Economic Analysis of Ideal Time for Farm Tractor Replacement. A Case Study of Tractor Owners and Operators Association of Nigeria, Kaduna State

BUBA BABA SHANI[1], ALIYU MUSA[2]
[1,2]*Department of Crop and Soil Science, Faculty of Agricultural Sciences, National Open University of Nigeria, Kaduna State, Nigeria*

Abstract *-- Today, of all the sources of farm power available, tractor stands out as the most important power sources in agriculture. Timely replacement of tractor is amongst the most important decisions that should be made by farmer. Adequate optimum performance in this case can lead to timely, high quality farm operations which in turns results in considerable decrease in product expenditures and more income. The study was performed to determine economically optimum life of MAHINDRA 605 tractors under Tractor owners and operators Association of Nigeria (TOOAN) in three regions of Kaduna state, Nigeria. Moreover, listed price of tractor, annual depreciation and Internal Rate of Return in the study period were calculated. Then, these components accompanied by their repair and maintenance cost were used to determine their economic life. Finally, replacement time for the study tractors was obtained equal as 5679 hours. These hours of operation are performed in about 10 years and thus the tractor should be replaced.*

Indexed Terms: *Economic, ideal, time, Tractor, TOOAN*

I. INTRODUCTION

Management of farm machinery is one of the important branches of farm management. Finding of replacement time of farm machinery is related to conditions of their economic and technological is one of the considered aims in management of farm machinery. A complete line of machinery is one of the largest investments that a farm business can make. The quality of mechanization inputs and consequently land and labor productivity in both situations may differ considerably (Gifford, Rijk 1980; Singh 1997; Singh, Chandra 2002). The use of modern technology during latter decades resulted in rapid growth of farm production. Tractors and farm machinery are important samples of this modern technology (Xinan et al. 2005; Singh 2000a; Singh 2000b). Today, tractor is one of the most important power sources in agriculture and effect of its power on agriculture economy is considerable (Singh 2006).

However, machinery must be constantly monitored, maintained and eventually replaced. How and when equipment is replaced can make a difference of thousands of Naira in annual production costs.

Decision to replacing old machinery by a new similar one is usually performed based on its economic life. Economic life, named as optimum life, has a direct relation with repair and maintenance costs. Costs of owning and operating of farm machinery represent about 35 to 50% of the costs of agricultural production when excluding the land (Anderson 1988).

The R&M (repair and maintenance cost) is an important component in costs of owning and operation. In general, the costs other than those for R&M usually decrease with increasing usage, but the reverse is true with respect to R&M costs. The cost of R&M is usually about 10% of the total cost; as the machine age increases the cost increases until it becomes the largest cost component of owning and operating of farm machines (Rotz and Bowers, 1991).

Several studies were conducted in both developed and undeveloped countries either to develop models to determine the cost during a certain period or to get absolute numbers to represent owning and operating of certain equipment (Bowers, Hunt 1970; Fairbanks et al. 1971; Farrow et al. 1980; Ward et al. 1985; Rotz 1987; Gliem et al. 1986; Gliem et al.1989).

Based on ASAE, replacement age for a machine that is placed on economic life arrives typically before fundamental breakdowns resulted worn out and technological disabling (ASAE Standards S495, 2006). Economic or optimum life for a machine presents a time period based on constant and variable

costs that using the machine is economical (ASAE Standards EP496, 2006; Hunt 2001). Each machine has a determined economical life that thereafter using the machine is not economical. It is known that repair and maintenance cost have a large share from machine ownership costs.

While machine age is raised, fixed cost is reduced, both repair and maintenance (variable) costs is raised. As it is required, indication of total annual machine costs is obtained by adding fixed and variable costs. Minimum point of this curve, that is intersection point of constant and variable cost curves, presents the most appropriate time for replacing machine (Ward et al. 1985).

Mahindra and Mahindra are the largest tractor manufacturer in the world with a tractor assembly plant commissioned by Springfield Agro in Nigeria, which has a manufacturing capacity of 5,000 tractors and associated agricultural. It produces various ranges of tractors from 25Hp to 80Hp to cater to a wide spectrum of customers' needs. Over the years, it has created thousands of satisfied customers in Nigeria and millions across the world.

Tractor owners and operators association of Nigeria (TOOAN), is one of Nigeria's most respected service providers. The association was founded in Sawonjo Farm Settlement, Yewa North, Ogun State in 1984 but was finally incorporated by the CAC on the 17th July, 1997. It came into Limelight by the spread across the Country through the program 'lease finance/tractor acquisition initiated and promoted by an NGO known as PROPCOM in 2010.

