Developing an Advanced Crime Prediction Model and Evaluating Criminometric Indicators for Assessing Structural Changes in Law Enforcement Agencies

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I. INTRODUCTION:

Crime fore-castes are necessary to law enforcement agencies to make policy decisions. The various resources of law enforcement agencies can be allotted to different purposes more efficiently if the availability of these resources can be matched with the demand for their use. Given the increasing public interest in crime control, crime forecasts are necessary, to evaluate crime deterrence programs because, measurement of crime reduction requires a knowledge of the crime level that world prevail in the absence of the new program. Many of the criminologists developed the various structural models in the literature to predict and explain crime as a statistical function of a number of socio, economic and demographic variables such as unemployment, income of household, age, probability of conviction, etc. Since structural models are theoretically based models, there is a need of developing criminometric models for empirical studies.

II. SPECIFICATION OF CRIME FORECASTING MODEL:

In many statistical applications to criminology research problems, the explanatory variables assume generally positive values, and criminometricians must decide whether a linear or log-linear model is appropriate. It is a problem of testing the functional form of regression, choosing between linear and log-linear regression models.

Suppose Y denotes a dependent variable which refers to number of arrests made in connection with cognizable crimes and X_1, X_2, ….., X_k denote K explanatory variables such as police strength, population, unemployment, per capit income etc. Consider the following three specifications as

$$\left.\begin{array}{l}\text{(i) } Y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \dots\dots\dots + \beta_k X_k + \in \\ \text{(ii) } Y = \beta_o X_1^{\beta_1} X_2^{\beta_2} \dots\dots\dots X_K^{\beta_k} e^{\in} \\ \text{(iii) } Y = \gamma\left[\beta_1 X_1^{-\ell} + \beta_2 X_2^{-\ell} + \dots\dots\dots + \beta_k X_k^{-\ell}\right]^{-1/\ell} \in \end{array}\right\} \quad (2.1)$$

Here, (i). is the multiple linear regression specification;

(ii). is the generalized Cobb – Douglas production functional specification.

and (iii). is the constant elasticity of substitution (CES) production functional specification.

Model (i) can be estimated by applying the OLS estimation;

Model (ii) can be estimated by applying the OLS method of estimation.

After taking logarithmic transformation of the model.

Model (iii) can be estimated by applying the OLS method of estimation after taking linear approximation to the model by using Taylor series expansion. Otherwise, Model (iii), can be estimated by using the Marginal Products method of estimation.

By assuming that each of the explanatory variables an exponential is function of time (t) and its relationship may be given by

$$X_i = ae_{\varepsilon}^{bt}, \quad i = 1, 2, \dots k \qquad (2.2)$$

First predict the values of each of the explanatory variables for future time periods = (i.e., for (n+1), (n+2), . . .) by fitting the exponential curve to the time series data on each explanatory variable X. Now estimate the values of the Y for future time periods say $\hat{Y}_{n+1}, \hat{Y}_{n+2}, \dots$ by substituting the predicted values of the explanatory variables in the estimated equations of the three specifications (i), (ii) and (iii). These estimates of Y give the crime for-castes for the time periods (n+1), (n+2),--------- under three specifications (i), (ii) and (iii) respectively.

Generally, one may wish to select any one of the three specifications given in (2.1) for forecasting crime. This problem becomes a problem of choosing between linear and log-linear regression models.

One may state the null and alternative hypothesis as

H_0: Linear Regression model: Y is a linear function of explanatory variables X's.

H_1: Log – Linear Regression Model: lnY is a linear function of logs of explanatory variables say l_n X's.

Step (1): Apply the OLS method and estimate the linear regression model and find the estimates of Y values as $\hat{Y}$'s and hence obtain OLS residuals e's.

Step (2): Apply again the OLS method to the log – linear model and find estimated l_n y values as l_n y's and hence obtain the OLS log residuals e^*'s.

Step (3): Compute $Z_i = [l_n e_j - e_j^*],\ j = 1, 2, \ldots n.$ n is the no. of observations.

Step (4): Regress Y on X's and new difference regression Z. If the regression coefficient of Z is significant, then one may reject H_0 in favour of H_1. Thus, the log-linear regression model may be chosen for crime forecasts.

