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DETROIT RESEARCH INSTITUTE
P.O. BOX 36504 • GROSSE POINTE, MICHIGAN 48236 • (313) 886-7976

LEONARD G. JOHNSON
EDITOR

WANG H. YEE
DIRECTOR

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# THE DOLLAR ENTROPY METHOD OF ASSESSING FIELD FAILURE COSTS

## INTRODUCTION

In the present age of emphasis on product quality and the satisfaction of customers it follows that we must make a systematic analysis of dollar losses sustained as a result of product defects and operating failures which hurt our competitive standings. For example, American vehicle manufacturers have lost ground to foreign auto makers simply because countries like Japan have made systematic studies of loss functions involved in vehicle defects found in both laboratory tests and field tests. In fact, this whole approach, involving loss functions, has attained world-wide fame under the name of Taguchi, its Japanese promoter.

At Detroit Research Institute we have for a couple of decades promoted the so-called ENTROPY METHOD of studying product reliability. The Dollar Loss Function idea of Taguchi is just another form of Entropy Analysis wherein deffects are assigned dollar values instead of just being counted as occurences (number of cases).

In this bulletin we shall take Dollar Loss Data on vehicles in the field and show how we can use such data to construct Entropy plots which show how rapidly or slowly Dollar Losses per Sold Vehicle accumulate with vehicle age. In this way we will be evaluating failures the way they should be evaluated, namely, in terms of Dollar Losses which, after all, truly reflect the seriousness of defects. The actual number of defects is not as significant as the Dollar Losses they cause.

## A FIELD EXAMPLE

Suppose that on a certain data after the start of a model year we find that we have sold 2876 vehicles with the following relevant facts known about these sold vehicles:

TABLE 1 (DOLLAR LOSSES VS. VEHICLE AGES)

| VEHICLE AGE (DAYS OF OWNERSHIP) | NO. OF VEHICLES IN THE INTERVAL | DOLLAR LOST DUE TO FAILURE IN THE INTERVAL |
|---|---|---|
| 0 - 30 Days | 506 | $18,511 |
| 31 - 60 Days | 609 | $12,052 |
| 61 - 90 Days | 751 | $ 7,185 |
| 91 - 120 Days | 552 | $ 3,510 |
| 121 - 150 Days | 458 | $ 952 |

## STEP #1 IN THE ANALYSIS:
## COUNTING THE NUMBER OF VEHICLES ACTIVE TO EACH TIME INTERVAL END POINT

In order to perform Entropy Analysis on such a data set we must first of all determine how many vehicles are active within each interval all the way to its end point. This total activity number consists of two parts:

(1) The fully active vehicles (which have reached at least the age at the end point of the interval by being older.)

(2) The partially active vehicles (which are still inside the interval)

Item (1) (fully active vehicles) for any interval end point is calculated by summing up the vehicles subsequent to the interval.

Item (2) is estimated by taking half of the vehicles within the interval under consideration.

Thus, at the end of 30 days we have

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 609 | + | 751 | + | 552 | + | 458 | = 2370 Fully Active |
| | | and 1/2(506) | | | | | = 253 Partially Active |
| | | | | | | SUM | = 2623 Active to 30 days |

Likewise, for 31 to 60 days, we have

| | | | | | | |
|---|---|---|---|---|---|---|
| 751 | + | 552 | + | 458 | = | 1761 Fully Active |
| | and 1/2(609) | | | | = | 304.5 Partially Active |
| | | | | SUM | = | 2065.5 Active in Interval 31 to 60 days |

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For the interval 61 to 90 days, we have

| | | | |
|---|---|---|---|
| 552 + 458 | = | 1010 | Fully Active |
| and 1/2(751) | = | 375.5 | Partially Active |
| SUM | = | 1385.5 | Active in Interval 61 to 90 days |

For the interval 91 to 120 days, we have

| | | | |
|---|---|---|---|
| | | 458 | Fully Active |
| and 1/2(552) | = | 276 | Partially Active |
| SUM | = | 734 | Active in Interval 91 to 120 days |

Finally, for the interval 121 to 150 days, we have

| | | | |
|---|---|---|---|
| | | 0 | Fully Active |
| and 1/2(458) | = | 229 | Partially Active |
| SUM | = | 229 | Active in Interval 121 to 150 days |