Several specific studies were performed to determine the economic life of MAHINDRA 605 tractors in different regions of Kaduna state, Nigeria. Tractor owners and operators Association of Nigeria (TOOAN) of Nigeria obtained 10years with 14000 hours operation for these tractors. B.Shani, A.Musa and Umar R, determined the economic lifes of the tractor in the six selected local areas of the zones.

Table 1 below showed that, all economic life has been obtained in the range of 14000 hours reported by TOOAN. The life time reported by B.Shani is highly greater than the others. He explained that its reason was due to the wide increase of list price of MAHINDRA 605 tractors in recent years in Nigeria.

TABLE 1: The Economic Life of Mahindra 605 In Various Local Area of Kaduna

Useful Life M605 Tractors		Study Area	Researcher	Date
Year	Hours			
13	14000	ZARIA	B.B. SHANI	2017
12	12900	LERE	B. B.SHANI	2015
9	10296	GIWA	A. MUSA	2016
8	11975	IGABI	A. MUSA	2017
7	9654	KAURU	UMAR R	2012
12	13960	JAMAA	UMAR.R	2014

The main objective of this study is to make available to stakeholders, a statically analysis on constant and variable costs for MAHINDRA 605 tractor in order to get the best time for replacing tractor. Determining economical life for farm machinery provides planners and policy makers and also farmers an opportunity to evaluate the performance of machinery economic.

II. RESEARCH ELABORATIONS

Study area

Kaduna state is located at the Northern part of Nigeria's High Plains. The vegetation cover is Sudan Savannah type, characterized by scattered short trees, shrubs and grasses. The soil is mostly loamy to sandy type. A substantial amount of clay is found also. Kaduna State, Is 10.53°N 7.44°E 626m asl. Kaduna State consists of twenty-three (23) Local Government Areas. The climate is tropical in Kaduna. When compared with winter, the summers have much more rainfall. The climate here is classified as Aw by the Köppen-Geiger system. The average annual temperature in Kaduna is 25.2 °C. About 1211 mm of precipitation falls annually. This region has dry and warm climate. Soil of this region is heavy and semi-heavy, and each farm size is 25 ha in regular forms.

Totally, 65 tractors model MAHINDRA 605, are censored to be used in the state by the members of Tractor owners and operators Association of Nigeria (TOOAN). These tractors are operated in

implementing of all farming operations. Records of service and maintenance of tractors have been kept for 10 years ago.

Determination of Machinery Costs

Machinery costs are divided into two categories, fixed costs and variable costs. Variable costs increase proportionally with the amount of operational use given to the machine, while fixed costs are independent of use. It is not always clear as to which category some of the specific costs belong. The costs of interest on the machinery investment, taxes, housing and insurance are dependent on calendar-year time and are clearly independent of use. The costs of fuel, lubrication, daily service and maintenance, power and labor are clearly cost associated with

use. The two remaining cost components, depreciation and the cost of repairing, seem to be functions of both use and time. There are no personal property taxes and insurance in Nigeria. Also, insurance of farm machinery is not popular and the farmers accept the risk of sudden costs. Housing for the mentioned tractors is the campus of maintenance unit of TOOAN and has not any considerable cost. Therefore, only depreciation and interest on investment were investigated in this research.

Estimation of yearly costs is adequate for determining crop production costs and for deciding if machine ownership is profitable; but the time of replacement depends on the accumulated costs over a period of years.

Determination of Depreciation

Depreciation is a commonly used accounting concept used to help accountants track the value of assets over time. This is especially important to keep track of equipment like tractors, which have varying useful lives depending on the usage and quality of the vehicle. The most common method for calculating depreciation is the straight-line method, which depreciates an equal amount every year based on two things: the original cost of the tractor and the tractor's useful life.

Introduction of new technology or a major design change may make an older machine suddenly obsolete, causing a sharp decline in its remaining value. But age and accumulated hours of use usually are the most important factors in determining the remaining value (V) of a machine at any time.

