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**TRANSLATION OF PUBLISHED ARTICLE**

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# SOCIAL-ECONOMIC FACTORS IN THE PREDICTIVE ESTIMATION OF CRIMES IN UKRAINE

*(ABSTRACT, KEY WORDS)*

**Problem statement.** The development of new forms of crime, as well as modern methods of its research, leads to the formation of fundamentally new approaches to the knowledge of the relationship between criminological indicators and predictors of crime. In the structure of crime, such interdependencies represent the most probable object of study, where the structure, level, intensity, and quality of crime are affected by a large number of identified and uncertain factors. A number of indicators are considered that affect the number of reported crimes, with the highest focus on macroeconomic indicators. First of all: the number of unemployed; the average monthly salary; consumer price index; the volume of industrial products sold; retail trade turnover; industrial production index; natural population decline. **The purpose** and the objectives of the study are: 1) conducting a correlation analysis between the relative quantitative indicator of crime and the relative indicators of economic development of the regions of Ukraine; 2) conducting a regression analysis and constructing a regression model of the relationship between individual socioeconomic indicators and the state of crime. The solution to these problems is to apply the author's approach to modeling the relationship between the crime rate and the relative indicators of economic development of the region, as well as to create a regression model of the prediction of the crime rate depending on the factors determined by the researcher and development factors. **Methods.** The research method is General scientific dialectical, statistic methods. **The result** of the study is the construction of an informative predictive model of crime, which allows quantifying the impact on crime by individual socio-economic factors. **Conclusions.** Construction of regression models and assessment of their quality showed that the most accurate equation is the dependence of the crime rate on retail turnover (per 10 thousand population) and on the number of unemployed (UAH per 1 person). On the basis of the basic variant of the projection, the principal possibility of forecasting the number of registered crimes per 10 thousand population by introducing into the model quantitative indicators of the economic development of the region, namely the number of unemployed and retail trade (in relative terms) is proved. The global tendencies of the dependence of crime on macroeconomic factors and technological development are analyzed. The practical significance of the obtained results for the development of programs for forecasting and minimizing the impact of future trends and patterns of crime are outlined.

***Key words:*** *macroeconomic factors; relative indicators; regression models; forecasting the number of crimes; criminological and mathematical methods; the impact of technology development*

## Problem statement

The development of new forms of crime, as well as modern methods of its research, has led to the formation of fundamentally new approaches to the knowledge of the relationship between criminological indicators and predictors of crime.

In the structure of crime, such interdependencies represent the most probable object of study, where the structure, level, intensity and quality of crime are affected by a large number of identified and uncertain factors. Factors in criminology are understood as factors of influence, predictors, determinants, etc., that is, those aspects of influence on crime that operate in different directions without the possibility of specifying what that influence is: causal (which inevitably entails consequences) or influence conditions (which implements a temporary coincidence of all kinds of circumstances of a situational nature, which by themselves do not have the content of a specific negative premise).

Thus, according to the results of our research [1], the following three levels of factors are mainly influenced by the reliability of estimating and predicting crime rates:

– social, economic, political. These factors are general in nature and unrelated to a specific type of crime, but they have an impact on all processes occurring in society and the level of crime in general;

– the territory of the crime, the physical characteristics of the object, the temporal factors (above all, the external conditions of the crime, which, unlike the causes, are temporary), material conditions, and more. These factors are local in nature and related to the specificities of a particular place and region;

– personal, directly related to the person of the perpetrator and the victim.

However, it is the action of the macroeconomic indicators of these factors that has a comprehensive and demonstrable impact on various types of crime. These are such as individual influence on the formation of criminal motivation; the overall impact on the structure of crime and on the level of crime of selfish and selfish and violent direction; general and individual impact on the nature and results of crime prevention and resocialization and others.

Of particular importance are socio-economic factors of influence. For example, in the study of the determinants of regional crime that cause quantitative and qualitative changes in regional crime in Ukraine, A.M. Babenko calls the presence of aggregate resource and natural-resource potential in the regions, organizational and managerial miscalculations, negative consequences of economic transformations, factors of size and location of settlements, number and structure of population of the region, fertility, marriage and divorce, mortality, level of urbanization, migration [2, p.251–282]. V.M. Beschastnyj among the socio-economic factors, that have a pronounced connection with the criminal activity of the population, notes an increase in consumer prices (food, utilities, household goods, appliances, current housing maintenance, health care); decrease in real incomes of the population; rising unemployment; reducing the level of social protection of low-income groups [3, p.47-49].

