Mathematical Model of Crime and Literacy Rates

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Abstract *- This study explores the use of Mathematical modeling of crime behaviour which helps to establish the relationship between crimes and socio-economic factors. The concentration of criminal activities is not proportional in every area. Criminal activities depend on socio-economic factors like population densities, unemployment, literacy rate, per capita income, schedule castes and schedule tribes etc. There is a correlation between the volume of crime and literacy rate. The equation of the line of regression is formulated to interpret the nature of relationship between crimes and literacy rate.*

Keywords: *Per capita income, Regression equation, literacy rate, Volume of crime*

I. Introduction

Crimes are common in all society. It depends on socio-economic factors. Volume of crime and literacy, volume of crime and scheduled castes and tribes and volume of crime and per capita income in a certain area exhibit some relationship. The relationship can be expressed in the form of an equation connecting the dependent variable *Y* and one independent variable *X*. More precisely, the equation takes the form

$$Y = C + BX \qquad (2.1)$$

This is called the simplest regression equation, where C and B are said to be the regression coefficients.

Similarly, if more than one variable are considered then the regression equation can take another form. In particular, we already know that criminal activities are somewhat related with population density, per capita income, literacy rate, unemployment and proportion of scheduled castes and tribes *etc*.

Then the regression equation takes the following form:-

$$Y = C + B_1X_1 - B_2X_2 - B_3X_3 + B_4X_4 + B_5X_5 \qquad (2.2)$$

Where Y =Volume of crime per million population

X_1 = Population density; X_2 = Per capita income; X_3 = Literacy rate;

X_4 = Unemployment; X_5 = Percentage of scheduled castes and tribes;

and C and B_i's are regression coefficients.

It is remarkable that the negative sign before the third and fourth terms in relation (2.2) indicates that the volume of crime reduces for increase of per capita income and literacy rate. Hence there is a negative relationship.

Per capita income and literacy have apparently an inverse relation (negative relation) with crime which suggests that as income levels and literacy rise, crime tends to decrease. The hypothesis is supported to the extent that the bulk of reported crime can be traced to the economically deprived sections and the illiterate on whom the full impact of law-enforcement is felt. It does not necessarily absolve the affluent and the literate from criminality which may assume more subtle forms which do not form part of Penal Code and also have the capacity to defy conventional law-enforcement [13]. On the other hand, unemployment has significantly positive correlation with crime, followed by population density. Although not very significant, the percentage of scheduled castes and tribes appears to have some positive relationship. The marginal significance of this factor can be ascribed to the fairly uniform proportion of this segment in all states. The relationship between the major socio-economic variables hold good for nearly high percentage of crime under the Indian Penal Code and establishes unemployment as the most significant criminogenic factor.

The above equation no. (2.2) suggests that the relationship between two variables is such as a change in one variable results in a positive or negative change in the other, also greater change in one variable results in a corresponding greater change in the other, is known as correlation.

II. Literature Review

A mathematician and sociologist ***Quetelet*** applied statistics to discover relationships between crime and social factors in 19th century. Recently, crime is being investigated systematically with attempts to explain observed trends based on statistics and on different life course surveys. In statistical analyses, some modeler tried to relate crime rates to possible explicative variables through least squares linear regressions [9].

The models assume that crime rate = f(explicative variables) …….(i) , where f(.) is a linear function and the explicative variables considered as average income, gender inequality, age, education level, race etc.

Statistical crime data aggregated based on justice and police contacts- sometimes over reported and also sometimes under-reported. Sometimes correct data are obtained from governmental agencies. A few researchers were aware of these problems, which may have misled investigations. Sometimes conclusions drawn by different authors are contradictory. For example-in a survey of crime factors 11 places for all types of crimes- ***Entorf and Spengler*** [6] conclude that higher income and also higher urbanization are associated with higher crime rates, while ***Fajnzylber et al***. (2002)[8] based on data of homicide and robbery from 45 countries over 1970-1994, conclude that average income is not correlated with violent crime and that higher urbanization is associated with higher robbery rates but not with homicide rates.

Eide [7] points out in a survey of statistical approaches of criminal behavior, the above relation (i) is meaningful only if the explicative variables are not simultaneous with crime rates. He also discussed about the nature of correlatives between the crime rates and probabilities of punishment.

Spelman[14] discussed in detail the relationship between crime and prison rates, comparing several published studies on similar data using different technical specification for the analysis. The author shows that there is a strong time auto-correlation crime rates and prison population.

There is a contradictory aspect in different studies in respects of the explicative variables.

Isaac Ehrich (1973) [3] proposes the mean family income as an indicator of illegal income opportunities for criminals. He argues that higher income means a higher level of transferable wealth, and thus, more profitable targets for offenders. But other authors use same variable (i.e. mean family income) to measure legal income opportunities. They argue that higher absolute wealth is an indicator for more rewarding legal jobs.