In this study, declining-balance method was used to calculate depreciation for the mentioned tractors. A uniform rate is applied each year to the remaining value (includes salvage value) of the machine at the beginning of the year. The depreciation amount is different for each year of the machine´s life. Equations 1, 2 and 3 express the relationships by formulas.

$$D = V_n - V_{n+1} \quad (1)$$

$$V_n = P\left(1 - \frac{x}{L}\right)^n \quad (2)$$

$$V_{n+1} = P\left(1 - \frac{x}{L}\right)^{n+1} \quad (3)$$

Where: D (Depreciation), is amount of depreciation charged for year n+1,

n, is a number representing age of the machine in years at beginning of year in question,

V, is remaining value at any time and x, is ratio of depreciation rate used to that of straight-line method (x may have any value between 1 and 2). If x = 2, the method is called a double-declining-balance method and is the maximum rate method permitted.

For tractors model MAHINDRA 605, the rate value was x = 1.5.

Determination of Interest on Investment

The interest on investment in a farm machine is included in operational cost estimates. Even if the investment money is not actually borrowed, a charge is made since that money cannot be used for some other interest-paying enterprise. Nominal interest rates include, expected inflation. In times of substantial monetary inflation, a machinery manager must include the effects of inflation on machinery planning. Inflation causes increased prices for goods and services in future years.

The real interest rate, I_r, is a function of the nominal interest rate, Ip and the rate of inflation, Ig, as shown in Eq. 4.

$$I_r = \frac{I_p + I_g}{1 + I_g} \quad (4)$$

Therefore, the interest on investment was calculated by using Eq.5

$$In = V_n . I_r \quad (5)$$

Where, In is the interest on investment in n-th year ($) and I_r is the real interest rate.

Determination of Repair and maintenance cost

Data were collected from 65 MAHINDRA 605 tractors operated in the Local Government areas by using reports of service and maintenance form. The service and maintenance reports had different information such as tractors entry and exit from shooting gallery, type of tractor failure, replaced and repaired parts.

The mean working hours per year were obtained, separately, for each year, after stratifying service reports. Also, for each year, the mean annual repair and maintenance costs were separately calculated. Repair costs are the expenditures for parts and labor for, 1: installing replacement parts after a part failure and 2: reconditioning renewable parts as a result of wear. The anticipated annual cost of repair for any machine is highly uncertain.

Determination of Time of Replacement

To determine time of replacement for the study tractors, accumulated depreciation, interest on investment and repair costs were calculated and then, regression analysis was performed on the data by using computer software SPSS 16.0 (version 2009).

III. RESULTS AND DISCUSSION

Accumulated depreciation, interest on investment, repair and total costs for the tractors operated in Kaduna state are presented in Table 2. The major challenges in the analysis of the machinery costs is that they (costs) change over time. Depreciation, often the largest cost of farm machinery, measures the amount by which the values of a machine decrease with the passage of time whether used or not.

As it is shown in Table 2, depreciation tends to be excellent at first, especially for a new machine, but declines over time.

Table 2. Accumulated costs for MAHINDRA 605 tractor

Age	Accumulated Repair &Maintainance Cost ₦	Accumulated Depreciation Cost ₦	Accumulated Interest On Investment Cost ₦	Total Accumulated Cost ₦
1	30,900	407,100	210,900	648,900
2	67,200	689,700	406,200	1,163,100
3	125,400	951,000	586,500	1,662,900
4	203,400	1,192,800	753,600	2,149,500
5	304,200	1,416,300	908,100	2,628,600
6	432,600	1,623,300	1,050,900	3,106,800
7	582,000	1,814,700	1,182,900	3,579,600
8	756,300	1,991,700	1,305,300	4,053,000
9	944,400	2,155,200	1,418,400	4,518,000
10	1,150,200	2,306,700	1,522,800	4,979,700
11	1,384,500	2,446,800	1,619,700	5,450,700
12	1,641,000	2,576,400	1,709,100	5,926,200
13	1,919,400	2,696,100	1,791,900	6,407,400

As it is shown in the Figure 2, the first year´s costs are high due to the high exchange rate of naira to dollars in the real marketplace depreciation obtained from the estimate value method. The yearly costs drop to their lowest value (9th year) and then begin to rise if the annual repair costs increase with age. The accumulate cost curve drops more gradually and levels out at the point where it crosses the yearly cost curve. The average total costs were obtained through an equation of quadratic (y = -0.0281 + 1140.8) with a correlation coefficient r^2 = 0.82 for MAHINDRA 605 tractors.

At the same time, interest usage is high initially but gradually diminishes. This is true whether the interest cost is cash interest paid on a loan, or an opportunity cost based on revenue foregone by continuing to own a machine year after year.