Step (5): Compute $D_j = [\text{anti}\log(e_j^* - e_j)],\ j = 1, 2, \ldots n.$

Step (6): Regress lny on ln X's and another new difference regressor D obtained in Step (5). If the regression coefficient of D is significant then one may reject H_1in favour of H_0. Thus, linear regression model may be chosen for crime forecasts.

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Suppose $Y_j^{(1)}$, $Y_j^{(2)}$, and $Y_j^{(3)}$, be the forecasts obtained from the three different forecasting specifications respectively, j = 1, 2, . . . n. Let w_1, w_2 and w_3 be the corresponding weights to be assigned to these fore castes. Now, one may regress y on $y^{(1)}$, $y^{(2)}$ and $y^{(3)}$ as

$$Y_j = w_0 + w_1\, y_j^{(1)} + w_2\, y_j^{(2)} + w_2\, y_j^{(3)} + \epsilon_j\,,\ j = 1, 2 \ldots .n \qquad (2.3)$$

By applying the OLS method, the estimated forecasting regression model is given by

$$\hat{Y}_j = \hat{w}_0 + \hat{w}_1 y_j^{(1)} + \hat{w}_2 y_j^{(2)} + \hat{w}_3 y_j^{(3)} \qquad (2.4)$$

Where, $\hat{w}_0, \hat{w}_1, \hat{w}_2, \hat{w}_3$ are the OLS estimates of the weighted parameters w_0, w_1, w_2 and w_3 respectively.

Using the equation (2.4), the crime forecasts may be obtained.

III. A CRIMINOMETRIC TEST FOR STRUCTURL CHANGE IN EPOCHS POLICE FORCE:

Suppose one may wish to test whether there is any change or shift in the police output among different time periods. Such a change may be referred to as a structural change or structural break in the police output.

Consider the police output for the period from t_1 to t_n years. Now, divide this time series data on police output into 'm' epochs. Suppose there exists a linear relationship between police output and time variable (year), one may have,

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$$\begin{aligned}
&\text{epoch } 1: \mathrm{Y} = \alpha_1 + \beta_1 \mathrm{X} + \varepsilon \text{ , for } \mathrm{n}_1 \text{ observations} \\
&\text{epoch } 2: \mathrm{Y} = \alpha_2 + \beta_2 \mathrm{X} + \varepsilon \text{ , for } \mathrm{n}_2 \text{ observations} \\
&\;. \\
&\;. \\
&\;. \\
&\text{epoch } \mathrm{m}: \mathrm{Y} = \alpha_\mathrm{m} + \beta_\mathrm{m} \mathrm{X} + \varepsilon \text{ , for } \mathrm{n}_\mathrm{m} \text{ observations}
\end{aligned} \tag{3.1}$$

Where, Y denotes police output

X denotes time variable (Year)

The above model allows intercepts and slopes to be different in the m epochs.