In turn, O.M. Humin, on the impact of such a factor as unemployment, emphasizes that among the violent criminals there is a steady increase in the number of non-students who are not studying, are not engaged in work or other socially beneficial activities, although they have objective opportunities for this. This affects the formation of the motivational sphere of the offender [4, p.140]. O.O. Belousova notes that such a factor as the instability of the economy also causes a significant influence on the strengthening of the positions of criminal formations in the regions (83% of the polled experts) [5, p.25].

According to a study by Alves L.G. Ribeiro H. V., Lenzi E. K., Mendes R. S. (2013) on the link between homicides and eleven factors in Brazilian cities, gross domestic product per capita, income levels, and the criminal age of the male population have a positive correlation with homicide; while child labor, the elderly population, the female population, illiteracy, poor living conditions, unemployment have a negative correlation with homicides [6].

Kelly M. (2000) on the link between economic inequality and crime for urban areas in the United States has demonstrated that socially disadvantaged people have committed the most violent crimes, and the most deprived members of society living in areas with significant social inequality face great pressure and incentives to commit crimes. This is what leads to their criminalization [7]. For Hojman D.E. (2004), inequality, unemployment, and crime in Latin American cities, taking into account the diversity of cities, are factors that influence poverty and inequality as causes of crime [8].

In general, the link between crime and various influences such as demographics [6] is demonstrated by Alves L.G. Ribeiro H.V., Lenzi E.K., Mendes R.S. (2013); economics [7; 9; 10] – Kelly M. (2000), Cotte Poveda A. (2012) and Lauritsen J.L., Rezey M.L., Heimer K. (2014) and unemployment [8; 11; 12] – study by Hojman D.E. (2004, 2002) and Levitt S.D. (2001). Therefore, the purpose of the article is to describe an informative predictive model of crime, which quantitatively characterizes the impact on crime of certain socio-economic factors. His scientific novelty is to model the relationship between crime rates and relative indicators of economic development in the region, as well as to create a regression model for predicting crime rates depending on the factors of relative economic indicators of the region's development. The objectives of the article are: analysis of crime statistics in the regions and dynamics of indicators of regional economic development; establishment of correlation between the relative quantitative index of crime and the relative indexes of economic development of the regions of Ukraine; constructing a regression model of the relationship between individual socio-economic indicators and the state of crime; outlining the world trends and main directions of further research.

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**Analysis of regional statistics and correlation between crime rate and economic development indicators**

There are three main approaches to estimating crime rates: revenue, cost and comparability. At the same time, the crime rate is estimated on the basis of the moral-psychological personality traits of the offender, and indicators of the economic development of the territory in which the crime is committed are often disregarded.

Tables 1 and 2 provide statistics on crime in the regions and the dynamics of regional economic development indicators as of 2018. Due to the lack of reliable data, since 2014, official state statistics do not contain statistical data on the Autonomous Republic of Crimea and Sevastopol.

