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Application of Three Parameter Model to Concave and Convex Curves

R.B. Tiwari

Department of Statistics, D.A-V. College, Kanpur-208001, U. P., India

***Abstract* – Many linear and non-linear models have been proposed by various authors for the study of approximation of non linear models by statistical models which are linear in its parameters. Several non linear models have been suggested for the data sets which are prima facie appear like convex or concave curves. Smith (1938), jessen (1942) and Hansen et.al. (1953), Misra (2010), Shukla et.al. 2018), Tiwari (2022) have proposed various non-linear models for the comparative study for such data sets and they compared the parameters like coefficient of determination and sum of squired error. In this paper I have suggested an application of a three parameter linear model to compare these parameters of interest for the data sets which form convex or concave curves.**

Keywords: Convex Curve, Concave Curve, Linear model, non-linear model, three parameter model, coefficient of determination, sum of squired error.

I. INTRODUCTION

The intrinsically nonlinear model of the form,

$$Y = \theta_1\left(1 - e^{-\theta_2 t}\right) + \in \quad \textbf{(1)}$$

is fitted to various data sets reported in Draper and Smith (1981). θ_1 and θ_2 are parameters of the model **(1)** and t is treated as independent variable.

$\in {}'s$are i.i.d.r.v. distributed normally with mean zero and fixed variance σ^2. The deterministic part of model **(1)** can be written as

$$Y = \theta_1\left(1 - e^{-\theta_2 t}\right) \quad \textbf{(2)}$$

The relation **(2)** belongs to the family of concave/convex curves and Ratkowsky (1989) has not categorized the relation **(2)** as close-to-linear model.

The form **(2)** can be written as

$$Y = \theta_1\,(1 - \beta^t) \quad \textbf{(3)}$$

where,

$$\theta_2 = -\log(\beta) \quad \textbf{(4)}$$

Relation **(3)** can be categorized as parameterization of form **(2)**. The nonlinearly appearing parameter in **(3)** is β and due to the termβ^t, the direct use of least squares method is not possible. As discussed earlier, the term β^t is approximated by an inverse term, resulting into model of the form,

$$Y = a + bt + \frac{c}{t},\ t > 0 \quad \textbf{(5)}$$

Approximating the relation **(3)** and hence relation **(2)** which is parameterization of **(3)**, on the lines of suggestions made earlier.

Table given below, reports the fitted forms for the model **(5)** on various data sets in Draper and Smith (1981). The data sets are listed as under:

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II. RESULT TABLE

Fitted curves, R^2 and s^2 values for the functional forms **(5)**

Source	**Functional Forms**					
			(5)			**(2)**
	a	b	c	R^2	S^2	S^2
Draper & Smith (1981) Ex. L, Pg. 522-524						
Data Set 1	130.7126	11.6284	-62.7046	0.9816	50.8199	252.0
Data Set 2	1.1148	0.1157	-0.8289	0.9689	0.0173	0.0262
Data Set 3	421.6973	51.9357	-316.1272	0.9773	1854.73	3376.5
Data Set 4	11.8338	1.8019	-5.6243	0.8601	8.1535	17.004
Data Set 5	9.9117	0.5962	-6.1770	0.9922	0.1285	0.866
Data Set 6	14.9176	0.8368	-8.7852	0.9891	0.3601	3.716
Data Set 7	158.054	7.7589	-57.3651	0.9656	112.04	1168.0
Data Set 8	16.1349	0.6220	-8.8585	0.9501	8.94	25.990
Data Set 9	6828.96	875.30	-2994.63	0.99	18.66	68349.0

III. CONCLUSION

It is seen from the table that relation **(5)** fits the data well and s^2 values for the form **(5)** are much lower than s^2 values for the form **(2)** in all cases.

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