The above set of models can be written in the matrix form as

$$\begin{bmatrix} Y_1 \\ Y_2 \\ . \\ . \\ . \\ Y_{n_1} \\ \cdots\cdots \\ Y_{n_1+1} \\ Y_{n_1+2} \\ . \\ . \\ . \\ Y_{n_1+n_2} \\ \cdots\cdots \\ . \\ . \\ . \\ \cdots\cdots \\ . \\ . \\ . \\ Y_{n_1+n_2+\cdots\cdots n_m} \end{bmatrix} = \begin{bmatrix} 1 & X_1 & 0 & 0 & \cdots\cdots & 0 & 0 \\ 1 & X_2 & 0 & 0 & \cdots\cdots & 0 & 0 \\ . & . & & . & & . & . \\ . & . & & . & & . & . \\ . & . & & . & & . & . \\ 1 & X_{n_1} & 0 & 0 & \cdots\cdots & 0 & 0 \\ \cdots & \cdots & & & & \cdots & \cdots \\ 0 & 0 & 1 & X_{n_1+1} & \cdots\cdots & 0 & 0 \\ 0 & 0 & 1 & X_{n_1+2} & \cdots\cdots & 0 & 0 \\ . & . & & . & & . & . \\ . & . & & . & & . & . \\ . & . & & . & & . & . \\ 0 & 0 & 1 & X_{n_1+n_2} & \cdots\cdots & 0 & 0 \\ \cdots & \cdots & & \cdots & \cdots & \cdots & \cdots \\ . & . & & . & & . & . \\ . & . & & . & & . & . \\ . & . & & . & & . & . \\ \cdots & \cdots & & \cdots & \cdots & \cdots & \cdots \\ 0 & 0 & 0 & 0 & \cdots\cdots & \cdots 1 & 0 \\ . & . & & . & & . & . \\ . & . & & . & & . & . \\ . & . & & . & & . & . \\ 0 & 0 & 0 & 0 & \cdots\cdots & \cdots 1 & X_{n_1+n_2+\cdots\cdots n_m} \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \beta_1 \\ \alpha_2 \\ \beta_2 \\ . \\ . \\ . \\ . \\ . \\ . \\ . \\ . \\ . \\ \alpha_m \\ \beta_m \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ . \\ . \\ . \\ \varepsilon_{n_1} \\ \cdots\cdots \\ \varepsilon_{n_1+1} \\ \varepsilon_{n_1+2} \\ . \\ . \\ . \\ \varepsilon_{n_1+n_2} \\ \cdots\cdots \\ . \\ . \\ . \\ \cdots\cdots \\ . \\ . \\ . \\ \varepsilon_{n_1+n_2+\cdots\cdots n_m} \end{bmatrix}$$

or more compactly expressed as

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$$\begin{bmatrix} Y_1^* \\ \cdots\cdots \\ Y_2^* \\ \cdots\cdots \\ \cdot \\ \cdot \\ \cdot \\ \cdots\cdots \\ Y_m^* \end{bmatrix}_{n\times 1} = \begin{bmatrix} X_1^* & 0 & \cdots\cdots\cdots\cdots\cdots\cdots\cdots 0 & 0 \\ -- & -- & ---- & \\ 0 & X_2^* & \cdots\cdots\cdots\cdots\cdots\cdots\cdots 0 & 0 \\ -- & -- & ---- & \\ \cdot & \cdot & \cdot\ \cdot & \\ \cdot & \cdot & \cdot\ \cdot & \\ \cdot & \cdot & \cdot\ \cdot & \\ -- & -- & ---- & \\ 0 & 0 & \cdots\cdots\cdots\cdots\cdots\cdots\cdots 0 & X_m^* \end{bmatrix}_{n\times 2m} \begin{bmatrix} \alpha_1 \\ \beta_1 \\ \alpha_2 \\ \beta_2 \\ \cdot \\ \cdot \\ \cdot \\ \alpha_m \\ \beta_m \end{bmatrix}_{2m\times 1} + \begin{bmatrix} \varepsilon_1^* \\ \cdots\cdots \\ \varepsilon_2^* \\ \cdots\cdots \\ \cdot \\ \cdot \\ \cdot \\ \cdots\cdots \\ \varepsilon_m^* \end{bmatrix}_{n\times 1} \quad (3.2)$$

Where, $n = n_1 + n_2 + \cdots\cdots\cdots + n_m$;

Y_i^* *is* $(n_i \times 1)$ *observation vector*;

X_i^* *is* $(n_i \times 2)$ matrix, which has units in the first column;

0's are null matrices;

ε_i^* *is* $(n_i \times 1)$ *error vector*; $i = 1,2,\cdots\cdots, m.$

Model 3.2 can be written as,

$$Y_{n\times 1}^* = X_{n\times 2m}^* \ \beta_{2m\times 1} + \varepsilon_{n\times 1} \quad (3.3)$$

By applying ordinary least squares (OLS) estimation to (3.3), one can obtain the OLS estimators of the parameters as

