ENHANCING ACCURACY AND CONSISTENCY IN THE VALUATION OF PLANT AND EQUIPMENT THROUGH CUBIC REGRESSION MODELS OF PHYSICAL DETERIORATION

Osasumwen EDIONWE

Abstract

The valuation of plant and equipment often involves valuers deducting physical, functional and economic depreciation from replacement cost estimates. These calculations have faced accuracy and consistency problems in the aspect of determining how much physical deterioration should be deducted. This study attempted to develop cubic regression models to resolve these accuracy and consistency problems in one industrial sector (the basic metal, iron and steel and fabricated metal product sectors) in the two main industrial cities of the western industrial zone of Nigeria (Sango Ota and Agbara). Questionnaire surveys were administered on senior operators of plant and equipment in these sectors to draw information on the degree of physical deterioration of plant and equipment over service life, using expenditure on repairs as a proxy for physical deterioration. The questionnaire sought information on the service lives of plant and equipment, the movement of transition of physical depreciation over the service lives, and the degree to which the movement of transition is influenced by various operational factors. Data were analysed using means, standard deviations, multiple linear regressions and cubic regressions, to produce what could be the first potentially accurate and consistent valuation model of physical deterioration in Africa. The service lives of various plant and equipment in selected sectors were found to range at various time points between 8 to 60 years. Cubic regression analyses showed that the pattern of the movement of transitions of expenditure on repairs (proxy for physical deterioration) over useful life of plant and equipment were not linear but cubic, and generally followed S-shaped patterns. Multiple regression analyses showed that the S-shaped patterns were in turn influenced by operational factors (such as intensity of use and power outages). The study concluded that valuers' interests in accuracy and consistency in plant and equipment valuation were not served by any of the accounting methods hitherto used by valuers; accuracy in physical deterioration modelling follows an S-shaped transition over

time. This S shape is exuberated where there is inappropriate operational use of the plant and equipment.

Keywords: Plant and equipment, physical deterioration, service lives, pattern of physical deterioration

1.0. Introduction

The professional services of an Estate Surveyor and Valuer are often required to determine the value of Plant and Equipment (P & E) assets. Theoretically, in carrying out this valuation task, the five valuation methods (the comparison, investment, replacement cost, profits and residual methods) can be adopted. However, P & M assets are often specialised assets. Specialised assets are 'property that are rarely, if ever, sold in the market, except by way of sale of the business or entity of which it is part, due to the uniqueness arising from its specialized nature and design, its configuration, size, location, or otherwise' (Royal Institute of Chartered Surveyors, 2005; Plimmer & Sayce, 2006). The specialised nature of P & M assets implies that the method of valuation almost invariably used is depreciated replacement cost. (International Valuation Standards, 2017). Depreciated Replacement Cost (DRC) is 'the current cost of reproduction or replacement of an asset less deductions for physical deterioration and all relevant forms of obsolescence and optimization' (Ogunba, 2013)

Depreciation from the view point of valuation standards means a loss of value in a property/asset due to three types of deterioration: physical deterioration, economic obsolescence and functional obsolescence. Physical deterioration is a situation where an asset (building, plant and equipment) suffers a reduction in value due to age, wear and tear. Functional obsolescence in P & M valuation is a loss in value of assets caused by advances in technology that result in new P & M assets that are cheaper and more efficient than the asset being valued. Economic obsolescence is loss in value of an asset resulting from changed economic conditions which reduce the capacity utilization of the asset being valued (Ogunba, 2013). The typical P & M valuation involves the valuer determining the replacement cost of the P & M asset, and then make deductions for physical deterioration, functional obsolescence and economic obsolescence.

Experience has shown that the inaccuracy problem that usually occurs in P & M valuation is not with the determination of replacement cost but with the quantum of deductions for physical deterioration, functional obsolescence and economic obsolescence. Valuation is often viewed as both an art and a science. It is an art to the extent that it requires use of a valuer's skill, judgement and experience. However, it is also a social science because it requires the valuer to use scientific modelling of the behaviour of property market participants in determining values they would place on buildings, plant and equipment. One implication of being an art is that valuations might never be exactly consistent (in terms of the valuations of different valuers tallying) or accurate (in terms of valuations being a true reflection of price or worthwhileness). Even where valuers have access to the same replacement cost data and operate contemporaneously, the use of judgement to determine the quantum of depreciation or judgement to select from different models purporting to estimate the quantum of depreciation (where each model has different assumptions), would result in inaccuracy and inconstancy. Appraisers in the United States do not face the problem of accurate or consistent determination of functional and economic obsolescence, because the valuation of functional and economic obsolescence valuations has been scientifically modelled and are documented in their standard textbook 'the Appraisal of Real Estate' (Ogunniyi & Ogunba, 2019). Valuers in other parts of the world may consider adopting or modifying such models without seeking to as it were, 'reinvent the wheel'.

One is not aware of any standard models for the valuation of the physical deterioration (wear and tear of assets) aspect of depreciation even in the United States. Rather, it appears that across the world, a variety of models have been put forward (and are in use) on how to measure physical deterioration of assets. These include estimated percentage depreciation (Shapiro, Mackmin, & Sams, 2012), and several models borrowed from the field of financial accounting: the so-called accelerated methods such as the sum of year's digit and reducing balance; the straight-line method; and the decelerated methods such as the sinking fund model. However, these financial accounting depreciation models have divergent assumptions about how physical deterioration is patterned over service life. For instance, as Ogunba (2013) states, the straight-line depreciation model writes off the value of an asset in a constant rate throughout the useful life of the asset, while the reducing balance and sum of year's digit depreciation models assume a higher depreciation at the early stage of the service life of an asset and a decreased depreciation at the later service life of the asset. The sinking fund depreciation model assumes a higher depreciation in the later years of assets. On the other hand, the estimated percentage depreciation method (which is in popular use in African Commonwealth countries like Nigeria and Ghana) is not based on any definable assumptions or scientific modelling but relies on the valuer's skill, experience and judgement. The accuracy of all these models in terms of being a reflection of the pattern of wear and tear of P & M assets over service life is are very questionable.

