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VEHICLE REPLACEMENT IN GOVERNMENT PARASTATALS: A COMPARATIVE STUDY OF MAJOR GOVERNMENT REPLACEMENT POLICIES.

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ABSTRACT

Three major Government Replacement policies in Nigeria were compared using an economic replacement model for vehicles.
These policies are all practiced by the government in different parastatals following various management systems, and adopting deviant operation management policies. The policies were compared based on data collected over a ten-year period, from a non-profit making government parastatal in Nigeria.
The data included repair and maintenance expenditure and the analysis of the data indicated that the correlation between vehicle accumulated repair and maintenance costs and its cumulative age in use was best described by an exponential function.
The result of the comparative analysis of the policies shows that using the table discounted cost as a performance measure, the individual vehicle policy is preferred to the age of group vehicle policy, which in turn is preferred to average vehicle policy.

KEYWORDS: Vehicle, Replacement, Model, Policy.

INTRODUCTION

Models on replacement of used equipment abound in the literature ranging from the family of models which model the deterioration of equipment as a multistage discrete time controlled Markov process: see Apostolos, B.G. (1977), Kao,E.P.C. (1972), and Feldman,R.M. (1976.),This family of models do not specify a formalized and structured approach to the identification of states of the Markov process. The choice of state might be arbitrary and therefore would affect the transitional probabilities. In the family of repair limit replacement models, an equipment that requires repair is first inspected and the repair cost estimated. If the estimated cost in terms of money or time exceeds a certain amount known as the "repair limit", the equipment is not repaired but replaced: see Drinkwater,R.W. and Hastings,N.A.J.(1967)and Nkagawa,T. and Osaki,S. (1974)). This family of models require detailed prior data so as to estimate certain future parameters. They seem to provide limits for situations where there is a catastrophy and the repair cost is too high.

In a normal breakdown, the solution might be sub-optimal, if the repair cost becomes too high for a particular year. The family of economic life models is used to find the optimal age at which it is economically best to replace a vehicle under various assumptions by studying the average rate at which annual expenditure or income tend to increase or decrease with the age of the vehicle: see Bellman, R.(1955),Eilon etal. (1966), Lake, O. H. and Muhlemann, A. .(1979),Christer,A.H. and Goodbody,W. (1980) and Schwartz,E. and Mcnamara, J.R.(1983).

The model due to Bellman,R. (1955) was applied

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to the case study data. This model was preferred to others because it gave an annual average minimum cost when compared with other economic life models. The model was giving as:

$$\text{Min } V(N) = \frac{[A - S(N)]\, R^{N-1} + f(0)\, R^{N-1} \sum_{t=1}^{N-1} f(t)\, R^{t-1}}{1 - R^{N}} \quad (1)$$

where,
V (N) = The annual average cost at age N
A = The acquisition cost of a new equipment
S (N) = The salvage value of an equipment at age N
R = Discount factor
f (t) = Maintenance cost function at period t

Replacement of used items has been a decision problem facing the policy makers in most organizations. This problem is most frequent in government establishments with the result that used items including vehicles which breakdown are seen to be littered in the premises or be packed away in the stores. One can then imagine the great economic loss which is incurred by parking away such items which may need little repair to be put back to shape. Again, even when the government has made up her mind to replace such vehicles, the problem of which policy option to adopt comes into play, namely, would the government take the individual replacement policy whereby a policy to replace a vehicle will be based on the optimum lifetime of that vehicle only or take age group replacement policy whereby a pool of vehicles of the same age are replaced after a given period of time in their economic life or take the
average vehicle replacement policy whereby on the average, any used vehicle is replaced after a period of time based on the average performance of such vehicles. Therefore this study was undertaken because of scarcity of information in the literature concerning the topic in order to achieve the following objectives.

1. To review a replacement model and then apply it to the case study data so as to establish optimum replacement age for a vehicle in a non-profit making government establishment.
2. To compare the optimum replacement age among the three major policies namely: individual vehicle replacement policy, age group vehicle replacement policy and average vehicle replacement policy and
3. To establish the optimum policy to be adopted using the total discounted cost as a performance measure.