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$$\begin{bmatrix} \hat{\alpha}_1 \\ \hat{\beta}_1 \\ \ldots\ldots \\ \hat{\alpha}_2 \\ \hat{\beta}_2 \\ \ldots\ldots \\ . \\ . \\ . \\ \ldots\ldots \\ \hat{\alpha}_m \\ \hat{\beta}_m \end{bmatrix} = \begin{bmatrix} \left(X_1^{*1} X_1^{*}\right)^{-1} X_1^{*1} \; Y_1^{*} \\ -- \; -- \; ---- \\ \left(X_2^{*1} X_2^{*}\right)^{-1} X_2^{*1} \; Y_2^{*} \\ -- \; -- \; ---- \\ .\;.\;.\;. \\ .\;.\;.\;. \\ .\;.\;.\;. \\ -- \; -- \; ---- \\ \left(X_m^{*1} X_m^{*}\right)^{-1} X_m^{*1} \; Y_m^{*} \end{bmatrix} \qquad (3.4)$$

These estimates are identical with those can be obtained by applying OLS estimation separately to the m equations in the model (3.1). Using equation (3.4), one can obtain the vector e of $n_1 + n_2 + \ldots\ldots + n_m$ OLS residuals, and $e^1 e$ gives the unrestricted residual sum of squares.

i.e ., $e'e = e_1'e_1 + e_2'e_2 + \ldots\ldots + e_m'e_m$

Where, $e_i'e_i$ is the OLS residual sum of squares corresponds to i^{th} equation.

State the null hypothesis as

Ho: There is no structural change in the output of police force during the study period from t_1 to t_m years.

Or Ho: $\begin{bmatrix} \alpha_1 \\ \beta_1 \end{bmatrix} = \begin{bmatrix} \alpha_2 \\ \beta_2 \end{bmatrix} = \ldots\ldots = \begin{bmatrix} \alpha_m \\ \beta_m \end{bmatrix} = \begin{bmatrix} \alpha \\ \beta \end{bmatrix} \quad (say)$

Under the null hypothesis, the restricted model can be formulated as

$$\begin{bmatrix} y_1^* \\ y_2^* \\ . \\ . \\ y_m^* \end{bmatrix}_{nx1} = \begin{bmatrix} x_1^* \\ x_2^* \\ . \\ . \\ x_m^* \end{bmatrix}_{nx2} \begin{bmatrix} \alpha \\ \beta \end{bmatrix} + \begin{bmatrix} \varepsilon_1^* \\ \varepsilon_2^* \\ . \\ . \\ \varepsilon_m^* \end{bmatrix}_{nx1} \qquad (3.5)$$

Using the model (3.5), one can obtain the restricted residual sum of squares as $e^{*1}e^*$ based n observations.

A criminometric test statistic for testing structural change in the output of police force is give by

$$F = \left[\frac{\left(e^{*1}e^* - e^1 e\right)/2}{e^1 e/n-2m} \right] \sim F_{[2,(n-2m)]} \qquad (3.6)$$

$$Where \quad n = n_1 + n_2 + \ldots\ldots + n_m$$

Remark: Suppose there exists an exponential relationship between police output(y) and time variable (X).

Then one may have, $y = a\ b^{x} e^{\varepsilon}$ for each of m epochs. This implies that,

$$\log y = \log a + (\log b)\ X + \varepsilon$$

$$or \quad Y = \alpha + \beta X + \varepsilon$$

$$where, Y = \log y, \ \alpha = \log a \quad and \quad \beta = \log b$$

Now, one may wish to test for structural change in the output of police force same as given in the above proposed criminometric test procedure.

IV. EMPIRICAL RESULTS OBTAINED FROM CRIMINOMETRIC TEST FOR STRUCTURAL CHANGE IN POLICE OUTPUT:

To test for the structural change in the police output during the study period from the years 1953 to 2007, the time series crime data has been divided into three/two epochs and then the proposed criminometric tests have been applied to the Indian Crime data. The empirical results obtained from the proposed criminometric

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tests have been presented in tables 4.2 and 4.3. The incidence of Cognizable Crimes under different selected crime heads has been given in table 4.1.

Table 4.1.