**Table 1 – Indicators of economic development of Ukrainian regions in 2018**[1]

| Regions of Ukraine | Number of unemployed (thousand people) | Average monthly salary of the employee (UAH) | Consumer price index (%) | Sales volume of industrial products (UAH million) | Retail trade turnover (UAH million) | Industrial production index (%) | Natural movement of the population (decrease) (persons) |
|---|---|---|---|---|---|---|---|
| Vinnytsia Oblast | 20,8 | 7672 | 109,0 | 69878,9 | 25264,5 | 101,2 | 10368 |
| Volyn Oblast | 7,8 | 7 | 109,9 | 27398,6 | 16322,7 | 102,3 | 1949 |
| Dnipropetrovsk | 25,7 | 8743 | 109,2 | 435789,1 | 85085,4 | 102,3 | 24198 |
| Zhytomyr Oblast | 14,3 | 7259 | 109,1 | 40176,0 | 23376,7 | 97,3 | 8450 |
| Zakarpattia Oblast | 4,6 | 7902 | 112,2 | 21543,8 | 21921,8 | 104,6 | 952 |
| Zaporizhia Oblast | 22,3 | 8573 | 109,2 | 192905,8 | 38486,2 | 103,2 | 13685 |
| Ivano-Frankivsk | 8,1 | 7480 | 109,1 | 65011,4 | 21922,1 | 110,0 | 4114 |
| Kyiv Oblast | 12,3 | 8909 | 110,0 | 102345,2 | 65600,7 | 100,4 | 12078 |
| Kirovohrad Oblast | 15,6 | 7101 | 109,0 | 26750,1 | 16844,1 | 101,7 | 7538 |
| Lviv Oblast | 13,4 | 7893 | 110,1 | 90707,4 | 57552,0 | 101,4 | 8167 |
| Mykolaiv Oblast | 16,4 | 7980 | 109,4 | 51655,5 | 22369,4 | 102,6 | 7210 |
| Odessa Oblast | 16,6 | 7871 | 109,3 | 52490,7 | 69047,4 | 91,8 | 8920 |
| Poltava Oblast | 20,3 | 8232 | 109,3 | 168177,1 | 30932,0 | 101,4 | 12028 |
| Rivne Oblast | 12,0 | 7279 | 109,3 | 33553,3 | 17237,0 | 95,3 | 751 |
| Sumy Oblast | 15,5 | 7223 | 109,7 | 43767,6 | 19457,9 | 110,4 | 9707 |
| Ternopil Oblast | 9,6 | 6848 | 109,7 | 19670,6 | 13022,6 | 98,3 | 5780 |
| Kharkiv Oblast | 22,0 | 7528 | 111,2 | 169449,9 | 72132,3 | 101,9 | 20165 |
| Kherson Oblast | 11,2 | 6930 | 109,5 | 25645,7 | 21763,9 | 99,8 | 6204 |
| Khmelnytskyi Oblast | 12,9 | 7199 | 109,2 | 39543,4 | 20551,0 | 95,2 | 7974 |
| Cherkasy Oblast | 17,8 | 7375 | 109,7 | 63388,1 | 22532,7 | 101,9 | 10404 |
| Chernivtsi Oblast | 5,9 | 6805 | 108,7 | 13578,1 | 15151,8 | 105,5 | 2132 |
| Chernihiv Oblast | 11,8 | 6904 | 109,6 | 31687,9 | 18088,2 | 98,7 | 11152 |
| Kyiv | 8,6 | 13270 | 108,8 | 167980,6 | 176964,7 | 97,8 | 2790 |
| Donetsk Oblast | 10,7 | 9444 | 111,2 | 228893,5 | 22652,2 | 102,3 | 17745 |
| Luhansk Oblast | 8,2 | 7245 | 109,3 | 20748,5 | 8176,9 | 102,3 | 9316 |

[1] Compiled by the author on the basis of [13, p.25–27; 14–16].

**Table 2 – Indicators of crime rate and structure, as well as population in regions of Ukraine in 2018**[2]

| Regions of Ukraine | Number of reported criminal offenses | Number of serious and especially serious crimes | The number of crimes committed while intoxicated | Number of crimes committed by persons who have previously committed crimes | Number of persons found to have committed crimes | The size of the population in the region |
|---|---|---|---|---|---|---|
| Vinnytsia Oblast | 12589 | 4700 | 596 | 1839 | 4277 | 1561811 |
| Volyn Oblast | 9296 | 3576 | 399 | 1293 | 2446 | 1035867 |
| Dnipropetrovsk Oblast | 45652 | 17871 | 611 | 9605 | 12586 | 3209075 |
| Zhytomyr Oblast | 14178 | 5303 | 340 | 1425 | 4125 | 1221469 |
| Zakarpattia Oblast | 11006 | 4423 | 366 | 1171 | 3157 | 1257139 |
| Zaporizhia Oblast | 26607 | 9444 | 793 | 5207 | 6869 | 1707288 |
| Ivano-Frankivsk Oblast | 7386 | 2758 | 247 | 477 | 2281 | 1373705 |
| Kyiv Oblast | 20109 | 9396 | 384 | 2035 | 5580 | 1767172 |
| Kirovohrad Oblast | 15415 | 7206 | 363 | 2003 | 3194 | 946621 |
| Lviv Oblast | 25764 | 9036 | 471 | 3282 | 5844 | 2523116 |
| Mykolaiv Oblast | 19146 | 6534 | 442 | 2118 | 4223 | 1131984 |
| Odessa Oblast | 33038 | 14332 | 328 | 1711 | 5346 | 2380512 |
| Poltava Oblast | 21363 | 6591 | 686 | 4971 | 4847 | 1401694 |
| Rivne Oblast | 10273 | 3659 | 254 | 1454 | 2946 | 1157822 |
| Sumy Oblast | 11872 | 3839 | 243 | 2516 | 3870 | 1082317 |
| Ternopil Oblast | 7063 | 2240 | 63 | 442 | 2467 | 1046287 |
| Kharkiv Oblast | 36353 | 14130 | 1193 | 7429 | 7908 | 2678133 |
| Kherson Oblast | 16032 | 5790 | 319 | 3988 | 4170 | 1038691 |
| Khmelnytskyi Oblast | 11172 | 3458 | 341 | 1610 | 3526 | 1265781 |
| Cherkasy Oblast | 15559 | 6132 | 291 | 1100 | 2931 | 1207583 |
| Chernivtsi Oblast | 7725 | 2323 | 173 | 765 | 1949 | 904646 |
| Chernihiv Oblast | 14203 | 4403 | 501 | 1557 | 2917 | 1007224 |
| Kyiv | 60037 | 23390 | 142 | 2803 | 8204 | 2949558 |
| Donetsk Oblast | 20953 | 7537 | - | - | - | 4175471 |
| Luhansk Oblast | 10358 | 4262 | 492 | 2077 | 3677 | 2153216 |