The pursuit of accuracy and consistency requires that valuation move more in the direction of a science than in the direction of an art. Science requires the valuer to use scientific modelling of the behaviour of property market participants in determining values they would place on assets. This study accordingly seeks to enhance accuracy and consistency in the valuation of plant and equipment through developing polynomial regression models of physical deterioration. Nigeria is used as a study of how an African country can develop models to enhance its valuation practice. The locational scope of the study is on the western industrial zone of Nigeria and the subject cope is on plant and equipment in the basic metal, iron and steel and fabricated metal product sector.

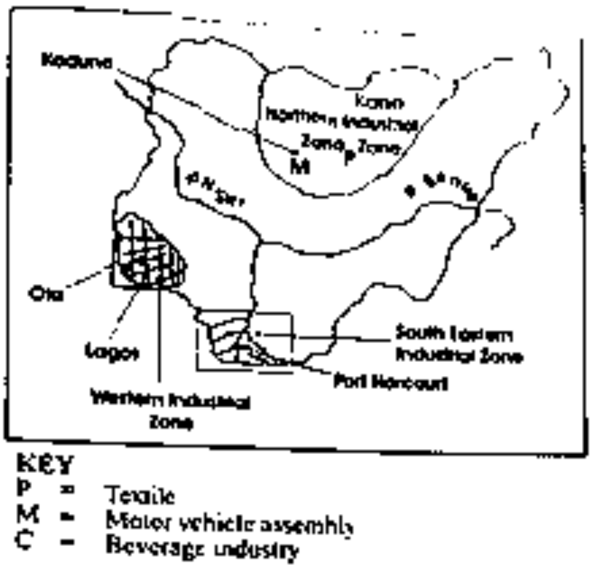


Figure 1: Industrial zones in Nigeria.

The paper is structured into six sections. The first section introduces the paper, stating the problem and the aim of the paper. The second section provides a review of relevant literature. In the third section a methodology is provided while the results and discussion are the focus on the fourth section. The fifth section demonstrates the usage of the models developed while the sixth concludes the paper and provides recommendations.

2.0. Review of Literature

The review of literature is focused on selected empirical papers that have examined depreciation patterns of buildings or plant and machinery over their service life.

Koumanakoos and Hwang (1988) examined the forms and rate of economic depreciation of a selection of assets in manufacturing and non-manufacturing sectors in Canada using the Hulten and Wykoff Box-Cox depreciation model. Most assets were found to have convex depreciation functions. The price-age behaviours of some assets were found to be volatile. Manufacturing industries had convex depreciation functions close to the geometric form for both building construction and Equipment and Equipment with only a few exceptions. In non-manufacturing industries also, the depreciation functions were of the convex geometric form, but with a less pronounced convexity in building construction than in plant and equipment. However, this study was not done in Nigeria.

Wu and Perry (2004) estimated farm equipment depreciation to ascertain which functional form is best in forecasting Equipment depreciation. Observations were gathered from 16 years of auction sales (1984 to 1999) for 17 types of equipment including tractors, combines, corn headers, balers, cotton harvesters, forage harvesters, mower-conditioners, mower-cutters, swathes, discs, plows, drills, planters, manure spreaders, skid steer loaders, and pickup trucks. The study found, using the Box–Cox functional form, that changes in depreciation rates were flexible: sometimes positive or negative (or both). The changes were sometimes linear and sometimes decelerated in conformity with the Sum of Years Digit.

Plimmer and Sayce (2006) examined the methodology adopted by UK valuers when using depreciated replacement cost method in the valuation of building assets with a view to creating a more consistent method for valuers to adopt. It was noted that DRC valuations were based a variety of depreciation methods resulting in yearly variation in valuation estimates. The paper indicated that yearly variation should be the result of market-based factors rather than due to variation in the methods of valuing depreciation and suggested that some form of guidelines to valuers is necessary to ensure consistency in valuation output. However, the study was focused on buildings, not on plant and equipment.

Ogunba (2011) examined the choice of depreciation model valuers adopt in DRC valuation in Nigeria. In a questionnaire survey of valuers, the study observed that cross sectional models, breakdown models and the S curve model were the depreciation models rated as most suitable for depreciation measurement, but valuers tended to use easiest models (particularly the estimated depreciation model) rather than more suitable models. However, though the study suggested which is most suitable from among available models, the model was designed for buildings rather than plant and equipment. Moreover, the regression version of the model was linear, not capturing the s shape.

Bello (2014) examined perceptions of valuers on the accuracy and consistency of depreciation measurement in the use of the replacement cost method of valuation in Lagos, Nigeria using weighted mean methods. The study found substantial inaccuracy and inconsistency in the use of depreciation measurement. However, the study focused on residential properties and did not extend to model development.

Bello, Ogunba and Adegunle (2015) evaluated the appropriateness of the depreciation approaches used by valuers in the replacement cost method of valuation for buildings in Lagos, Nigeria. Questionnaires were administered on registered estate surveyors and valuers firms in this regard. Responses were analysed using Relative significance indices; the study observed that most respondents viewed an S shaped depreciation pattern as most significant but this depreciation pattern was not used. What was used was estimated depreciation valuation which was rated inaccurate, inconsistent and incapable of separating depreciation components. However, the study focused on residential buildings rather than on plant and equipment and did not extend to model development.

Sahu, Narang, Sahu & Sahu (2016) estimated the economic life of machines for use in the depreciation-replacement model, and presented a straight-line depreciation method, which could be used to determine the economic life of productive equipment and equipment. However, given several studies which suggest that an S shape is more typical of asset depreciation, a straight line model might not accurately represent the movement of the pattern of wear and tear over useful life. Moreover, the study did not consider the influence of operational factors on the service life of P & E.

Okoh, Ebi and Johnson (2017) examined the causes of depreciation in process plant in cement industry from the perception of Estate Surveyors and Valuers practicing in Lagos and Ogun states. Questionnaires were administered. The method of data analysis was Descriptive analysis (Mean Item Score) and statistical package for social science (SPSS). The study revealed that the most important cause of depreciation in process plant in brewery industry is wear and tear. Under physical deterioration wear and tear was the most the most significant factor causing depreciation, others were age, use in service and condition of machine were ranked super high as the cause of reduction in value. However, the study did not provide information on the level of influence of each of factor.