Incidence Of Cognizable Crimes (IPC) Under Different Crime Heads During 1953 To 2007

Sl. No.	Year	Murder	Attempt to commit Murder	C.H. not amounting to murder	Rape	Kidnapping & Abduction	Dacoity	Preparation & Assembly for dacoity	Robbery	Burglary (House-Breaking)	Theft	Riots
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1	1953	9802	*	*	*	5261	5579	*	8407	147379	256567	20529
2	1954	9765	*	*	*	5514	5395	*	7600	132457	223866	22777
3	1955	9700	*	*	*	5529	4779	*	6710	121744	212028	23609
4	1956	10025	*	*	*	5905	5397	*	7618	134556	236214	24700
5	1957	10419	*	*	*	5821	5560	*	7408	129632	233239	23750
6	1958	10661	*	*	*	6043	4658	*	7120	124695	236103	24942
7	1959	10712	*	*	*	6549	3774	*	6267	118205	233052	26987
8	1960	10910	*	*	*	6024	3981	*	6263	114540	228842	26890
9	1961	11188	*	*	*	6698	4213	*	6428	122605	232868	27199
10	1962	11586	*	*	*	7119	4890	*	7551	134324	252453	29096
11	1963	10754	*	*	*	6924	4997	*	7694	137025	242487	28114
12	1964	11748	*	*	*	8050	5287	*	8336	153862	273676	32693
13	1965	12310	*	*	*	7927	4955	*	8067	142015	273702	32940
14	1966	12631	*	*	*	7854	4817	*	8585	150180	298701	34696
15	1967	13398	*	*	*	8192	6300	*	10252	173575	339861	42447
16	1968	13849	*	*	*	8830	6384	*	10194	156206	315546	45801
17	1969	14732	*	*	*	8464	6049	*	9922	145429	300140	55796
18	1970	15708	*	*	*	10111	9837	*	16958	166339	337211	68331
19	1971	16180	*	2357	2487	9647	11193	*	18402	165807	335204	64114
20	1972	15475	*	2196	2605	9402	10411	*	17054	167062	346382	65781
21	1973	17072	*	2408	2919	10223	10627	*	18857	181433	379412	73388
22	1974	18649	*	2514	2962	10543	13697	*	22286	199878	436918	80547
23	1975	17563	*	2502	3376	11139	12506	*	21656	192854	421891	67241
24	1976	16673	*	2584	3893	11250	10910	*	17974	168655	365138	63675
25	1977	18376	*	2615	4058	12240	12599	*	22725	193622	432046	80449
26	1978	19314	*	2728	4558	13616	13195	*	22923	183991	437187	96488
27	1979	20349	*	3008	4300	13125	14028	*	22860	168574	430483	98896

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(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
28	1980	22149	*	3032	5023	13595	15194	*	23493	166695	431036	106957
29	1981	22727	*	3272	5409	13833	14626	*	22996	157540	422059	110361
30	1982	23339	*	3427	5427	13341	12700	*	21938	142726	375240	106511
31	1983	25112	*	3793	6019	13842	12382	*	21310	139103	353536	108101
32	1984	25786	*	4093	6740	15141	12301	*	23204	136272	330669	101460
33	1985	25970	*	3995	7289	16051	11254	*	22501	130354	330554	99757
34	1986	27269	*	4195	7952	15667	10444	*	22395	128946	323533	94197
35	1987	28513	*	3721	8559	15251	10036	*	22917	125466	310575	90789
36	1988	28771	20689	3755	9099	15771	9306	931	21611	124304	319848	94587
37	1989	31222	23748	4100	9752	17318	9896	1015	22480	129020	341240	98943
38	1990	35045	27095	4281	10068	18474	11089	1286	25440	131331	353191	102846
39	1991	39174	29778	4243	10410	20079	10831	1393	26428	132087	362928	105309
40	1992	40105	31202	4621	11708	20518	11308	1297	26444	127281	350582	104749
41	1993	38240	29725	3890	12218	19830	9357	1102	24354	123020	320434	93838
42	1994	38577	30020	3946	13208	20983	9271	946	23933	121536	303564	94344
43	1995	37464	29571	3830	13754	20426	8335	961	22443	116507	294306	96520
44	1996	37671	29597	3728	14846	20848	8035	888	22705	115097	284985	92831
45	1997	37543	29322	3869	15330	21898	7867	1049	22141	113319	277077	91812
46	1998	38584	30577	3681	15151	23520	8091	1266	23603	119260	287967	90767
47	1999	37170	29628	3912	15468	23236	7079	1501	21332	111296	271907	80838
48	2000	37399	30743	3773	16496	22871	6825	1505	20926	105391	258588	80456
49	2001	36202	31523	3367	16075	22487	6154	1614	19901	101182	252803	76222
50	2002	35290	30380	3624	16373	21850	6101	1841	18764	96461	247462	68945
51	2003	32716	25942	4029	15847	19992	5303	2302	17512	92827	245237	57334
52	2004	33608	27890	3935	18233	23327	5311	2340	18458	92490	273045	59971
53	2005	32719	28031	3578	18359	15750	5141	2834	17673	90108	273111	56235
54	2006	**32481**	27230	3535	**19348**	**23991**	**4747**	3129	**18456**	**91666**	274354	**56641**
55	2007	**32318**	27401	3644	**20737**	**27561**	**4579**	3205	**19136**	**91218**	285043	**59915**