On the other hand, repair costs may amount to little or nothing when a machine is still under warranty,

maintenance requirement rise. Accumulated operating hours, total accumulated costs and also average total costs are presented in Table 3. As it is seen in the table, average total costs in 9th year (6981 hours usage) drop to their lowest value.

Regarding to other studies in Nigeria, the appropriate time for replacement of the MAHINDRA 605 tractors was less than the others based on hours of use (6981 hours) and was approximately similar to other studies based on years of tractor life (9 years) and the minimum average total cost was 986.1 Naira per hectare.

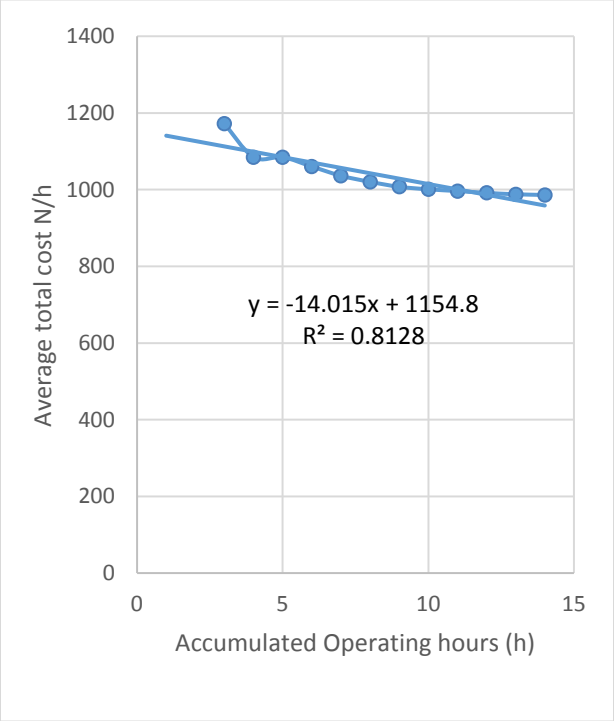

Figure 2: Average total costs for Mahindra 605 tractor

Annual operating hours for the mentioned tractors in this study were less than the others. As shown in Table 3, the annual hours of tractor usage were about 500 hours in each year.

This means that, the R&M costs for each year was little in this study but the amount of depreciation and interest costs were equal to the other studies. These costs (depreciation and interest costs) are affected by list price of tractors (P in the Eq. 2 and 3) and aren't depended on the hours of tractor operation in each year. Therefore, the effective factor affecting the appropriate year of tractor replacement, are the depreciation and interest costs and the other factor which affects the appropriate hours of tractor usage is R&M cost. It is concluded that the useful life of farm tractors depends on propensity of R&M cost and the amount of depreciation and interest costs. Whatever the level of R&M cost is greater, the useful life will be sooner and whatever the depreciation and interest costs is more, the useful life of tractors will be forced to later.

In other words, the amount of R&M costs doesn't show on the tractor replacement point however, intensity of increase in R&M costs in the recent years greatly dictates on Finding of the useful time.

Table 3: Operating hours and cost for MAHINDRA 605 tractor

Average total cost N/h	Total accumulated cost N	Accumulate operating hours h	Annual Age operating hours h	Age
1352.1	836,700	480	480	1
1172.4	1,570,500	992	512	2
1084.5	2,198,400	1493	501	3
1084.5	2760000	1982	489	4
1060.2	3,270,900	2479	497	5
1036.2	3747300	2998	519	6
1020.3	4191600	3508	510	7
1007.4	4615500	4023	515	8
1000.8	5015700	4515	492	9
996.3	5400600	4998	483	10
991.5	5778000	5479	481	11
987.9	6162900	5981	502	12
986.1	6553800	6489	508	13

The standard rule for minimizing the long-run cost of equipment is to make a change when the annualized total cost of owning and operating the machine begins to increase. In the study, this happens in about the 10th year of ownership. At this point repair costs begin to increase faster than depreciation and interest costs decrease. However, the rate at which total costs rise is often very gradual. Thus, while the rule of increasing total cost can give a general picture of period to replace a machine, it cannot give a precise answer.

IV. CONCLUSION

The appropriate time for replacement of MAHINDRA 605 tractors operated by Tractor owners and operators Association of Nigeria (TOOAN). in Kaduna state of Nigeria based on economic analysis is about 13 years with 6981 hours operation.

The interest and depreciation costs effect on the year of tractor replacement and R&M costs determine the amount of tractor economical usage.

