Development Of A Predictive Model For Productivity In A Beverage Company In Oyo State

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Abstract— **Productivity is a key measurable performance index which finds it application in all sectors of human endeavor. Production system is not an exception as significant flow of resources takes place throughout the life of its output. However, it is quite tasking for many organization to come up with a reliable evaluation matrix as efforts are made to improve upon the traditional method of estimation. In this study a computer assisted measure was deployed in the development of appropriate predictive model for determining the productivity of a Beverage Company considering the economically dependent variables of costs of safety and labour. Computer code was developed into productivity calculator for labour productivity and profit determination using MATLAB programming platform. The model was subsequently trained and validated to a significant level of p = 0.5 using relevant records gathered from the company. The predictive calculator has the capacity to assist decision makers in the planning and controlling scarce resources - in the beverage companies and related production firms- which characterizes the current economic situation in Nigeria.**

Keywords— Productivity, Safety. Predictive model, Computer program, Resource management

I. INTRODUCTION

Nigeria is a country believed to be fast growing in industrialization which is a good development as it creates job opportunities. However, productivity of workers is a subject of concern since there are no complete automated systems. Productivity is the effective and efficient utilization of available resources in generating desired output (Spring, 2011). A scenario is that of cement industries in Nigeria where the exhaust end do spread into the atmosphere, a toxic dust which is poisonous to humans. This toxic waste could have been precipitated and serve as a byproduct reusable within cement production process (Key, 2013). The lack of quantitative means of evaluating and monitoring labour productivity has led to a fall in profit gained in manufacturing companies. The statistics of World Health Organisation states that 160 million has work-related illnesses and 268 million involved in non fatal workplace accidents (ILO, 2005). This will adversely affect the final output of employees. Thus, a need to look into developing user-friendly software which can serve as managers' tool for predicting at a glance, what labour productivity will look like from system safety dimension as determinants..

II. LITERATURE REVIEW

The general belief by firms that investing in safety is a cost has negatively affected the productivity and competitive power of affected industry because high accident rate do deteriorate human capital (Fernadiz-Muniz, Montes-Peon and Vazquez-Ordas, 2009). In other words, there is a feedback on the financial productivity. The food and drink processing industries are in many ways the manufacturing sector which is most fundamentally linked to human existence (Tumoda, 1993). Repeated needs to stand for long hours in a refrigerated room add to the risk of strains in elbow and wrist. Respiratory disorders, frostbite and rheumatic disorders are what workers can also suffer from. Workers in high temperature environments are exposed to the risk of burns. All of these have consequential effect on productivity of workers.

Productivity measurement is a pre requisite for improving productivity as it helps to know a progressing organization in their maximal utilization of available resources (Spring, 2011). Productivity measurement has been a challenging concern for theorist, experts in productivity and industries for over ninety four years now. Thus, the phenomenon has gone through different iterations resulting in various models (Jeremy, 2011).

Table 1: Productivity Indicators

Indicator	Formula	What it measures
Labour Productivity	$\frac{ValueAdded}{Numberofemployees}$	Efficiency and effectiveness of employees in the generation of value added
Sales per employee	$\frac{Sales}{Numberofemployees}$	Efficiency and effectiveness of marketing strategy
Value -added –to- Sales ratio	$\frac{ValueAdded}{Sales}$	Proportion of sales created in organization over and above purchased material and services
Profit-to-Value Added Ratio	$\frac{Operting\ Profit}{ValueAdded}$	Operating profit allocated to the providers of capital as a proportion of value added
Labour Cost Competitiveness	$\frac{ValueAdded}{LabourCost}$	Efficiency and effectiveness of the organization in term of its labour cost
Labour Cost per employee	$\frac{LabourCosts}{Numberofemployee}$	Average renumeration per employee
Capital Productivity	$\frac{ValueAdded}{FixedAssets}$	Efficiency and effectiveness of fixed assets in the generation of value added

Source: Spring 2011

According to Rifat (1996), Neural Network possessed variety of tools for optimization, predicting, approximation pattern and modeling. It is however advisable to combine the use of both model fitting and statistics for complex real world applications. Factor model was used for predicting daily productivity as:

$$PDP = \alpha + \beta_1 - -\beta_2 + \beta_3 + \omega + \theta + \lambda_1 C + \lambda_2 C^2 + \lambda_3 C^3$$

where PDP is Predicted Daily Productivity; α is constant term representing standard conditions; β_1 is work type coefficient; β_2 is physical element coefficient; β_3 is design detail coefficient; ω is construction method coefficient; θ is weather zone coefficient; C is crew size; $\lambda_1, \lambda_2, \lambda_3$ are corresponding coefficients for crew size term.