[2] Based on [15; 17].

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Table 3 presents the relative indicators of economic development of Ukrainian regions and crime rates in 2018.

**Table 3 – Relative indicators of economic development of Ukrainian regions and crime rates in 2018[3]**

| Regions of Ukraine | Number of unemployed (persons per 10 thousand population) | Volume of industrial products sold (UAH per 1 person) | Retail trade turnover (UAH per 1 person) | Natural movement of population (persons) (decrease) (in%) | Number of reported criminal offenses (per 10 thousand population) - crime rate |
|---|---|---|---|---|---|
| Vinnytsia Oblast | 133,18 | 44742,2 | 16176,4 | 0,66 | 80,6 |
| Volyn Oblast | 75,30 | 26449,9 | 15757,5 | 0,19 | 89,7 |
| Dnipropetrovsk Oblast | 80,09 | 135799,0 | 26514,0 | 0,75 | 142,3 |
| Zhytomyr Oblast | 117,07 | 32891,5 | 19138,2 | 0,69 | 116,1 |
| Zakarpattia Oblast | 36,59 | 17137,2 | 17437,8 | 0,08 | 87,5 |
| Zaporizhia Oblast | 130,62 | 112989,6 | 22542,3 | 0,80 | 155,8 |
| Ivano-Frankivsk Oblast | 58,96 | 47325,6 | 15958,4 | 0,30 | 53,8 |
| Kyiv Oblast | 69,60 | 57914,7 | 37121,9 | 0,68 | 113,8 |
| Kirovohrad Oblast | 164,80 | 28258,5 | 17793,9 | 0,80 | 162,8 |
| Lviv Oblast | 53,11 | 35950,5 | 22809,9 | 0,32 | 102,1 |
| Mykolaiv Oblast | 144,88 | 45632,7 | 19761,2 | 0,64 | 169,1 |
| Odessa Oblast | 69,73 | 22050,2 | 29005,3 | 0,37 | 138,8 |
| Poltava Oblast | 144,82 | 119981,3 | 22067,6 | 0,86 | 152,4 |
| Rivne Oblast | 103,64 | 28979,7 | 14887,4 | 0,06 | 88,7 |
| Sumy Oblast | 143,21 | 40438,8 | 17978,0 | 0,90 | 109,7 |
| Ternopil Oblast | 91,75 | 18800,4 | 12446,5 | 0,55 | 67,5 |
| Kharkiv Oblast | 82,15 | 63271,7 | 26933,8 | 0,75 | 135,7 |
| Kherson Oblast | 107,83 | 24690,4 | 20953,2 | 0,60 | 154,3 |
| Khmelnytskyi Oblast | 101,91 | 31240,3 | 16235,8 | 0,63 | 88,3 |
| Cherkasy Oblast | 147,40 | 52491,7 | 18659,3 | 0,86 | 128,8 |
| Chernivtsi Oblast | 65,22 | 15009,3 | 16748,9 | 0,24 | 85,4 |
| Chernihiv Oblast | 117,15 | 31460,6 | 17958,5 | 1,11 | 141,0 |
| Kyiv | 29,16 | 56951,1 | 59997,0 | 0,09 | 203,5 |
| Donetsk Oblast | 25,63 | 54818,6 | 5425,1 | 0,42 | 50,2 |
| Luhansk Oblast | 38,02 | 9636,1 | 3797,5 | 0,43 | 48,1 |

For the correlation analysis between crime and economic development of the region from tables 1 and 3, we select *the relative indicators of economic development of the regions and the number of reported criminal offenses per 10 thousand populations* (Y) – crimes. The factors of economic development are the following:

1) the number of unemployed per 10 thousand population of the region (X1) – persons;

2) average monthly salary of an employee in the region (X2) – UAH;

3) consumer price index in the region (X3) – %;

4) volume of industrial products sold per person (X4) – UAH;

5) retail trade turnover per person (X5) – UAH;

6) industrial production index (X6) – %;

7) natural decrease of the region's population (X7) – %.