STEP #2 IN THE ANALYSIS

CONSTRUCTION OF THE ENTROPY TABLE

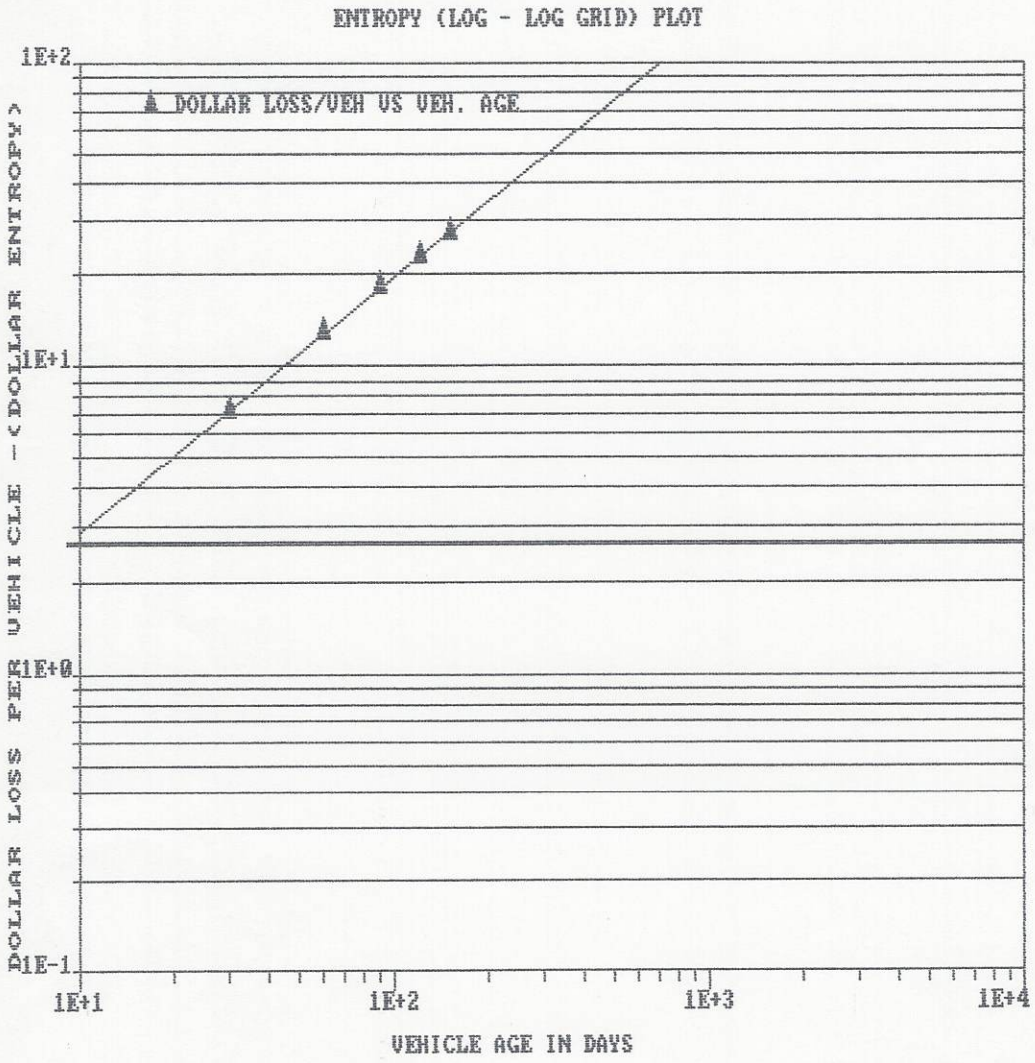
| VEHICLE AGE (DAYS OF) (OWNERSHIP) | NO. ACTIVE | DOLLAR LOST DUE TO FAILURE | DOLLAR HAZARD DOLLAR LOSS PER NO. ACTIVE | DOLLAR ENTROPY (CUMULATIVE) (DOLLAR) (HAZARD) |
|---|---|---|---|---|
| 0 - 30 DAYS | 2623 | $18,511 | 7.05719 | 7.05719 |
| 31 - 60 DAYS | 2065.5 | $12,052 | 5.83491 | 12.89210 |
| 61 - 90 DAYS | 1385.5 | $ 7,185 | 5.18585 | 18.07795 |
| 91 - 120 DAYS | 734 | $ 3,510 | 4.78202 | 22.85997 |
| 121 - 150 DAYS | 229 | $ 952 | 4.15721 | 27.01718 |

NOTE: The last column (DOLLAR ENTROPY) represents the Accumulated Dollar Loss per Vehicle up to the vehicle age shown in the first column.

Thus, after Sold Vehicles have been in the hands of the owners for 150 days, the Dollar Loss per Vehicle is $27.02.

STEP # 3

Slope of Line = .83728 (A slope less than 1 indicates Reliability Growth)
Goodness of Fit = .99973 (Correlation Coefficient) > (Very Good Fit)




THE REGRESSION POLYNOMIAL OF LINE 1 -

(-3.836E-01) + ( 8.373E-01)*X
THE VARIANCE - 2.318E-05

Graph shows : $10 Loss per Vehicle in 45 Days
$20 Loss per Vehicle in 103 Days
$58 Loss per Vehicle in 365 Days (1 Year)
$100 Loss per Vehicle in 700 Days

## CONCLUSION

It can be seen that the Dollar Entropy Analysis clearly defines the status of a vehicle model in the field. In the example it is obvious that there is no catostrophic growth of dollar losses per vehicle with age. In fact, the Entropy plot shows improvement with vehicle age as far as dollars lost per vehicle rates with respect to days of ownership are concerned.