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Incidence Of Cognizable Crimes (IPC) Under Different Crime Heads
During 1953 To 2007 (Concluded)

Sl. No.	Year	Crimi-nal Breach of Trust	Chea-ting	Counter-feiting	Arson	Hurt	Dowry Deaths	Moles-tation	Sexual Harass-ment	Cruelty by husband or Relatives	Importa-tion Of Girls	Causing Death by Negli-gence	Other IPC crimes	Total Cognizable Crimes under IPC
(1)	(2)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
1	1953	*	*	*	*	*	*	*	*	*	*	*	148440	601964
2	1954	15860	9934	815	*	*	*	*	*	*	*	*	122929	556912
3	1955	14644	9461	597	*	*	*	*	*	*	*	*	126435	535236
4	1956	15466	9519	596	*	*	*	*	*	*	*	*	135221	585217
5	1957	15362	9388	629	*	*	*	*	*	*	*	*	140163	581371
6	1958	16017	9503	555	*	*	*	*	*	*	*	*	173887	614184
7	1959	15878	9677	443	*	*	*	*	*	*	*	*	188772	620326
8	1960	15862	9207	554	*	*	*	*	*	*	*	*	183294	606367
9	1961	16895	9511	485	*	*	*	*	*	*	*	*	187561	625651
10	1962	18092	9738	423	*	*	*	*	*	*	*	*	199194	674466
11	1963	18438	8854	289	*	*	*	*	*	*	*	*	193254	658830
12	1964	21180	11670	317	*	*	*	*	*	*	*	*	232194	759013
13	1965	21354	11935	436	*	*	*	*	*	*	*	*	235974	751615
14	1966	22353	11606	655	*	*	*	*	*	*	*	*	242655	794733
15	1967	23950	12701	1413	*	*	*	*	*	*	*	*	249892	881981
16	1968	22408	12524	1425	*	*	*	*	*	*	*	*	268795	861962
17	1969	21118	12001	739	*	*	*	*	*	*	*	*	270777	845167
18	1970	22679	12331	650	*	*	*	*	*	*	*	*	295267	955422
19	1971	20270	11412	641	*	*	*	*	*	*	*	*	299711	952581
20	1972	21004	12646	670	*	*	*	*	*	*	*	*	318886	984773
21	1973	21837	14392	582	*	*	*	*	*	*	*	*	349358	1077181
22	1974	22274	15380	718	*	*	*	*	*	*	*	*	371387	1192277
23	1975	23287	17772	951	*	*	*	*	*	*	*	*	373660	1160520
24	1976	23656	19588	887	*	*	*	*	*	*	*	*	395491	1093897
25	1977	22868	19623	784	*	*	*	*	*	*	*	*	451672	1267004
26	1978	23255	19821	636	*	*	*	*	*	*	*	*	514542	1344968