The results of the correlation analysis are presented in table 4.

[3] Calculated on the basis of tables 1, 2.

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**Table 4 - Correlation coefficients between crime rates per 10,000 population (Y) and regional economic development indicators (X1–X7)**

| Variable | X1 | X2 | X3 | X4 | X5 | X6 | X7 | Y |
|---|---|---|---|---|---|---|---|---|
| X1 | 1,000000 | | | | | | | |
| X2 | -0,407647 | 1,000000 | | | | | | |
| X3 | -0,376302 | -0,009986 | 1,000000 | | | | | |
| X4 | 0,207349 | 0,392448 | -0,093435 | 1,000000 | | | | |
| X5 | -0,147058 | 0,752570 | -0,170053 | 0,306939 | 1,000000 | | | |
| X6 | 0,016347 | -0,111572 | 0,171944 | 0,153740 | -0,238936 | 1,000000 | | |
| X7 | 0,706983 | -0,270204 | -0,146201 | 0,397475 | -0,095720 | 0,081389 | 1,000000 | |
| Y | 0,404453 | 0,417271 | -0,255541 | 0,408920 | 0,702189 | -0,231757 | 0,338184 | 1,000000 |

From their analysis it can be established that:

– there is a strong correlation between the number of unemployed (X1) and the natural decrease of the population of the region (X7) – the correlation coefficient is 0.71, between the average monthly wage of the worker (X2) and the turnover of retail trade (X5) – 0.75, between the number crimes per 10 thousand population (Y) and retail trade turnover (X5) – 0.70;

– there is a weak correlation between the number of unemployed (X1) and the average monthly wage of an employee (X2) – (–0.41), the number of crimes per 10 thousand population (Y) and the number of unemployed (X1) – 0.40, the number of registered crimes (Y) and the average monthly wage (X2) – 0.42, the number of crimes (Y) and the volume of industrial production (X4) – 0.41, the volume of industrial production (X4) and the natural decrease in the population of the region (X7) – 0.40;

– there is practically no correlation between the number of reported crimes (Y) and the consumer price index (X3), the industrial production index (X6), and the natural decrease in the region's population (X7).

At the stage of constructing the regression model, the economic factors that have the greatest impact on crime are selected. Due to the fact that many factors make the model cumbersome, inconvenient to use and complicate the study of the impact of individual predictors, it is necessary to include only a rational set of factors in the final version of the regression model.

The factor exclusion method we use is that highly correlated factors are excluded from the regression. They are selected using the Cheddock scale. Significance criteria – even correlation coefficient: 0 to 0.3 – no relationship; 0.3 to 0.5 – weak link; 0.5 to 0.7 – moderate communication; 0.7 to 1.0 – strong connection [18].

Factors X1, X2, X4, X5 are closely related to the dependent variable Y, which is why they form the basis of the crime prediction model. Since factors X2 and X5 are highly correlated (0.75), only one of them should be included in the regression model. This is the factor X5 because of its greater correlation with the dependent variable (Y).

**Regression model of crime intensity depending on given factors**

For calculations, we have chosen a linear function because of its simplicity of interpretation and the smallest prediction error. Thus, the equation for the prediction of the crime rate is:

$$Y = Ao + A1 * X1 + A4 * X4 + A5 * X5,$$

where Y is the value of the function (the number of reported crimes per 10 thousand population is the crime rate);

Ao is a free member of the regression equation;

A1, A4, A5 are regression coefficients;

X1 – number of unemployed per 10 thousand population;

X4 – volume of industrial products sold per person;

X5 – retail trade turnover per 1 person.

The use of multivariate analysis to calculate the number of reported crimes gives more accurate results than the pair correlation, so in most cases such analysis is more prioritized. The multiple correlation method allows you to calculate the number of reported crimes as a whole, and the paired correlation method is better used to calculate individual changes. For a detailed study of the relationship and the estimation of the accuracy of the forecast, one can further build one-factor models:

$$Y = Ao + A1 * X1;$$
$$Y = Ao + A4 * X4;$$
$$Y = Ao + A5 * X5.$$

The initial data for constructing the regression models are presented in Table 5. The following is an assessment of the adequacy of the constructed regression equations and verification of the possibility of describing the relationship between the response function and the predictors of the linear model:

$$Y = Ao + A1 * X1 + A4 * X4 + A5 * X5.$$

The check used the STATISTICA Multiple Regression module (StatSoft Inc., USA).