ACKNOWLEDGEMENT

The authors wished to extend their profound gratitude to the leadership of Tractor owners and operators Association of Nigeria for the support they rendered to see to the success of this research.

REFERENCES

[1] Anderson AW. Factors affecting machinery costs in grain production, ASAE Paper. 1988. No. 88-1057. ASAE Standards S495. Uniform Terminology for Agricultural Machinery Management. 2006.

[2] ASAE Standards EP496. Agricultural Machinery Management Engineering Practice. 2006.

[3] Ashtiani AR, Ranjbar I, Toorchi M. Determining the economic life for three agricultural tractor models in Nigeria (Case Study: Mazandaran Dasht-e-Naz Farm Company), Journal of Agricultural Sciences, Islamic Azad University.2005. 12(1):221-230.

[4[Bowers W, Hunt DR. Application of mathematical formulas to repair cost data. Transactions of the ASAE. 1970. 13(6): 806-9.

[5] Fairbanks GE, Larson GH, Chung DS. Cost of using farm machinery. Transactions of the ASAE. 1971. 14(1): 98-101.

[6] Farrow S, Shepherd JF, Waelti H. A regional test of machinery repair cost equations. ASAE Paper. 1980. No. 80-1017.

[7] Gliem JA, Stinson DM, Carpenter TG, Holmes RG, OzcanHE.Updated variable costs of farm machinery operation in Ohaio,ASAE paper. 1986. No. 86-1024.

[8] Gliem JA, Persinger KM, Carpenter TG, Holmes RG. A comparison of ASAE estimated tractor and combine repair and maintenance costs to actual repair and maintenance costs of selected farms. ASAE paper. 1989. No. 89-1024.

[9] Hunt DR. Farm Power and Machinery Management, Tenth Edition, Iowa State University Press, Ames. USA. 2001.

[10] Lazarus W. Machinery cost estimates, Extension published by Department of Applied Economics, University of Minnesota.2008.

[11] Khoubakht GM. Finding of optimum life (economic life) for MF286 tractor, A case study in west region of Isfahan state), M.Sc. Thesis, Faculty of Agricultural Engineering and Technology, Department of Agricultural Machinery Engineering, University of Tehran, Nigeria.(2008).

[12] Rotz CA. A standard model for repair costs of agricultural machinery. Appl. Engineering in Agric. 1987. 3(1): 3-9.

[13] Rotz CA, Bowers W. Repair and maintenance cost data for agricultural equipment. ASAE Paper. 1991. No. 91-1531.

[14] Singh G. Estimation of a mechanization index and its impact on production and economic factors, A case study in India,Biosystems Engineering. 2006. 93(1): 99-106.

[15] Singh G. Modernization of agriculture in India (part I)—farm mechanisation. Agricultural Situation in India. 2006.

[16] Gifford RC, Rijk AG. Guidelines for Ministry of Agriculture,New Delhi. agricultural mechanisation strategy in development.

[17] Sharifi A. Finding of a mathematical model to predict the repair and maintenance cost of three models of farm tractors in Nigeria, M.Sc. Thesis, Faculty of Agricultural Engineering and

[18] Technology, Department of Agricultural Machinery Engineering, University of Tehran, Nigeria. (1994).

[19] Singh G. Data book on mechanization and agro processing in India after independence. Technical Bulletin CIAE/97/71,Central Institute of Agricultural Engineering, Nabi Bagh,Berasia Road, Bhopal, India. 1997.

[20] Singh G, Chandra H. Production and economic factors growth in Indian agriculture, Technical Bulletin No. CIAE/ 2002/91,Central Institute of Agricultural

Engineering, Nabi Bagh, Berasia Road, Bhopal, India. 2002.

[21] Singh RB. Environmental consequences of agricultural development: a case study from the Green Revolution state of Haryana, India. Agriculture, Ecosystems and Environ. 2000. 82:97-103.

[22] Taheri MR. Finding of a mathematical model to predict the repair and maintenance cost of three models of farm tractors in ParsabadAgro-industry Co., M.Sc. Thesis, Department of Agricultural Machinery Engineering, University of Tabriz, (1998).

[23] Ward SM, Mcnulty PB, Cunney MB. Repair costs of 2 and 4 WD tractors. Transactions of the ASAE. 1985. 28(4): 1074-6.

[24] Xinan D, Yuzhou L, Suocheng D, Xiusheng Y. Impact of resources and technology on farm production in northwestern China. Agril. Systems. 2005. 84: 155-169.