Davis (1994) developed a productivity forecast model for packaging operation of a pharmaceutical firm making use of factors involved in computing productivity index. This author opined that all labour elements having evident impact on productivity should undergo systematic analysis. This model enables supervisors to guess and test productivity consequences when direct and indirect labours are differently combined.

III. RESEARCH METHOD AND MATERIALS

A beverage production company was used for the study being a common example of small enterprises available. This was a good representation of the manufacturing industry since it is a general belief that small enterprises don't take system safety serious. Also, such a company becomes necessary to study as the country encourages sustainability of small scale businesses.

The primary source of data for this study was from first-hand information gathered from companies' records. These records allowed monitoring changes in the behavioural pattern of the subject matter to be predicted or studied over time since the records gave history of the subjects investigated as well as internal and external factors affecting the trend. Hence, data concerning costs of input and costs of output were collected and analyzed to get the Value Added per employee in calculation of Labour Productivity.

i. Computer program development

The implementation was done with Matlab R2013, the syntaxes are however compatible with earlier

version of Matlab. Matlab's NN (NN means Neural Network) tool is a powerful AI toolbox designed in Matlab. NN Toolbox for applications such as data fitting, pattern recognition, clustering, time-series prediction, and dynamic system modeling and control. Computer codes were written for the model to be developed. Twelve model equations were generated from this. The model equations were synchronised to develop predictive models for predicting profit and labour productivity from records of Safety training expenses, Medical expenses, Number of employees and Direct labour cost for the past six consecutive years (2009-2014).

ii. Computer program validation

The validation of neural network predictions come from supplying the network with the same problem with which it was trained and checking its deviation from the actual value. This was done using the data collected for the years 2009 - 2014 serving as historical data as presented in Table 2. The figures 1a and 1b shows the validation plots.

Table 2: Data collected between the years 2009 to 2014

Year	Safety Training (#)	Medical Expenses (#)	DirectLabour Cost (#)	Number of employees
2009	100001000	3005110	2100050	155
2010	102020603	4570052	2303180	164
2011	124502400	1421170	3005507	155
2012	153021107	412819.25	4264535	155
2013	183420324	410349.32	2300507	150
2014	170751611	357270.55	3600100	150

It can observed from figure 1a that there was a huge mean square error (MSE).This was suspected to be as a result of falsified data given as historical record or due to lack of proper record keeping process. However, this does not affect the accuracy and authenticity of the model developed.

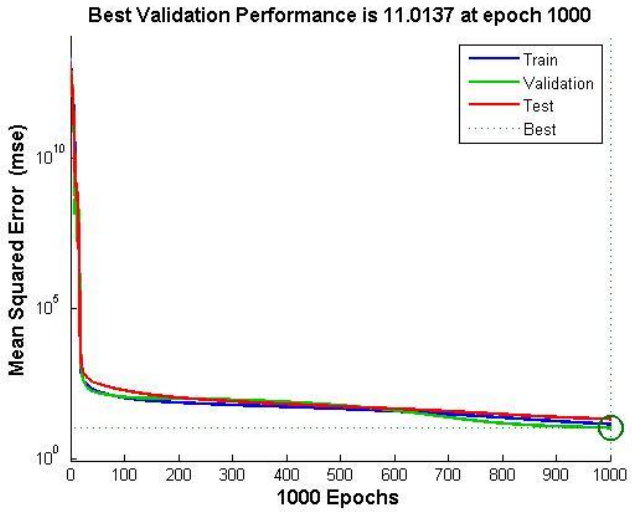

Figure 1a Plot of best validation performance

IV. RESULTS AND DISCUSSIONS

The Predictive model

The developed program is user- friendly and interactive. It accepts system input parameters from the users through input tabs and dialog boxes on the interface, perform necessary action and produces output. The Table 3 shows the variations between the original values collected and predicted values used in validating the model for reliability. The accurate prediction of this software was evident in the highest percentage error which was 0.09 when original data was compared with predicted value for six years. From the computer predictive software, when other variables are kept constant, medical expenses is inversely proportional to productivity and profit. This means, reduction in medical expenses leads to a rise in both dependent variables. However, the reduction in medical expenses must be a sizeable one else, labour productivity reduces while profit rises.