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**Table 5 - Baseline data for constructing a regression model[4]**

| Regions of Ukraine | Number of unemployed (persons per 10 thousand population) (X1) | Industrial output (UAH per person) (X4) | Retail trade turnover (UAH per 1 person) (X5) | The crime rate (per 10 thousand population) (Y) |
|---|---|---|---|---|
| Vinnytsia Oblast | 133,18 | 44742,2 | 16176,4 | 80,6 |
| Volyn Oblast | 75,30 | 26449,9 | 15757,5 | 89,7 |
| Dnipropetrovsk Oblast | 80,09 | 135799,0 | 26514,0 | 142,3 |
| Zhytomyr Oblast | 117,07 | 32891,5 | 19138,2 | 116,1 |
| Zakarpattia Oblast | 36,59 | 17137,2 | 17437,8 | 87,5 |
| Zaporizhia Oblast | 130,62 | 112989,6 | 22542,3 | 155,8 |
| Ivano-Frankivsk Oblast | 58,96 | 47325,6 | 15958,4 | 53,8 |
| Kyiv Oblast | 69,60 | 57914,7 | 37121,9 | 113,8 |
| Kirovohrad Oblast | 164,80 | 28258,5 | 17793,9 | 162,8 |
| Lviv Oblast | 53,11 | 35950,5 | 22809,9 | 102,1 |
| Mykolaiv Oblast | 144,88 | 45632,7 | 19761,2 | 169,1 |
| Odessa Oblast | 69,73 | 22050,2 | 29005,3 | 138,8 |
| Poltava Oblast | 144,82 | 119981,3 | 22067,6 | 152,4 |
| Rivne Oblast | 103,64 | 28979,7 | 14887,4 | 88,7 |
| Sumy Oblast | 143,21 | 40438,8 | 17978,0 | 109,7 |
| Ternopil Oblast | 91,75 | 18800,4 | 12446,5 | 67,5 |
| Kharkiv Oblast | 82,15 | 63271,7 | 26933,8 | 135,7 |
| Kherson Oblast | 107,83 | 24690,4 | 20953,2 | 154,3 |
| Khmelnytskyi Oblast | 101,91 | 31240,3 | 16235,8 | 88,3 |
| Cherkasy Oblast | 147,40 | 52491,7 | 18659,3 | 128,8 |
| Chernivtsi Oblast | 65,22 | 15009,3 | 16748,9 | 85,4 |
| Chernihiv Oblast | 117,15 | 31460,6 | 17958,5 | 141,0 |
| Kyiv | 29,16 | 56951,1 | 59997,0 | 203,5 |
| Donetsk Oblast | 25,63 | 54818,6 | 5425,1 | 50,2 |
| Luhansk Oblast | 38,02 | 9636,1 | 3797,5 | 48,1 |

The results of the information processing program are evaluation indicators and significant standardized regression coefficients:

Dependent: The crime rate.
Multiple R = 0,86979447 (multiple correlation coefficient);
F = 34,18241, df = 2,22, p = 0,000000 (F-criterion value, number of degrees of freedom, and significance level p) - used as a general F-criterion to test the hypothesis of predictor dependence and response;
$R^2$ = 0,75654243 (coefficient of determination);
No. of cases: 25 (the number of observations on which the regression model is constructed);
adjusted $R^2$ = 0,73440992 (adjusted coefficient of determination);
Standard error of estimate: 21,036395848 (standard error of estimation). These statistics are a measure of the scattering of the observed values relative to the regression line;
Intercept: 5,359584660 (estimation of free regression term Ao);
Std.Error: 14,44986 (standard free member evaluation error Ao);
t(22) = 0,37091, p = 0,7143 (t-criterion value and significance level p) to test the hypothesis that zero is free of Ao;
retail trade turnover b * = 0,779;
the number of unemployed b * = 0,519.

The variable "Volume of industrial products sold" was defined by the program as not being a significant predictor. It follows that the relationship between response and predictors is strong ($R^2$> 0.75); constructed linear regression adequately describes the relationship between response and predictors, the free term being statistically significant. In the table 6 shows the model performance.

[4] Based on Tables 1-3.

