Development of a performance measurement system for manufacturing systems

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Abstract: Taylor and Davis total productivity model has significant advantage over the traditional and more commonly used productivity models – its holistic nature. The model incorporates elements of net sales, inventory changes, wages and salary, investor's contribution, working and fixed capital. This paper presents a unique approach in the determination of the total factor productivity for a manufacturing organisation. This study is motivated by the dearth of models comprehensive enough to cover the major aspects of business apart from the usual input-output approach of productivity analysis which is limited to the output items and material/non-material resources. The results obtained clearly demonstrate the feasibility of applying Lagrange multiplier in optimising the variables and parameters of the model. The research has implications for decision making in several dimensions primarily it aids the utilisation of optimal solutions in arriving at decisions. This would avoid suboptimal decision making and promotes implementation of optimal decisions. This study is new, in that, it presents an enhanced version of a model that has been available to researchers several years back.

Keywords: productivity; performance; profitability; manufacturing system; Performance Measurement; PM; Lagrange multiplier; Taylor and Davis model; inputs; output.

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1 Introduction

Recent advances in manufacturing technologies have compelled investors to acquire modern equipment with high investment cost and offer a wide range of products with diverse characteristics that delivers varying bundles of benefits to consumers at the most economic process (Maxwell et al., 2007; Murakami, 2007; Park et al., 2007). This in turn has stimulated high competition in the business and industrial environment that requires high-end quality products from organisations whose human elements should have a good drive towards achieving top quality world class standards in product quality or service delivery (Olsen and Ward, 2006; Smith and Smith, 2007; Unahabhokha et al., 2007). Today's customers are selective thus making it difficult for organisations with poor product quality to survive. Therefore, management of organisations are increasingly aware of the need to monitor the performance of the various business units within the organisation to guarantee business survival (Losee, 2007; Tangen, 2003, 2004; Toni and Tonchia, 2001). As such, diverse tools, techniques and methodologies have been installed. In totality, all the various components of the organisation must be thoroughly assessed in order to determine their contributions towards enhanced profit making for the organisation. However, all these activities must be done at the optimal level so that maximum benefits to the organisation could be attained.

Performance Measurement (PM) is a powerful tool for improving organisational competitiveness through measurements, monitoring and control of organisational performance both in manufacturing and services (Unahabhokha et al., 2006). There are numerous academic and professional papers that debate on the design, improvement and installation of performance measures using both the traditional approaches and more recent advanced modern methodologies (Purbey et al., 2007; Sharma and Wanna, 2005). From developments in the performance literature, very few papers have addressed the issue of PM from a holistic viewpoint or total system perspective. Thus, there is a need for a paper that combines the field of PM with the field of mathematical optimisation. Particular emphasis is placed on the development of a performance model based on a traditional and widely accepted performance paradigm (Taylor and Davis model) and its integration with LaGrange undetermined multiplier in the formulation of a PM model.

This paper is sectioned into many parts: introduction, background for research, PM framework, case study and conclusion. The introduction motivates the reader in the subject of this paper. Section 2 explores the literature to explain the gap that the current paper fills. Well-accepted methodologies in the general PM literature are reviewed. Section 3 presents the mathematical model with a big picture of the necessary steps to apply and the breakdown of each step. In Section 4, the model behaviour and application have been tested with the help of a case study from an engineering tools manufacturer. Section 5 provides concluding remarks for this study.

2 Background for research

The PM literature naturally divides the studies into two distinct parts: Studies that deal with index, which are used by different employees in a company, and mathematical approaches that concern performance. In the succeeding statement, an exploration of the various approaches is made to appreciate what has been documented in the literature and its relevance to the current study. The literature for index-based performance measures cover Total-Factor Productivity (TFP), Paasche Productivity Index (PPI), Fisher Productivity Index (FPI), Tornqvist Productivity Index (TPI) (Selvalnathan and Rao, 1992), Laspeyres Productivity Index (LPI) and Malmquist Productivity Index (MPI). Other measures include PPP method, Operational Competitive Rating Analysis (OCRA) and American Productivity Centre (APC) model. However, this review shall be limited to a number of these indexes and methods.