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Sl. No.	Year	Crimi-nal Breach of Trust	Chea-ting	Counter-feiting	Arson	Hurt	Dowry Deaths	Moles-tation	Sexual Harass-ment	Cruelty by husband or Relatives	Importa-tion Of Girls	Causing Death by Negli-gence	Other IPC crimes	Total Cognizable Crimes under IPC
(1)	(2)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
27	1979	22016	18370	525	*	*	*	*	*	*	*	*	526942	1336168
28	1980	20684	17416	830	*	*	*	*	*	*	*	*	550480	1368529
29	1981	20579	17764	1004	*	*	*	*	*	*	*	*	582265	1385757
30	1982	18259	17471	939	*	*	*	*	*	*	*	*	612586	1353904
31	1983	18514	19767	809	*	*	*	*	*	*	*	*	627578	1349866
32	1984	18428	19077	1118	*	*	*	*	*	*	*	*	664371	1358660
33	1985	18417	21016	1504	*	*	*	*	*	*	*	*	696069	1384731
34	1986	19021	22579	1687	*	*	*	*	*	*	*	*	727950	1405835
35	1987	17847	22115	1653	*	*	*	*	*	*	*	*	749550	1406992
36	1988	17352	22705	1537	*	*	*	*	*	*	*	*	750090	1440356
37	1989	17541	23691	2075	*	*	*	*	*	*	*	*	797803	1529844
38	1990	16552	24466	2576	*	*	*	*	*	*	*	*	840709	1604449
39	1991	17495	27466	4467	*	*	*	*	*	*	*	*	886287	1678375
40	1992	17925	29397	5133	*	*	*	*	*	*	*	*	907071	1689341
41	1993	17039	30079	3728	*	*	*	*	*	*	*	*	903082	1629936
42	1994	16523	31207	2851	*	*	*	*	*	*	*	*	924342	1635251
43	1995	15503	30678	2203	12028	203812	4648	26856	4689	28579	*	*	722583	1695696
44	1996	15368	33823	2796	12425	223977	5513	28939	5671	35246	*	*	714587	1709576
45	1997	15077	35228	2228	12363	228497	6006	30764	5796	36592	*	*	726042	1719820
46	1998	16157	38271	1353	12913	235870	6975	30959	8053	41375	*	*	744422	1778815
47	1999	15454	41403	1347	11218	236313	6699	32311	8858	43823	1	*	763835	1764629
48	2000	14581	41701	2299	10392	240580	6995	32940	11024	45778	64	*	779757	1771084
49	2001	14798	44727	1683	10534	271487	6851	34124	9746	49170	114	57182	701362	1769308
50	2002	14027	46271	1522	11820	265025	6822	33943	10155	49237	76	64044	730297	1780330
51	2003	13432	47478	2055	9365	261444	6208	32939	12325	50703	46	60672	700412	1716120
52	2004	14176	51939	1529	8637	276868	7026	34567	10001	58121	89	69423	741031	1832015
53	2005	13572	53625	2383	8451	270861	6787	34175	9984	58319	149	71698	741977	1822602
54	2006	13636	58076	2169	8480	264748	7618	36617	9966	63128	67	78513	779697	1878293
55	2007	15531	65326	2204	9024	273067	8093	38734	10950	75930	61	86790	829206	1989673

"*" Information not collected

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TABLE-4.2: RESULTS FROM CRIMINOMETRIC TEST FOR STRUCTURAL CHANGE IN OUTPUT OF POLICE FORCE USING LINEAR SPECIFICATION

I.P.C. CRIME HEADS	$e_1^1 e_1$	$e_2^1 e_2$	$e_3^1 e_3$	$e^{*1} e^*$	**F-Value**
MURDER	15024100.04	11823107.78	13693379.7	689733255.6	392.3283
** CULPABLE HOMICIDE NOT AMOUNTING TO MURDER	846507.4782	816260.9975	-	7956221.101	70.0211
** RAPE	3935134.613	7928470.39	-	20726039.34	13.8200
KIDNAPPING AND ABDUCTION	3143713.506	5989570.301	85536351.32	135110755.1	10.4659
DACOITY	72511304.42	25864259.76	3106609.586	562406690.8	111.2772
ROBBERY	185514240.7	27753159.72	15850731.88	1020804137	84.6564
BURGLARY	3890663234	1312115432	166383888.2	30902719200	116.5121
THERFTS	16508564126	13197142864	7797076302	2.12175E+11	114.1108
RIOTS	1219247264	1719948633	324740585.4	26749292431	176.2875
* CRIMINAL BREACH OF TRUST	44728565.45	9081009.558	8962655.056	418747095.5	136.1015
* CHEATING	29199987.81	28584898	94092907.74	1719598437	247.7340
*COUNTERFERTING	1593884.899	999599.5429	10055395.75	31319338.26	35.4253
OTHR I.P.C. OFFENCE	5344844283	3193439820	69258209510	4.89728E+11	129.7273
TOTAL CONGNIZABLE CRIMES UNDER I.P.C	79050069046	47876859178	32533817293	2.81601E+11	18.7660