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**Table 6 - Model: regression results**

| N=25 | Beta | Std. Err. of Beta | B | Std.Err. of B | t(22) | p-level |
|---|---|---|---|---|---|---|
| Intercept | | | 5,359585 | 14,44986 | 0,370909 | 0,714253 |
| Retail trade turnover | 0,778503 | 0,106353 | 0,002979 | 0,00041 | 7,320022 | 0,000000 |
| Number of unemployed | 0,518938 | 0,106353 | 0,514737 | 0,10549 | 4,879415 | 0,000071 |

Table 6 contains standardized (Beta) and nonstandardized (B) regression coefficients (weights), their standard errors, and significance levels. Beta coefficients are estimated from standardized data having a sample mean of 0 and a standard deviation of 1. This compares the contributions of each predictor to the response prediction. Yes, the dependent variable Y (the crime rate) contributes more to variable X5 (Retail trade turnover) and less to X1 (Unemployed). The fact that the coefficients for the variables are not negative numbers means that with the increase in retail trade turnover and the number of unemployed, the number of registered crimes increases.

The regression equation can be used to predict the values of the response - the number of crimes reported per 10,000 population by the values of the predictors: retail turnover and the number of unemployed.

For example, if you enter the value "retail trade turnover (UAH per 1 person)" – 40,000, and "number of unemployed (persons per 10 thousand population)" – 150, then the predicted (number of registered crimes (crime rate) – 201,7470 per 10 thousand population with 95% confidence interval (178,0996; 225,3943).

One of the conditions for the correct application of regression analysis is compliance of the law of distribution of residues with the normal law, the graph of which is presented in the diagram.

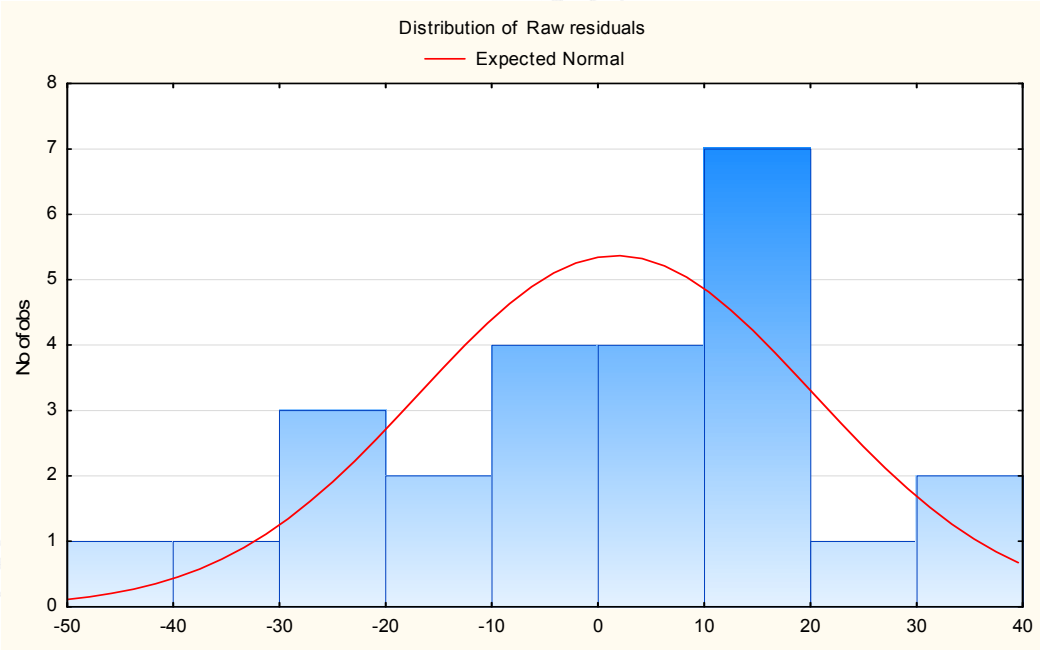


**Diagram - Schedule of distribution of residues**

The graph shows that due to the small number of observations (25), the distribution of residues does not fully correspond to the normal law.

By regression analysis, we can determine that the linear model looks like:

Y (The crime rate) = 5.3596 + 0.514737 * X1 (Unemployed) + 0.002979 * X5 (Retail trade turnover)

Summand "Retail trade turnover" with a coefficient of 0.002979 from this particular model can be

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excluded because of the statistical insignificance of the coefficient. That is, the hypothesis of equality of zero is correct.

Note that this model will be sufficiently accurate, provided that the independent variables (predictors) lie within the limits specified by the data table. Outside these limits, the model may be unreliable.