Ogunniyi & Ogunba (2019) attempted to model plant and machinery in Osogbo, a state capital in Nigeria. They sampled machine operators in this city to determine physical deterioration trends of plant and equipment which were developed into physical deterioration models using log transformations. However, their study was focused on manufacturing companies in Osogbo which is not an industrial city, meaning that only small-scale manufacturing companies could be sampled. Moreover, the use of log transformation regressions produced straight line regression equations which did not reflect the wear and tear patterns suggested in their scatter diagrams. Moreover, the influence of operational factors on the physical deterioration models produced were not included in the analysis which, could lead to underestimations of the quantum of deterioration.

Overall, five gaps were discovered in the review of literature. First, some of the papers focused on the use of DRC on buildings rather than on plant and machinery. For valuation purposes, it is unlikely that the pattern of physical deterioration (wear and tear) observable for buildings is not necessarily the same as the pattern for plant and machinery. Second, some papers did not focus on the situation in African countries. It is necessary for research to have a separate look at the situation in Africa where the wear and tear pattern might be exuberated by harsher operational factors. Third is that some papers stopped short at criticizing accuracy and consistency of depreciation models in popular used but did not embark on model development. Fourth is that the few papers that looked at model development using linear regression or log transformations. Linear regression and log transformations are linear approximations of scatter diagram patterns which inadvertently obscure the scatter diagram patterns of wear and tear. What is required is the modelling non-linear regression relationships (polynomial regression model). This would definitely better capture the actual pattern of wear and tear of plant and equipment. Fifth, is that papers that developed models of physical depreciation did not consider the influence of operational factors on the models so developed. For example, if the same type of plant is purchased for use in the United States and another in Nigeria, the one in Nigeria, may face harsher operation factors such as frequent power outages, less frequent maintenance etc., and may therefore experience more physical deterioration (wear and tear). The influence of operational factors should be included in modelling for greater accuracy.

This study intends to fill all these gaps. Plant and equipment in Sango Ota and Agbara (two of

Nigeria's foremost industrial towns located in Nigeria's western industrial zone State) are used as an example of how physical deterioration modelling in one African country can to enhance accuracy and consistency.

3.0. Methodology

In the study cities – Sango Ota and Agbara - the study focused on plant and equipment in the basic metal, iron and steel and fabricated metal product sector. Discussions with officials of Manufacturers Association of Nigeria and reference to the Association's Directory (MAN, 2019) showed that there are thirty-seven manufacturing companies registered under the basic metal sector in Ogun State, Nigeria.

The intent of the study was to measure the pattern of physical deterioration (pattern of wear and tear) for each plant and equipment in this sector, every two years until the end of their respective useful lives. The study adopted a quantitative (cross sectional survey) design to model the path of movement of expenditure on wear and tear over plant and equipment service life, rather than a longitudinal design. This is because, an earlier study (Ogunba, 2011) had shown that a longitudinal survey would be impracticable for a study of this nature; it would have to span the entire service life of each of the plant and equipment. The study population appropriate for providing information on wear and tear costs were the most senior operators of the plant and machines in the thirty-seven companies. Questionnaire were accordingly self-administered on a cross section of senior (most experienced) plant and equipment operators in the employ of manufacturing companies in the metal sector of the two most industrialised cities of the western industrial zone of Nigeria. The findings were analysed using polynomial (cubic) regression rather than linear regression so as not to obscure the accurate pattern of wear and tear.

The measurement of wear and tear was operationalised by measuring yearly expenditure on repairs and maintenance for each plant/machinery, captured every two years over the plant/machinery service life. A pilot survey conducted in October 2021 indicated that there are nine types of plant and twenty-five equipment (machines) common to companies in this sectorial group. The measurement of wear and tear costs was done for each of these items of plant and equipment.

The procedure was to first inquire into the plant and equipment that are common to the thirty-seven manufacturing companies in the industrial sector and ascertain the service life of each item of plant and equipment for the purpose of determining the average service life. Next the study investigated the pattern of physical deterioration over useful life, operationalised by measuring yearly expenditure in two-yearly intervals. The next step was to investigate operational factors that could increase or decrease the pattern of expenditure on repairs and maintenance. Finally, the study demonstrated the use of the model for readers of -the paper and for plant and equipment valuers.

The method of physical deterioration considered to be most appropriate for modelling non-linear regression relationships is polynomial regression. The other approach sometimes used for non-linear regression, that is, log transformations - used by Ogunniyi and Ogunba (2019) – was discounted because it produces a straight line. Polynomial regression finds an equation that produces a curved line that closely fits the scatter plot lines. The curved lines are produced using an equation where the independent variables are raised to powers such as X^2 and X^3 depending on the number of inflections (bends). Where there is one bend in the regression line, a squared term (that is, a polynomial of degree two) is added to the independent variables. The polynomial regression equation is described as quadratic and takes the form

$Y = a + b_1X_1 + \ldots + b_2X^2$ .... (1).

Where there are two bends in the line, the polynomial regression equation is described as cubic and takes the form

$Y = a + b_1X_1 + \ldots + b_4X^4$ .... (2)

The R^2 results in the regression equation showed the degree to which the independent variables explain the variation in the dependent variable. The p values show the degree of reliability of the alpha and beta coefficients. Generally, where p values are below 0.05, the results could be considered reliable whereas when the p values are above 0.05, the results would have to be interpreted with caution.

4.0. Results and Discussion

The questionnaire was self-administered on senior operators in the basic metal, iron and steel and fabricated metal product sector in the two cities of Sango-Ota and Agbara in the last months (October to December) of 2021. The responses were analysed in the months of February and March 2022 using SPSS software.

As earlier stated, at the first level of inquiry, the study identified the plant and equipment that are common to the thirty-seven manufacturing companies in the industrial sector, and investigated their respective mean service lives. The findings are documented in Table 1.

