue from the planned one

Days	Shop numbers										
	1	2	3	4	5	6	7	8	9	10	11
1	2	3	4	5	6	7	8	9	10	11	12
1	1	– 1	0	0	– 1	1	0	1	1	0	1
2	1	– 2	1	1	0	2	1	3	1	– 2	– 1

Table 16 (the end)

1	2	3	4	5	6	7	8	9	10	11	12
3	2	0	2	1	– 2	3	2	4	2	– 3	– 2
4	2	– 3	3	2	– 3	4	5	6	3	– 4	– 5
5	4	– 6	5	7	– 4	6	6	7	4	– 5	– 7
6	5	– 6	6	6	– 7	7	7	4	6	– 7	– 6

Table 17

Data for Task 3

Variant	Shop numbers	Variant	Shop numbers
1	1, 2, 3, 4, 5	15	6, 7, 8, 9, 10
2	2, 3, 4, 5, 6	16	7, 8, 9, 10, 11
3	3, 4, 5, 6, 7	17	4, 5, 9, 10, 11
4	1, 2, 4, 5, 6	18	6, 7, 9, 10, 11
5	1, 3, 4, 5, 6	19	6, 8, 9, 10, 11
6	1, 2, 5, 6, 7	20	5, 7, 8, 10, 11
7	1, 2, 4, 5, 8	21	1, 2, 7, 10, 11
8	2, 4, 5, 6, 8	22	5, 7, 8, 9, 10
9	2, 3, 5, 6, 7	23	4, 7, 8, 9, 10
10	1, 2, 3, 6, 7	24	3, 7, 8, 9, 10
11	1, 4, 5, 6, 7	25	2, 7, 8, 9, 10
12	1, 4, 5, 6, 10	26	1,7, 8, 9, 10
13	1, 3, 5, 7, 9	27	1, 3, 5, 8, 10
14	1, 3, 5, 6, 7	28	2, 3, 6, 7, 8

Table 18

The values of the criterion F-Fisher at 0.95

Kerr	The number of degrees of freedom for the greater variation of (Kf)									
	1	2	3	4	5	11	14	20	30	60
1	2	3	4	5	6	7	8	9	10	11
1	161.4	199.5	215.7	224.6	230.2	243	245	248	250	252
2	18.51	19.00	19.16	19.25	19.3	19.33	19.35	19.37	19.38	19.48
3	10.13	9.55	9.28	9.117	9.014	8.941	8.887	8.845	8.812	8.58
4	7.709	6.944	6.591	6.388	6.256	6.163	6.094	6.041	5.999	26.35
5	6.608	5.786	5.410	5.192	5.050	4.950	4.876	4.818	4.773	4.44
6	5.987	5.143	4.757	4.534	4.387	4.287	4.207	4.147	4.099	9.24
7	5.591	4.737	4.347	4.120	3.972	3.866	3.787	3.726	3.677	3.32
8	5.318	4.459	4.066	3.838	3.688	3.581	3.501	3.438	3.388	5.85
9	5.117	4.257	3.863	3.633	3.482	3.374	3.293	3.230	3.179	2.80
10	4.965	4.103	3.708	3.478	3.326	3.217	3.136	3.072	3.020	4.51
11	4.84	3.982	3.587	3.357	3.204	3.095	3.012	2.948	2.896	2.50
12	4.474	3.885	3.490	3.259	3.106	2.996	2.913	2.849	2.796	3.80
13	4.667	3.806	3.411	3.179	3.025	2.915	2.832	2.767	2.714	2.32
14	4.600	3.739	3.344	3.112	2.958	2.848	2.764	2.699	2.646	3.37
15	4.543	3.682	3.287	3.056	2.901	2.791	2.707	2.641	2.588	2.18
16	4.494	3.634	3.239	3.007	2.852	2.741	2.657	2.591	2.538	3.07
17	4.451	3.592	3.197	2.965	2.810	2.699	2.614	2.548	2.494	2.08
18	4.414	3.555	3.160	2.928	2.773	2.661	2.577	2.510	2.456	2.86
19	4.381	3.522	3.127	2.895	2.74	2.628	2.544	2.477	2.423	2.00
20	4.351	3.493	3.098	2.866	2.711	2.599	2.514	2.447	2.393	2.70
21	4.242	3.385	2.991	2.759	2.603	2.490	2.405	2.337	2.282	1.93
22	8.02	4.87	4.04	3.65	3.40	3.24	3.07	2.88	2.58	2.58
23	4.28	3.03	2.64	2.45	2.32	2.24	2.14	2.4	1.96	1.88
24	7.88	4.76	3.94	3.54	3.30	3.14	2.97	2.78	2.62	2.49

Table 18 (the end)

1	2	3	4	5	6	7	8	9	10	11
25	4.24	2.99	2.60	2.41	2.28	2.20	2.11	2.00	1.92	1.84
26	7.77	4.68	3.86	3.46	3.21	3.05	2.89	2.70	2.54	2.40
27	4.21	2.96	2.57	2.37	2.25	2.16	2.18	1.97	1.88	1.80
28	7.68	4.60	3.79	3.39	3.14	2.98	2.83	2.63	2.45	2.33
29	4.18	2.93	2.54	2.35	2.22	2.14	2.05	1.94	1.85	1.77
30	7.60	4.54	3.73	3.33	3.08	2.92	2.77	2.57	2.41	2.27

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9. State Statistics Committee of Ukraine [Electronic resource]. – Access mode : http://www.ukrstat.gov.ua.
10. National Bank of Ukraine [Electronic resource]. – Access mode : http://www.bank.gov.ua.
11. Press Service of the National Bank of Ukraine [Electronic resource]. – Access mode : http://pr.www.bank.gov.ua/ukr.

Content

EDUCATIONAL EDITION

Guidelines
to interdisciplinary training
"ORGANIZATION AND MODELLING OF INNOVATIVE ACTIVITY"
for full-time students of training direction 6.030601 "Management"

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