**Outlining the world trends and main directions of further research within the framework of criminological modeling and forecasting**

The practical application of this model is optimal within the framework of the general concept, the basic scheme of which [19, p.32] is given by Canadian criminologists led by Stephen Sneider (2007). According to these criminologists, the influence of two factors is quite significant: macroeconomic indicators (for example: economic development, unemployment, consumer spending) and demographic factors (the number of men at the age most prone to crime) [19, p.8]. In the case of Ukraine, modeling should also take into account the level of population migration. Another important factor is the development of technology in the country and the age structure of the population.

This shows that in countries with a large proportion of the young population there is a steady increase in crime and in countries with an "aging nation" – the crime rate tends to decrease. Time series models of the relationship between the potentially criminally active population and the crime rate tend to indicate that both property and violent crime rates correlate significantly with changes in population structure.

Although the impact of economic development on crime rates has been the subject of much debate, there is no doubt that such an impact is most noticeable when analyzing self-serving crime. Thus, in periods of economic growth in the country decreases the number of selfish encroachments, and in periods of regression and decline their number is steadily increasing. However, economic growth in countries with a significant shadow economy and significant corruption has no negative correlation with unemployment. Therefore, conclusions about the level of selfish and corrupt crime that are relevant to countries with a traditionally normalized economy do not always work for countries whose economies are corrupt.

On the other hand, there may be a situation where the growth of the shadow economy leads to a gradual enrichment of part of the population, thus creating the conditions for committing crimes against property. In this case, we are dealing with a macroeconomic indicator - consumer spending. Absence of correlation or a positive correlation between the unemployment rate and the level of consumer spending can indicate problems of economic development, which in turn inevitably lead to an increase in the real level of selfish and property crimes. It should be borne in mind that official statistics can conceal this fact because of the same corruption issues in law enforcement agencies and lack of control over the registration discipline.

The macroeconomic indicator of government spending per capita has a negative correlation with the level of self-serving crimes in the country. That is, with the reduction of spending from the budgets of all levels on social programs, education, medicine, etc., the number of selfish crimes increases. This conclusion is valid for countries with any economic development.

Regarding the impact of technological development of the state on crime, there is an opinion on the distribution of such influence in three directions: a) technological progress provides criminals with new tools for committing traditional crimes (for example: fraud, theft, money laundering and counterfeiting); b) technology itself becomes the target of criminal offenses (such as telecommunication theft, services and the spread of viruses); c) new technologies will be used to prevent or deter criminal acts [19, p.10].

Today, the most likely criminological prognosis for the future is the rapid impact on technology development in Ukraine of self-serving crime. Any automation programs in the country should be securely protected, and professionals should in a specific way minimize the risks involved in the introduction of new technological developments at the state level, with due consideration for the consequences of possible crimes.

Finally, there is another important factor in influencing crime. This is the criminal justice system itself. In Ukraine, it is constantly undergoing reform, but it does not produce stable positive results. The following are necessary steps in this direction: increasing the funding of law enforcement, judicial and penitentiary agencies; introduction of the latest technologies; improving the efficiency of correctional facilities; increasing the role of public and private individuals in crime prevention.

Predicting crime is one of the most controversial topics in criminal justice today. Studies have argued that this analytical approach is based on statistics, where most forecasting models are informational, and the use of large data sets, as noted by Liv Nadine (2019), places a primary emphasis on correlation rather than causality [20, p.5]. The main

problem with the use of crime prediction technologies is the display in the official statistics of police reactions to the facts of criminal behavior, and nowhere in the world can they claim full objectivity in displaying real crime rates.

## Conclusions

1. An assessment of the dependence of registered crime indicators on the economic development of the territory has shown a strong correlation between crime rates and the number of unemployed, as well as between crime rates and retail trade turnover.

2. Using regression models and assessing their quality confirmed that the most accurate is the equation of the crime rate ratio on retail trade turnover (per 10 thousand population) and the number of unemployed (UAH per 1 person). On the basis of the basic variant of the projection, the principal possibility of forecasting the number of registered crimes per 10 thousand population by introducing into the model quantitative indicators of the economic development of the region, namely the number of unemployed and retail trade (in relative terms) is proved.

3. Prospective directions of the research are construction of other estimation models of quantitative dependence of crime indicators (or individual crimes) on various factors (step, logarithmic, polynomial, exponential functions) and inclusion in the model of crime level prediction, along with indicators of economic development of the region, characterizing social, political, legislative, environmental and other changes in society and the state.

## Competing interests

The text of this article is made by the author himself. The author declares that there is no conflict of interest or infringement of the intellectual property rights of any third parties.

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