Table 1: Service Lives of plant & equipment in basic metal, iron and steel and fabricated metal product sectoral group

Plant	Mean of Service life	Standard deviation of service lives	Equipment	Mean of Service life	Standard deviation of service lives
Steel rolling/ Rolling mill plant	20	0	Straightening machine	15	5.77
Cutting plant	10	0	Blowers	60	0
Aida plant	10	0	Welding machine	23	1.73
Tube mill plant	10	0	Boiler	22	4.04
Water circulation/treatment Plant.	8	0	Compressor	28	11.5
Aluminium coil plant	13	1	Water circulation	36	5.29
			Corrugating machine	40	0
			Embossing machine	36	0
			Lathe Machine	45	0
			Crown making machine	20	0
			Industrial drilling machine	35	0
			Overhead crane/Fork lift	27	0
			Uncoilers	40	0
			Line motors, gear box, drivers	60	0
			Grinding machine	60	0
			Hydraulic machine	29	0
			Hard Diamond / Cutting machine	10	0
			Reversible cold rolling mill	30	0
			Reversible hot rolling mill	34	0
			Billet and slab casting machine	60	0
			Continuous casting machine	60	0
			Stagger blanking machine	60	0
			Melting and holding furnace	35	0
			Slitting line	60	0
			Flat line	60	0

Source: Field survey 2021

From the data gathered, it was observed that the estimated service life of plant such as steel rolling/ rolling mill plant, steel rolling / rolling mill plant, cutting Aida and tube mill plant, Aluminium coil plant and water circulation/ treatment plant in the basic metal sector ranged from 8 to 20 years (standard deviations of 0 to 1), with the most typical service life being 10 years standard deviations of 0). The mean service lives of equipment ranged from 15 to 60 years (standard deviations of 0 to 11.5 years) with the most typical service life being 60 years with standard deviation of 0. These results largely conform with the service lives found the study of Ogunniyi and Ogunba (2019).

Having identified the common plant and equipment and determined the service lives, the next level of inquiry was to investigate the pattern of physical deterioration of each item of plant and equipment over service life. This was achieved by asking the senior operators in the thirty-seven companies to indicate annual expenditure on repairs and maintenance of each plant/equipment every two years until the end of service life. The data obtained were averaged and based on observation of scatter diagrams, model development was based on polynomial rather than linear or log regression. The results are depicted in figures 2 to 28.