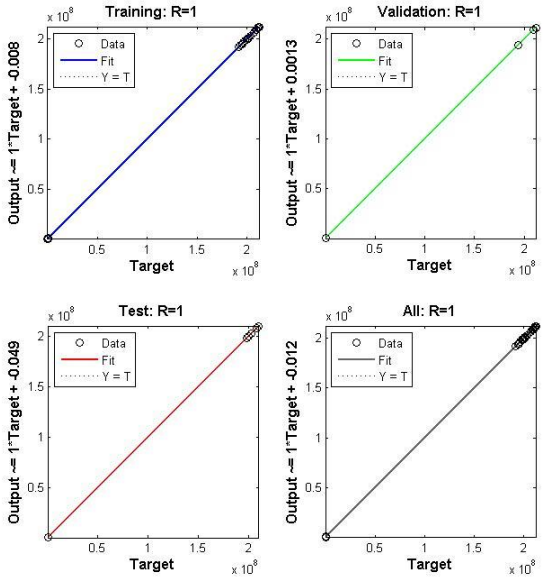

Figure 1b Plots of training, test and validation

Table 3: Deviations of predicted values from original values

Year	Original Productivity	Labour Prod. Predicted	Percentage Error	Original Profit	Predicted Profit	Percentage Error
2009	4005	4000.72981	0.09	23808	23799.25	0.036
2010	4100	4097.394258	0.06	25253	25252.242	0.003
2011	7641	7637.868879	0.04	72805	72820.107	0.0002
2012	10205	10204.63485	0.003	75600	75600.114	0.00015
2013	7206	7202.28759	0.051	504300	504302.27	0.00045
2014	7005	7008.23646	0.04	212735533	212735525	0.0000038

Some of the model equations developed by different relationship of variables

Various model equations resulted from relating the available variables. These are given in equations 1 to 12.

Equation of Labour Productivity against Direct Labour Cost and Safety Training

$$f(\text{labourprod}) = 520.2 - 9.462\,Sin\,(0.9881\pi xy) + 0.3225\,e^{(-(0.3841y)^2)} \quad 1$$

where x and y are direct labour cost and safety training expenses respectively

Coefficients (with 95% confidence bounds)

Equation of Profit against Direct Labour Cost and Safety Training

$$f(\text{profit}) = 12.76 - 4.812\,Sin\,(0.9942\pi xy) + 0.3743\,e^{(-(0.1073y)^2)} \quad 2$$

where x and y are direct labour cost and safety training expenses respectively

Coefficients (with 95% confidence bounds)

Equation of Labour Productivity against Direct Labour Cost and Medical Expenses

$$f(\text{labourprod}) = 598.1 - 66.49\,Sin\,(0.006052\pi xy) + 0.3655\,e^{(-(0.7991y)^2)} \quad 3$$

where x and y are direct labour cost and medical expenses respectively

Coefficients (with 95% confidence bounds)

Equation of Profit against Direct Labour Cost and Medical Expenses

$$f(\text{profit}) = 12.6 - 3.256\,Sin\,(0.07443\pi xy) + 0.8209\,e^{(-(0.5866y)^2)} \quad 4$$

where x and y are direct labour cost and medical expenses respectively

Coefficients (with 95% confidence bounds)

Equation of Labour Productivity against Direct Labour Cost and Number of Employees

$$f(\text{labourprod}) = 483.5 - 21.22\,Sin\,(0.6063\pi xy) + 0.4572\,e^{(-(0.6432y)^2)} \quad 5$$

where x and y are direct labour cost and number of employees respectively

Coefficients (with 95% confidence bounds)

Equation of Profit against Direct Labour Cost and Number of Employees

$$f(\text{profit}) = 0.09446 + 0.3578\,Sin\,(0.5356\pi xy) + 0.6418\,e^{(-(0.07749y)^2)} \quad 6$$

where x and y are direct labour cost and number of employees respectively

Coefficients (with 95% confidence bounds)

Equation of Labour Productivity against Safety Training and Medical Expenses

$$f(\text{labourprod}) = 551.9 + 18.31\,Sin\,(0.1328\pi xy) + 0.1524\,e^{(-(0.849y)^2)} \quad 7$$

where x and y are safety training and medical expenses respectively

Coefficients (with 95% confidence bounds)

Equation of Profit against Safety Training and Medical Expenses

$$f(\text{profit}) = 14.09 + 1.417\,Sin\,(0.5754\pi xy) + 0.01496\,e^{(-(0.6189y)^2)} \quad 8$$

where x and y are safety training and medical expenses respectively

Coefficients (with 95% confidence bounds)

V. CONCLUSION

A predictor has been modeled which can predict profit and labour productivity of Beverage Production Industries when medical expenses, expenses on safety training and direct labour cost are taken as known independent variables. Such a managers' tool as this can be useful to small scale enterprises and in turn boost economy of the country as higher productivity means higher revenue for the government.

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