Ehrlich [3],[4] studied that there are the probability of punishment and severity of punishment for any deterrent effect on the punished criminals. He found that a deterrent effect of capital punishment, have been shown to be very sensitive to statistical analysis. It is also studied that crime rates are (negatively) correlated with the probability of punishment but not punishment severity [7].

Some author mentioned that there is no significative effect of Unemployment rates on crime rates [2],[11].But ***Fajnzylber*** *et al*.[8] there is correlation between crime and unemployment.

The relationship between income inequality and crime is also controversial. ***Becker*** mentioned in his economic model that the richer become more attractive targets for the poorer [1], and ***Ehrlich*** [3] confirmed that crime is (positively) correlated with income inequality. ***Kelly*** [10] found that inequality is highly correlated with violent crime. But relationship between inequality and property crime depends on the variables chosen for the regressions.

However, ***Levitt*** [12] found that the poorer became more victimized than richer in U.S.A between 1970 and 1990.

Ehrlich(1975)[5] found using statistical analyses of property crime that younger individuals of low educational qualification are attractive for committing property crime, but crimes like fraud and illegal business bear a positive correlative with the highly qualified adult individuals. On the otherhand , ***Touchen and Witt***[15] found that the probability of criminal activities reduces of the individuals who involve in work or school where degree has no significant effect.

III. Preliminaries

(i) If x and y are two random variables then the correlation coefficients between x and y is denoted by r or r_{xy} and is defined by

$$r = \frac{\sum x_i y_i - \frac{\sum x_i \sum y_i}{N}}{\sqrt{\sum x_i^2 - \frac{\left(\sum x_i\right)^2}{N}} \sqrt{\sum y_i^2 - \frac{\left(\sum y_i\right)^2}{N}}}$$

where, $-1 < r < 1$, r has not units and is a mere number

If r = 1, then there exist a perfect and positive correlation between the variables x and y. if $r = -1$, then there exist a perfect and negative correlation between the variables, x and y. This r is known as ***Karl Pearson's correlation coefficients.***

(ii)The equation of the line of regression of y over x is $y - \bar{y} = r\frac{\sigma_y}{\sigma_x}(x - \bar{x})$

(iii) The equation of the line of regression of x over y is $x - \bar{x} = r\frac{\sigma_x}{\sigma_y}(y - \bar{y})$

where $\bar{x}$ and $\bar{y}$ are the means of the values of x and y respectively.

IV. **Relationship between crime and literacy**

The following Table 2.1 gives the number of literacy percent and volume of crime of the states of India for the year 1971. We shall study the Coefficient of correlation and the nature of correlation coefficient.

Table2.1

Volume of crime and literacy rate of the following State, 1971

Sl. No.	**Name of State**	***x* = Literacy (*P.C. i.e. %*)**	***y* = Volume of Crime (*Per One Lakh Population*)**
1	Andhra Pradesh	25	106
2	Kerala	60	139
3	Karnataka	32	124
4	Tamil Nadu	31	144
5	Bihar	20	147
6	Uttar Pradesh	22	166
7	Gujarat	36	121
8	Maharastra	39	195
9	Assam	29	175
10	Orissa	26	138
11	West Bengal	33	176
12	Hariyana	27	82
13	Punjab	33	84
14	Rajastan	19	142
15	Madhya Pradesh	22	211
16	Himachal Pradesh	32	73
17	Jammu & Kashmir	19	119
18	Tripura	31	114
19	Manipur	33	180

Source: 1.Crime in India,Ministry of Home Affairs, New Delhi

2.Statistical Abstracts, Central Statistical Organization, Government of India, New Delhi

Table 2.2

Calculation for correlation coefficient

Sl. No.	x Literacy rate %	$u = x - \bar{x}$	u^2	y	v	v^2	uv
1	25	-1	1	106	-32	1024	32
2	60	34	1156	139	1	1	34
3	32	6	36	124	-14	196	-84
4	31	5	25	144	6	36	30
5	20	-6	36	147	9	81	-54
6	22	-4	16	166	28	784	-112
7	36	10	100	121	-17	289	-170
8	39	13	169	195	57	3249	741
9	29	3	9	175	37	1369	111
10	26	0	0	138	0	0	0
11	33	7	49	176	38	1444	266
12	27	1	1	82	-56	3136	-56
13	33	7	49	84	-54	2916	-378
14	19	-7	49	142	4	16	-28
15	22	-4	16	211	73	5329	-292
16	32	6	36	73	-65	4225	-390
17	19	-7	49	119	-19	361	133
18	31	5	25	114	-24	576	-120
19	33	7	49	180	42	1764	294
		$\sum u = 75$	$\sum u^2 = 1871$		$\sum v = 14$	$\sum v^2 = 26796$	$\sum uv = -43$