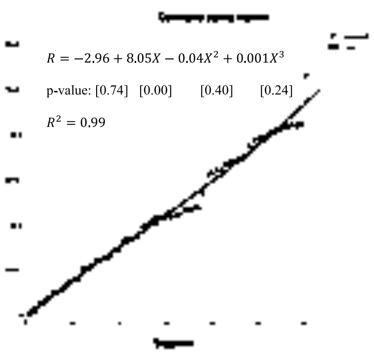


Figure 26: Physical Deterioration of Continuous casting machine

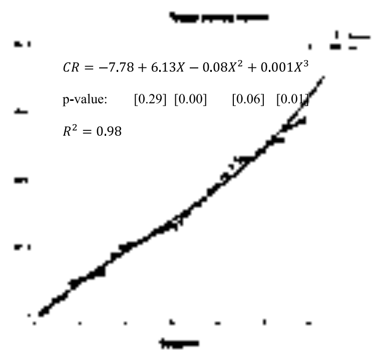


Figure 27: Physical Deterioration of Stagger blanking machine

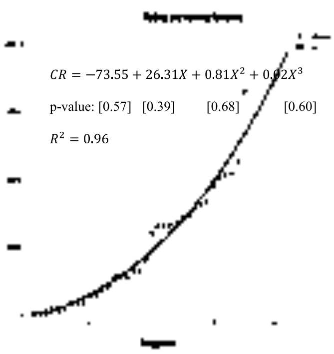


Figure 28: Physical Deterioration of Melting and holding furnace

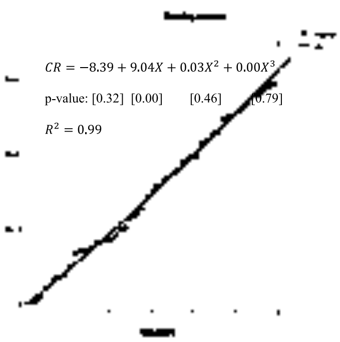


Figure 20: Physical Deterioration of Grinding machine

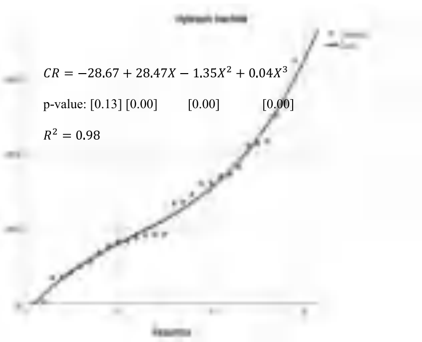


Figure 21: Physical Deterioration of Hydraulic machine

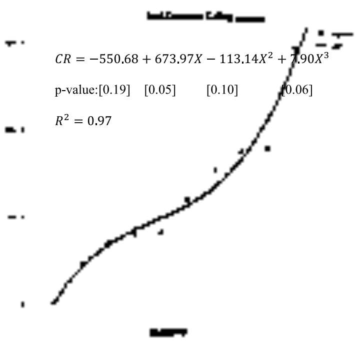


Figure 22: Physical Deterioration of Hard Diamond / Cutting machine

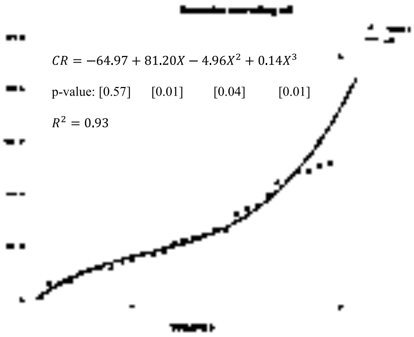


Figure 23: Physical Deterioration of Reversible cold rolling mill

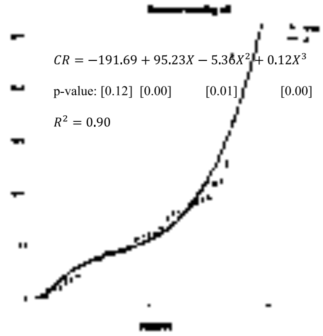


Figure 24: Physical Deterioration of Reversible hot rolling mill

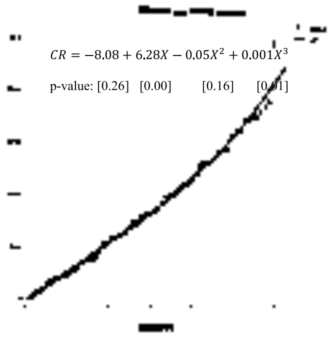


Figure 25: Physical Deterioration of Billet and slab casting machine

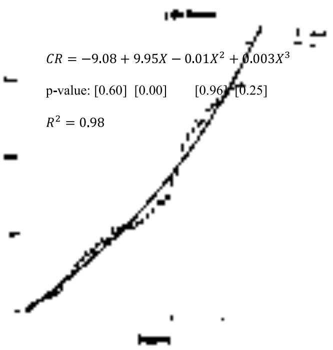


Figure 14: Physical Deterioration of Lathe Machine

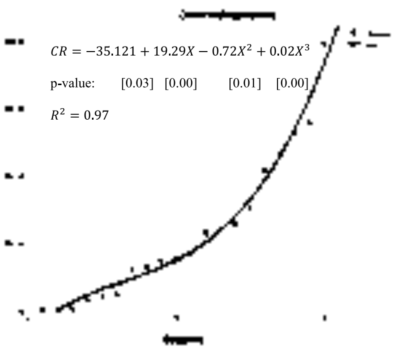


Figure 15: Physical Deterioration of Crown making machine

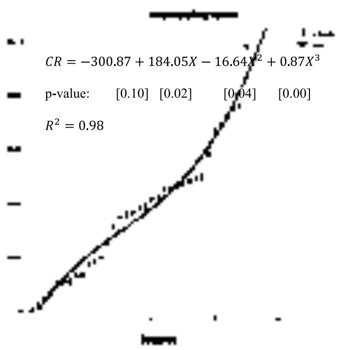


Figure 16: Physical Deterioration of Industrial drilling machine

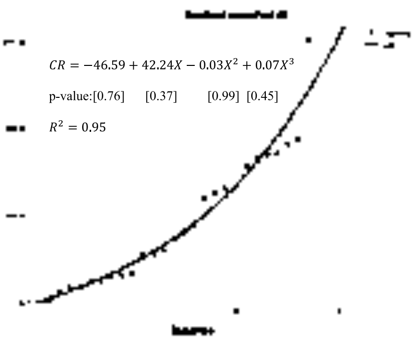


Figure 17: Physical Deterioration of Overhead crane/Fork lift

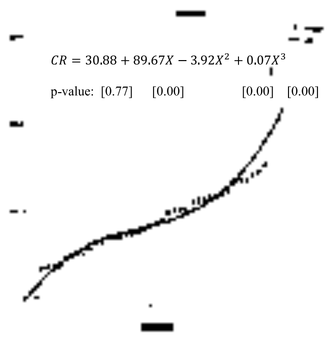


Figure 18: Physical Deterioration of Uncoilers

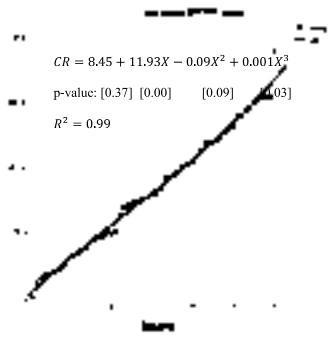


Figure 19: Physical Deterioration of Line motors, gear box, drivers

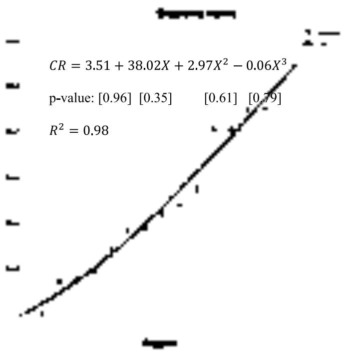


Figure 8: Physical Deterioration of Straightening machine

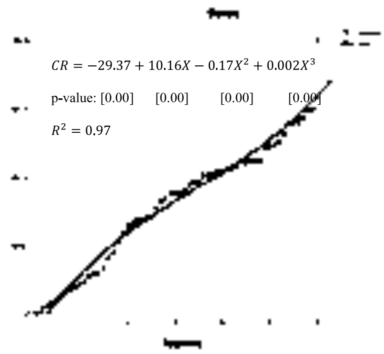


Figure 9: Physical Deterioration of Blowers

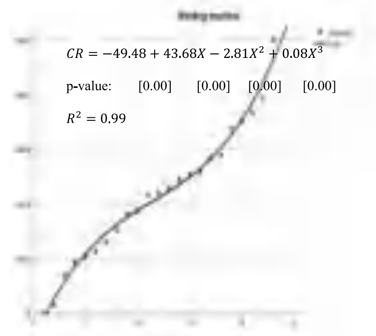


Figure 10: Physical Deterioration of Welding machine

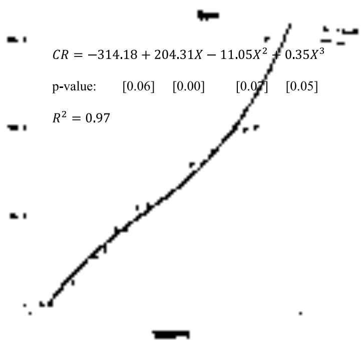


Figure 11: Physical Deterioration of Boiler

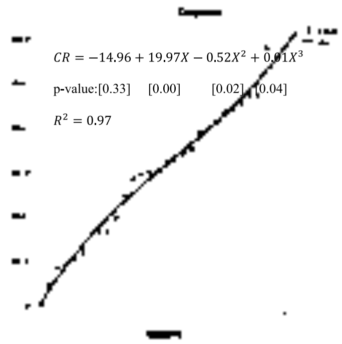


Figure 12: Physical Deterioration of Compressor

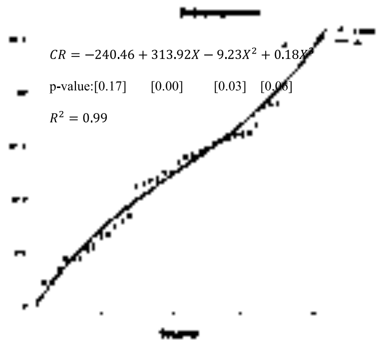


Figure 13: Physical Deterioration of Embossing machine

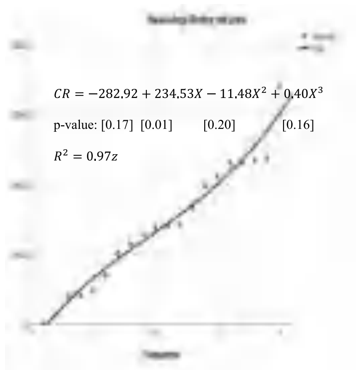


Figure 2: Physical Deterioration of Steel rolling/ Rolling mill plant

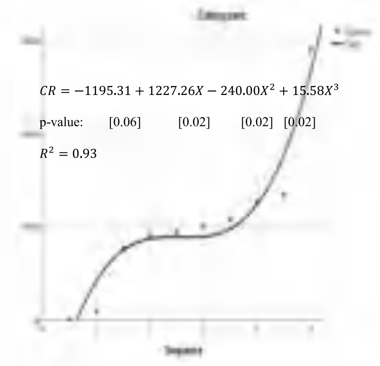


Figure 3: Physical Deterioration of Cutting plant

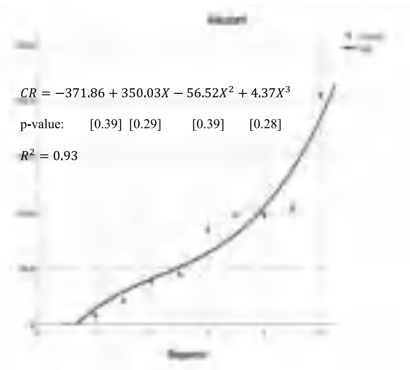


Figure 4: Physical Deterioration of Aida plant

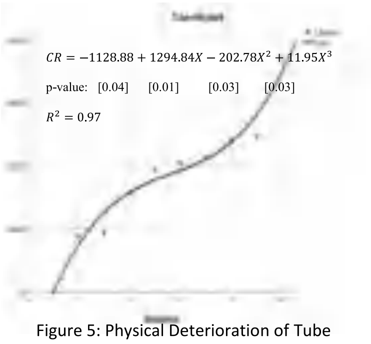


Figure 5: Physical Deterioration of Tube mill plant

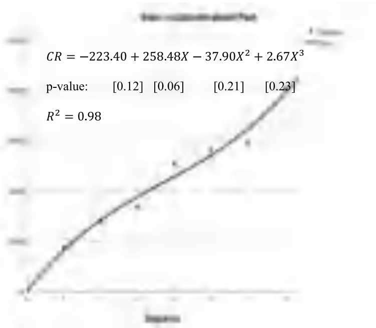


Figure 6: Physical Deterioration of Water circulation/treatment plant

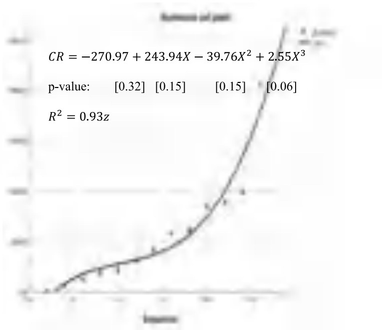


Figure 7: Physical Deterioration of Aluminium coil plant

The regression equations produced from scatter diagrams are somewhat S shaped, typically having two bends. The regression equations were therefore cubic of the form $CR = a + b_1X + b_2X^2 + b_3X^3$.