METHODOLOGY

Data pertaining to repair and maintenance expenditure (parts and labour), disposal value and vehicle age in use for 504 Peugeot vehicles were collected from a non-profit making government parastatal over a ten-year period. The total number of 504 Saloon vehicles surveyed was 40. The data was collected from the vehicle log book and it included, vehicle make and model, date of purchase, initial purchase price, vehicle registration, chasis and engine numbers and detailed repair and maintenance expenditure (parts and labour).

In addition, data on salvage values were also collected and the staff (mechanical engineers and maintenance management personnel) were interviewed. Since the vehicles were of different ages, vehicles of the same age were grouped together and the data for the different groups as well as the data for an average operating vehicle were analyzed. Data for the individual vehicles were analyzed using the model in equation (1).

All monitored costs in this study were accrued over a period of 10 years during which the inflation rate was remarkably high, consequently an inflation rate of (26%) was used to adjust these prices and costs (Central Bank of Nigeria, annual report and statement of accounts (1996-2000)). The data for the three policies was then set and analyzed using (MSTATC) statistical computer programme on IBM 586 personal

TABLE 1: REPLACEMENT AGE FOR AVERAGE VEHICLE

Replacement age N	Expected Total Discounted cost
1	₦1124999.01
2	₦ 1120364.95
3	₦ 118660.07
4	₦ 1117816.09
5	₦ 1117371.30
6	₦ 1117151.00
7	₦ 1117063.51
8 *	₦ 1117059.00
9	₦ 1117106.03
10	₦ 1117184.22
11	₦ 1117280.06
12	₦ 1117384.47
13	₦ 1117491.37
14	₦ 1117596.70
15	₦ 1117697.84

TABLE 2: ANALYSIS BASED ON AGE-GROUP VEHICLE DATA

Age of a vehicle	Optimal replacement period	Expected table cost
11	8	₦1117523
10	7	₦ 1117414.50
9	7	₦ 1117193.04
8	7	₦ 1116413.15
7	7	₦ 11161508.70
6	7	₦ 1116695.75
5	9	₦ 1115722.94
3	13	₦ 1114310.57

computer. The calculations of the optimal ages for the different policies were established by evaluating the model in equation (1) in the interactive mode of the software.

RESULTS AND DISCUSIONS

The three sets of data were analyzed namely: Data for the 40 individual vehicles were analyzed separately and their individual replacement intervals determined, data based on vehicles of the same age and the data for an average operating vehicle were also analyzed. The results of the analysis of data for an average operating vehicle is displayed in table 1. The results include the expected total discounted cost when the vehicle is replaced at different ages. The replacement age in asterisks has a minimum total discounted cost of ₦117059.00 and therefore the optimum replacement age for an average operating vehicle is 8 years. The results of the analysis of the data based on vehicles of the same age showed that their optimum replacement period varies from 7 years to 13 years depending on the age group of the vehicle. Table 2 shows a summary of this analysis. As an illustration from table 2, the vehicles in the age group of 11 years gave an optimum replacement period of 8 years with an expected total discounted cost of ₦1117523 while the vehicles of age group 3 has an optimum replacement period as 13 years with an expected total discounted cost of ₦1114310.57. Finally, table 3 summarizes the results of the analysis based on

TABLE 3: ANALYSIS BASED ON INDIVIDUAL VEHICLE DATA

Vehicle	Optimal Replacement period	Expected Discounted cost
1	8	₦ 1117689.92
2	7	₦ 1117331.38
3	8	₦ 1116354.30
4	9	₦ 1117637.94
5	6	₦ 1117120.83
6	7	₦ 11146601.17
7	7	₦ 1117917.75
8	7	₦ 1117062.07
9	8	₦ 1117714.04
10	7	₦ 11146840.06
11	7	₦ 1117514.11
12	7	₦ 1116566.62
13	7	₦ 1116875.53
14	8	₦ 1117669.55
15	7	₦ 1117557.20
16	7	₦ 1117155.30
17	6	₦ 1117041.80
18	7	₦ 1117041.98
19	8	₦ 1116959.02
20	8	₦ 1117238.43
21	8	₦ 1116815.29
22	8	₦ 1116601.19
23	8	₦ 1116602.01
24	7	₦ 1117144.45
25	8	₦ 1117144.95
26	8	₦ 1116163.42
27	7	₦ 1116049.20
28	7	₦ 1116996.14
29	7	₦ 1116944.95
30	7	₦ 1116834.53
31	7	₦ 1116570.11
32	9	₦ 1116813.44
33	10	₦ 1116048.90
34	11	₦ 1115536.86
35	9	₦ 1115787.71
36	10	₦ 1115640.60
37	15	₦ 1114436.88
38	14	₦ 1114153.02
39	14	₦ 1114199.29
40	13	₦ 1114461.76

individual vehicle data. This table reveals that the optimum replacement ages for individual vehicles vary from 6 year to14 years.