Coefficient of correlation,

$$r = \frac{\sum uv - \frac{\sum u \sum v}{n}}{\sqrt{\sum u^2 - \frac{\left(\sum u\right)^2}{n}} \sqrt{\sum v^2 - \frac{\left(\sum v\right)^2}{n}}}$$

$$= \frac{-43-\frac{75\times 14}{19}}{\sqrt{1871-\frac{(75)^2}{19}}\sqrt{26796-\frac{(14)^2}{19}}} \cong -0.0151$$

Now, the regression coefficient of x on y

$$= b_{xy} = r\frac{\sigma_x}{\sigma_y} = r\frac{\sigma_u}{\sigma_v}$$

$$= \frac{\sum uv - \frac{(\sum u)(\sum v)}{n}}{\sum v^2 - \frac{(\sum v)^2}{n}}$$

$$= -0.0037$$

Similarly, the regression coefficient of y on x

$$= b_{yx} = r\frac{\sigma_y}{\sigma_x} = r\frac{\sigma_v}{\sigma_u}$$

$$= \frac{\sum uv - \frac{(\sum u)(\sum v)}{n}}{\sum u^2 - \frac{(\sum u)^2}{n}}$$

$$= -0.0624$$

Hence, the equation of the line of regression of x over y is

$$x - \bar{x} = r\frac{\sigma_x}{\sigma_y}(y - \bar{y})$$

$$\Rightarrow x = -0.0037y + 30.46 \qquad (2.6)$$

where, arithmetic average of literacy rate

$$\bar{x} = \text{assumed average} + \frac{\sum u}{n}$$

$$= 26 + \frac{75}{19}$$

$$= 29.95$$

and arithmetic average of volume of crime, $\bar{y} = \text{assumed average} + \frac{\sum v}{n}$

$$= 138 + \frac{14}{19}$$

$$= 138.74$$

Similarly, the line of regression of *y* over *x* is given by

$$y - \bar{y} = r\frac{\sigma_y}{\sigma_x}(x - \bar{x})$$

$$\Rightarrow \quad y = -0.0624x + 140.61 \qquad (2.7)$$

The estimation explains that crime depends on the socio-economic factors.

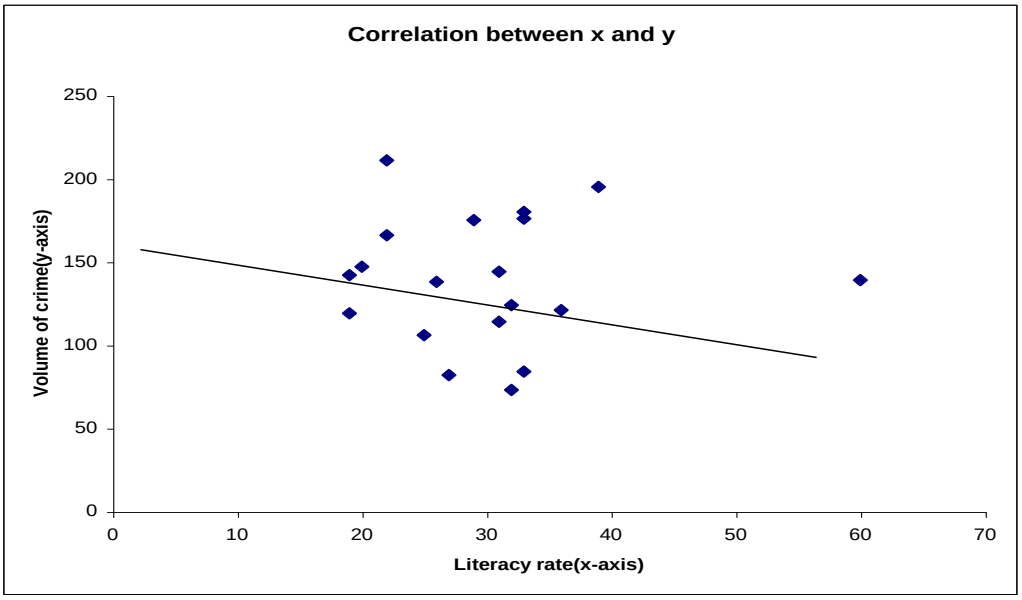

Fig. 2.1 Correlation between literacy rate and crime $r < 0$

Fig.2.1 shows that when the literacy rate increases the volume of crime decreases.

The above estimation and Fig.2.1 shows that crime and literacy rate is negatively correlated. When, literacy rate increases in a society the volume of crime decreases.

V. Conclusion

The negative correlation coefficient shows that, the volume of crime decreases as the literacy rate increases. The two equations of regression (2.6) and (2.7) represent straight line which exhibit that as literacy rate increases the volume of crime decreases. The Fig.-2.1 also exhibits the same interpretation**.**

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