The R^2 results showed the degree to which the independent variable (time) explains the variation in the dependent variable (cost of repairs). In the physical depreciation models of the plant and equipment (figures 2 to 28), most R^2 results were above 90 percent, indicating that a generally high degree of the variation in cost of repairs is explained by the movement of time till end of service life. The p values showed the degree of reliability of the alpha and beta coefficients. Generally, most of the p values were below 0.05, meaning most of the results are be considered reliable. In the few cases where the p values were above 0.05, the modelling results would have to be interpreted with caution.

Typically, the first one or two years of the S-shape patterns showed zero cost of repair. This is reasonable because brand new plant and machinery would evince minimal or no cost of repair, except there is a factory fault. Plant and Equipment, just like cars, do not develop faults in the first few years (say 0 to 4years). The patterns then show an upward swing (the first bend) from about the 2nd to the 4th year when costs of repairs and maintenance begin to increase, indicating an upswing in wear and tear. Between the 4th to the 6th years, the increase in cost of repairs stabilise, increasing at a decreasing rate, before finally up swinging again. This was the case, generally speaking with most plants and equipment across the basic metal sectors.

This S shape pattern of physical deterioration is in agreement with the pattern in a related study of physical depreciation of buildings by Bello, Ogunba and Adegunle (2015) which also showed an S shape pattern. It is also in agreement with the scatter diagrams in the study of Ogunniyi and Ogunba (2019), though that study's S pattern was later obscured into linear form by the paper's use of log transformations.

The paper's third level of inquiry was to model the influence of operational factors on the pattern of physical depreciation. Respondents (plant and equipment operators) were presented with various factors potentially influencing the pattern of physical deterioration (that is, level of maintenance, intensity of use of the P & E, work load imposed on the P & E, availability of spare parts, occurrence of power outages and over high electricity voltage). Respondents were presented with a five-point scale of scenarios of these factors (for example, scenarios ranging from overly high intensity of use of machine to scenarios of low intensity of use, and from very frequent maintainace of machines to very infrequent maintainace etc.) They were asked to indicate on a five-point scale by how much the cost of repairs (wear and tear) would increase in each scenario. The conceptual expectation was that with higher workloads on the plant and equipment, higher intensity of use beyond recommended use, higher/very low electricity voltage, and frequent power outage, the result would be an increase in physical deterioration (represented in this study by cost of repairs). Data obtained from this inquiry were averaged and modelled using multiple regression analysis. In the regression equation, the increase in cost of repairs was the dependent variable while the various factors causing increase were the independent variables. The Beta coefficients of each independent variable showed the degree of influence each factor had in increasing the cost of repairs.

The findings are presented in Tables 2 and 3 which pertain to plant and equipment respectively.