NOTE: EPOCH1 :1953-1975 EPOCH2:1976-1990 EPOCH3=1991-2007

- EPOCH1 :1954-1975 EPOCH2:1976-1990 EPOCH3=1991-2007

AND ** EPOCH1:1976-1990 EPOCH2=1991-2007

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TABLE-4.3: RESULTS FROM CRIMINOMETRIC TEST FOR STRUCTURAL CHANGE IN OUTPUT OF POLICE FORCE USING EXPONENTIAL SPECIFICATION

I.P.C. CRIME HEADS	$e_1^1\ e_1$	$e_2^1\ e_2$	$e_3^1\ e_3$	$e^{*1}\ e^*$	F-Value
MURDER	0.010157665	0.002804391	0.002128794	0.186885137	278.9081
** CULPABLE HOMICIDE NOT AMOUNTING TO MURDER	0.013935474	0.009818975	-	0.13474775	86.4417
** RAPE	0.004966374	0.007728163	-	0.093215936	117.3454
KIDNAPPING AND ABDUCTION	0.006439918	0.004981351	0.037791286	0.106585999	28.5628
DACOITY	0.235136363	0.032689295	0.005072758	1.569123402	116.3712
ROBBERY	0.202292902	0.011539049	0.006460844	0.920993415	77.9289
BURGLARY	0.032728274	0.009281488	0.002723067	0.292867207	135.9023
THERFTS	0.028246599	0.017531477	0.016672774	0.393382333	129.8272
RIOTS	0.065305052	0.042663823	0.013521127	1.378666545	253.5256
* CRIMINAL BREACH OF TRUST	0.022479153	0.003843667	0.007104464	0.232059042	142.6129
* CHEATING	0.032363199	0.013504661	0.003330677	0.121700697	35.3680
*COUNTERFERTING	0.54790844	0.110963639	0.279827553	1.718734866	19.9434
OTHR I.P.C. OFFENCE	0.016583092	0.004969879	0.020426521	0.499707573	267.1385
TOTAL CONGNIZABLE CRIMES UNDER I.P.C	0.014892233	0.005445733	0.001840477	0.107114992	93.8274

NOTE: EPOCH1 :1953-1975 EPOCH2:1976-1990 EPOCH3=1991-2007
* EPOCH1 :1954-1975 EPOCH2:1976-1990 EPOCH3=1991-2007
AND ** EPOCH1:1976-1990 EPOCH2=1991-2007

V. CONCLUSIONS:

In the present study a crime forecasting criminometric model has been proposed under three specifications and a method for choosing between linear and log-linear regression equations for crime forecasts has explained. A weighted regression forcasting technique has been developed to obtain more precise crime forecasts.

A criminometric test for structural change in police output has been discussed under two specifications namely linear and exponential specifications.

Under empirical investigation, the proposed new criminometric models based on probability distributions have been applied to Indian Crime data and computed the efficiency of police force in terms of police augmenting technological change during the period from year 1970 to 2007. The structural change in the output of Indian police force during the period from year 1953 to 2007 has been tested by using the developed criminometric test in the present study. The statistical data relevant to the present empirical investigation has been collected from the reports of 'CRIME IN INDIA' published by the Bureau of police Research and Development, Ministry of Home Affairs, Government of India.

It is observed from the F-values that, there is significant structural changes in the police output between the selected three/two epochs of the study period. Further, it is found that both the two specifications of Linear and Exponential specifications reveal the same conclusions about the structural changes in the police output.

The corresponding F-values are highly significant at 1% level.

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