The variation of the optimum replacement intervals from the average of 8 years is quite pronounced. This is because each vehicle has its peculiarities and problems, and making decisions based on the individual vehicle mould mean to avoid undertaking costly repairs to some vehicles but to the advantage of the fact that others run for

long periods with relatively little repair.

Comparison of the three vehicle replacement policies namely: the individual vehicle replacement policy, Age-group vehicle replacement policy and the average vehicle replacement policy. The individual policy requires detailed maintenance records to be kept on each of the vehicles, so that the optimum solution for each vehicle may be computed. The age-group policy treats vehicles of the same age as one vehicle and requires data on age of each vehicle and maintenance cost data for that age group, while the average vehicle policy dispensed with these detailed records, but still keep a few details as checks on the existing average policy.

Using the sum of the total discounted cost for the forty vehicles as the performance measures, the individual vehicle policy gives a total discounted cost of N44663373.07, the age-group vehicle policy gives a total of N44675216 while the average vehicle gives a total average discounted cost of N44682360. This result shows a preference to individual vehicle policy. It gives a cost saving of 0.03% compared to the age-group policy and 0.04% when compared to the average vehicle policy.

CONCLUSIONS

Based on the analysis of data utilized in this study, the following groups of conclusions are drawn.

1. Vehicle age in use was one of the major determinants of vehicle repair, maintenance and replacement.

2. The study indicated that the optimum replacement age of a vehicle is affected by the salvage value of vehicles of the same age.

3. Comparison of the modified model of replacement among the surveyed government policies, indicated that based on total annual discounted cost, the individual vehicle replacement policy is preferred to the Age group and average vehicle replacement policy.

4. Age group replacement policy is preferred to average vehicle replacement policy.

REFERENCE

Apostolos, B. G., 1977. Optimal systems for equipment maintenance and replacement under Markovian detrioration, EUR. J. Opl. RES. 1(2): 257-26.

Bellman, R., 1955. Equipment Replacement policy J. Soc. Industrial and Applied maths, 3: 133 – 136.

Central bank of Nigeria, 1990-200. Annual Report and statement of Accounts.

Christer, A. H. and GoodBody, W., 1980. Equipment Replacement in an unsteady economy. J. Opl Res. Soc. 31: pp.497-506.

Clapham, J. C. R., 1957. Economic life of Equipment, Opl Res. Q. Vol. B, P. 181-190.

Drinkwater, R. W. and Hastings, N. A. J. 1967. An economic replacement model, Opl. Res. Q. 18: 121-139.

Eilon, S., King, J. R. and Hutchinson, E. E., 1966. A study in equipment replacement. Opl. RES. Q. 17: 59-71.

Feldman, R. M., 1976. Optimal replacement with Semi-Markovian shock models. J. Appl. Prob. 12: 108-117.

Hawkins, C. A. and Nasoni, R.L., 1977. Capital replacement under variable discounting Opl RES. Q. 28: 313-324.

Kao, E.P.C., 1972. Optimal replacement rules when changes of state are Semi-Markovian.OPL. RES. 21: 1231-1249.

Kent, A., 1970. The Effect of discounted cash flow on replacement analysis. Opl. RES. Q. 21: 113-117.

Lake, O. H. and Muhlemann, A. P., 1979. An equipment replacement problem. J. Opl RES. Soc. 30: pp. 405-411.

Mitlal, J. and Kaul, R., 1984. Effect of inflation in depreciation analysis of farm machinery. AMA, 15 (1): 73-76.

Nakagawa, T. and Osaki, S., 1974. The Optimum repair limit replacement policies. Opl. RES. Q., 25: 311-317.

Schwartz, E. and Machnamara, J. R., 1983. The Optimal replacement cycle given an efficient resale market for used assets, The Engineering Economics, 28: 91-100.