Table 2: Regression Results on Increase in Cost of Repair of Plant as a Result of Operational Factors

Sector		Alpha	LM	IU	WL	AS	PO	EV	R^2
Basic metal, iron and steel fabricated metal product	**Beta Coefficient**	-8.933	-1.574	4.554	9.077	-6.212	6.432	-3.238	0.96
	P-value	0.002	0.395	0.027	0.000	0.006	0.003	0.085	0.00

Table 3: Regression Results on Increase in Cost of Repair of Equipment as a Result of Operational Factors

Sector		Alpha	LM	IU	WL	AS	PO	EV	R^2
Basic metal, iron and steel fabricated metal product	**Beta Coefficient**	-8.933	-0.157	0.455	0.908	-0.621	0.643	-0.324	0.96
	P-value	0.002	0.395	0.027	0.000	0.006	0.003	0.085	0.00

Source: Field survey 2021

Key:
LM = level of maintenance
IU = Intensity of use
WL = Workload
AS = Availability of spare parts
PO = Power outage
EV = Electric voltage

Tables 2 and 3 present the regression beta coefficients of the relationship between operational factors and costs of repairs (physical deterioration). Where there are negative coefficients, this indicate that the more the value of the independent variable on a five-point scale, the less the value of the dependent variable. Positive coefficients indicate that the more the value of the independent variable, the higher the cost of repairs. For example, where there is very high intensity of use with a rating of 5 over 5 and the beta coefficient is 3.591 the increase in cost of repairs would be 5 x 3.591 naira which is 18 naira. Where the beta coefficient is negative, for example – 4.515 for level of maintenance, and assuming higher level of maintenance with a rating of 5 over 5, then additional cost of repair would be - 4.515 x 5 which is minus 23 naira (reducing the cost of repairs).

The R^2 result (R^2 =0.97) indicates that a high (97%) level of variation in the dependent variable (cost of repairs) is explained by the independent variables. The p value of the beta coefficients for QM, FM, SO and CM are less than 0.05, meaning that these beta coefficient are reliable. The p value of the beta coefficient for LM and RM is more than 0.05 but less than 0.10, meaning that the beta coefficients are only reliable at the 90 per cent confidence level and should be interpreted with caution.

Generally, the results are consistent with common sense. It makes sense to see that the more the level of maintenance and availability of spare parts the less the wear and tear (proxied by cost of repairs). It also makes sense to find that the more the intensity of use and power outages, the more the wear and tear (cost of repairs).

5.0. Demonstration of the Use of the Modelling of Physical Deterioration

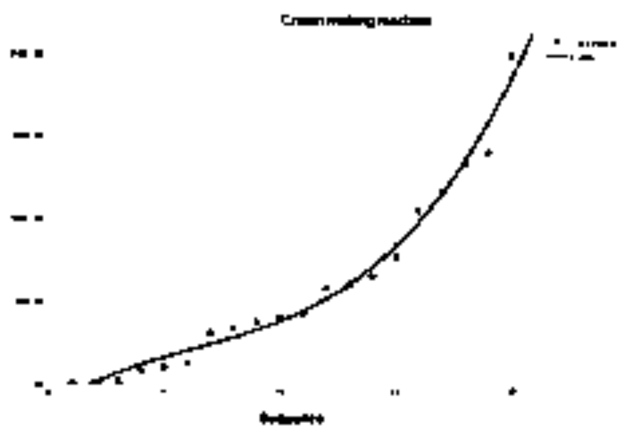
The paper would now proceed to demonstrate the usage of the physical deterioration model developed. Ogunba (2011) had earlier pointed out that valuers tend to use easiest models rather than more suitable models. The authors are anxious to point to the usability of the model produced; potential users need not be put off by apparently complex models which may look to them to be another demonstration of academic wizardry.

For demonstration purposes, we may suppose a valuer is asked to value a crown making machine in the basic metal sector (using DRC). We may assume further that the valuer has consulted with the manufacturer and ascertained that replacement cost is 500,000 naira. Physical inspection and inquiry from the operators indicates that the machine has used four years of its service life.

The relevant valuation equation is:
Depreciated Replacement cost = Replacement cost minus (physical deterioration + functional obsolescence + economic obsolescence)

For simplicity, we may assume that the machine is neither functionally nor economically obsolete.

The equation then becomes:
Depreciated Replacement cost = N500,000 - (physical deterioration + 0 + 0).
In the model developed in this paper, physical deterioration is operationalised by cost of repairs. The relevant cubic regression equation for physical depreciation is $CR = -300.87 + 184.05x - 16.64x^2 + 0.87x^3$, where x is the number of years used out of the service life of 20 years (in this case 4 years). Alternatively, instead of using the formula, the amount of wear and tear (cost of repairs) can simply be read off from the regression line in figure 15 as show below.



Thus, given that the plant has used four years of its service life, the physical deterioration (represented by cost of repair) would be CR = -300.87 + 184.05x - 16.64x2 + 0.87x3 = N264.77. However, this cost of repair is a generalised cost of repair that has not taken into account the influence of operational factors peculiar to the machinery being valued. The findings have shown that wear and tear (and cost of repairs) is influenced by levels of maintenance intensity of use, workload, availability of spare parts, power outage and electricity voltage peculiar to the usage of the P and M. The valuer using the model would rate each of these operational issues on a five-point scale drawing from his/her inspection of the plant/equipment and discussions with the operators. The rating of each factor would be multiplied by the corresponding beta coefficient in the regression equation.

In the model, the additional cost of repairs is represented by multiplying the ratings with the beta coefficients in following equation:

Additional costs of repair = $-8.93 - 1.57LM + 4.55IU + 9.08WL - 6.21AS + 6.43PO - 3.24EV$

In a worst case scenario (that is, where the plant or equipment is found to be very badly used), the ratings would be as follows: level of maintenance is extremely low (1 on a 5 point scale), the intensity of use of machine is very high (5 on a 5 point scale), workload on machine is very high (5 on a 5 point scale), availability of spare parts is very low (1 on a 5 point scale), power outages are very frequent (5 on a 5 point scale), and level of conformity of electricity supply with voltages specifications (220 volts) is low (1 on a 5 point scale),

When these ratings are multiplied by the beta coefficients, the equation becomes:

Additional costs of repair = $-8.93 - (1.57\ x\ 1) + (4.55\ x\ 5) + (9.08\ x\ 5) - (6.21\ x\ 5) + (6.43\ x\ 5) - (3.24\ x\ 1) = -8.93 - (1.57) + (22.75) + (45.4) - (31.05) + (22.15) - (3.24)$ = 45.51 naira

The physical deterioration of the crown making machine in the basic metal sector that has been badly used for 4 years of its service life of 20 years is therefore

$(CR = -300.87 + 184.05X - 16.64X^2 + 0.87X^3) + (-8.93 - 1.57LM + 4.55IU + 9.08WL - 6.21AS + 6.43PO - 3.24EV)$ = N264.77 + 45.51 = N310.28

The valuation is therefore concluded as follows

Depreciation Replacement cost = 00,000 - (N310.28 + 0 + 0) = 499,689.72.51 naira

6.0. Conclusion

The study started with a focus on the problem of inaccuracy and inconsistency in valuation of plant and equipment which is often valued using the depreciated replacement cost method. The problem was narrowed down to inaccuracy and inconsistency in the determination of physical obsolescence where valuers make use of varied methods such as estimated percentage depreciation or methods borrowed from the field of financial accounting. It was noted that financial accounting methods are based on different assumptions of the pattern that physical deterioration follows over service life, ranging from straight line to convex or concave patterns.

The pursuit of accuracy and consistency requires that valuation move more in the direction of a science than in the direction of an art. Science requires the valuer to use scientific modelling of the behaviour of property market participants in determining values they would place on assets. This study has developed a cubic regression model for physical deterioration by tracing the path of costs of repair experienced in the use of plant and equipment over their service life. This model can be combined with mathematical models for economic obsolescence and functional obsolescence already in use by the American Society of Appraisers so as to have a holistic coverage of the three components of depreciation when valuing plant and equipment valuation.

The paper accordingly recommends that in the use of DRC method of valuation, there should be a paradigm shift away from the use of depreciation models like estimated percentage depreciation (which is in popular use in African Commonwealth countries like Nigeria, Kenya and Ghana), as this model is not based on any definable assumptions or scientific modelling. It is largely an art, relying on the valuer's skill, experience and judgement. This method obviously cannot guarantee consistency and accuracy. There should also be a shift away from the use of the financial accounting methods for estimating physical deterioration, since the straight line, concave and convex depreciation patterns suggested by these accounting methods do not reflect the S shaped path of costs of repair actually experienced by machine operators.

The study would also advice that valuers be not put off by what looks like statistical complexity in the use of the cubic regression models; as has been demonstrated, the amount of wear and tear (cost of repairs) for an asset can simply be read off from the regression curve. There are however additional costs to be added after reading off from the regression curve;

the study has found that factors like poor maintenance, intensity of use, excess work load, non-availability of spare parts, power outage and electric voltage fluctuations can increase wear and tear (and cost of repairs) of plant and equipment being valued.

References

Bello, I. K. (2014). Depreciation Method in Cost Method of Valuation in Lagos Metropolis. *American Journal of Social and Management Sciences. 5(2), 73-83.*

Bello, I. K., Ogunba, O. A. & Adegunle T. O., (2015). Appropriateness of Depreciation Measurement in the Cost Method of Property Valuation I Lagos Nigeria. *E3 Journal of Business Management and Economics 6(2), 17-26.*

IVSC. (2016). IVS 105: *Valuation Approaches and Methods International Valuation Standards London: International Valuation Standards Council.*

IAS 16 (2003) International Accounting Standard 16 – Property Plant and Equipment

Koumanakos, P. & Hwang J. C. (1988). The Forms and Rates of Economic Depreciation. The *Cananda Experience, Statistics Canada, Investment and Capital Stock Division, Revised 1993*

Ogunba O. A. (2011). Valuers Perception of Depreciation Models in DRC Valuation: A Case *Study of Nigeria's Valuation Community. Journal of Property Investment & Finance, 29(2) 190-209.*

Ogunba, O. A. (2011). An Examination of Depreciation Sustainability in Depreciated Replacement Cost Valuations. *Journal of Property Investment & finance. 23(2): 45-53.*

Ogunba, O. A. (2013). *Principles and Practice of Property Valuation in Nigeria.* Ibadan: Atlantis Books

Ogunniyi, K. & Ogunba, O. A. (2019) "Depreciation Modelling in the use of Depreciation Replacement Cost for the Valuation of Plant and Machinery" In Developing New Frontiers for the African Real Estate Sector: The 1*9th Annual AFRES Conference, 90-91. AFRES. Arusha,* Tanzania: African Real Estate Society, 2019.

Okoh, V.P., Ebi, U. & Johnson, O.O. (2017). Causes of Depreciation in Process Plant in Cement Industry: Analysis of the Perception of Practicing Estate Surveyors and Valuers in Lagos and Ogun States. *International Journal of Humanities and Social Science 6.* Retrieved from http://publication.babcock.edu.ng/asset/docs/publications/COSC/9459/2454.pdf

Plimmer, F. & Sayce, S. (2006) Depreciated Replacement Cost – Consistent Methodology? Shaping the Change XXII FIG Congress Munich, Germany, October 8-13 https://www.fig.net/resources/proceedings/fig_proceedings/fig2006/papers/ts86/ts86_01_plimmer_sayce_0268.pdf.

RICS (2005) Royal Institute of Chartered Surveyors

Shapiro, E., Mackmin D., & Sams G. (2012). Modern Methods of Valuation 12th ed., Estates Gazette. London.

Sahu, A. K., Narang, H. K., Sahu, A. K. & Sahu, N. K., (2016). Machine Economic Life Estimation Based on Depreciation-Replacement Model. Cogent Engineering.The Appraisal Institute 14th Edition 2013

Wu J. & Perry G. M. (2004). Estimating Farm Equipment Depreciation: Which Functional Form is Best? *American Journal of Agricultural Economics, 86(2) 483–491. Retrieved from* https://academic.oup.com/ajae/article-abstract/86/2/483/71802 on 08 July 2019