The TFP has been extensively utilised in solving productivity problems, in the analysis of provincial economy, dialysis and the growth of telecommunication. For example, Qingwang et al. (2006) applied the non-parametric Data Envelopment Analysis (DEA)-malmquist index approach to estimate TFP growth, efficiency change and the rate of technological progress from 1979 to 2003 of China's provincial economy. Kontodimopoulos and Niakas (2006) examined TFP of dialysis facilities in Greece over a 12-year period, using nationally representative panel data. DEA was used to compute malmquist productivity indices, which when decomposed into technical efficiency change and technological change. Bernstein et al. (2006) measured TFP growth of telecommunication in Peru, and computed a telecommunication *x*-factor or offset based on annual average TFP growth of 1.66%, the *x*-factor is computed to be 4.06% per year. However, this paper shares part of its structure from the TFP framework, in that, it is an index that incorporates the relationship between output and input. The additional feature in this paper that the TFP platform lacks is the advantage of optimising the framework through Lagrange multiplier, which is a tested mathematical tool. This is meant to provide a better result than is currently obtained using TFP framework alone.

FPI is an established productivity framework that has been applied for decades by the economists in the measurement of productivity. An application of FPI is shown in Zofio and Prieto (2006) that employed the duality between a return to dollar definition of profit and the generalised distance function by establishing the relationship between the Laspeynes, Paasche and FPIs and their alternative malmquist indexes counterparts. Its special structure permits integration with other indexes. The next group of productivity indexes is referred to as the MPI. Shestalova (2003) applied both the standard DEA methodology with contemporaneous frontiers and DEA with sequential frontiers to study the changes in productivity and efficiency in manufacturing for OECD countries. The author used a decomposition of the industrial malmquist productivity indices to locate the sources of productivity growth.

The OCRA method is well documented in the literature (Parkan, 2006). Parkan (2005) presented an actual case study that benchmarked the operational performances of two hotels in a large city, using the non-parametric PM method called OCRA. While the hotels' performances converge near the end of the study period, they both fall short of reaching their respective benchmark performance levels. Parkan and Wu (1999) constructed a bank's performance profile using OCRA. This paper included comparisons of OCRA and DEA ratings and profits scores to show the validity support among the approaches as well as underscore their differences. Wang (2006) commented on the OCRA method by Parkan and Wu (1999). They noted that since the premise of the OCRA method is that cost/revenue ratios must be known, costs and revenues cannot be measured in any units other than dollar value in any practical cases. This property makes the OCRA method faulty. Further, it was shown that the invalid weighting approach used in the OCRA method provides an illusion to management that a category with large cost/revenue ratio is more important than a cost category with small ratio.

Rao (2006) reintroduced the APC model (developed by the APC) through a spreadsheet application of the model in a real-world setting, with a case study of Harlingen waterworks, Texas, USA. From the above review, it becomes necessary to investigate into the integration of performance measure with some available optimising techniques in the literature.

3 Performance measurement framework

The model discussed in this section links two performance criteria together in order to achieve an optimal solution. The model links profitability and productivity together (Sink and Tuttle, 1989; Sumanth, 1994). The profitability model considered is the ratio of revenue to cost. This profitability measure is then multiplied with an inflation factor. The productivity measure utilised for the modelling is a conventional productivity model. Thus, the following gives the notational definitions of the terms used in the study.

3.1 Nomenclature

The terms that are then used in the work are as follows:

P_f profitability measure of the manufacturing system

P_t productivity measure of the manufacturing system

Q	number of goods sold
U_o	unit selling price of goods
M_o	miscellaneous revenue in monetary units (Naira)
m	number of workers who receive salaries, wages and bonuses
C_w	cost of maintaining an average worker
I	number of goods or raw materials fed into production system
C_r	unit cost price of the raw materials
N_o	cost of purchasing miscellaneous materials and services
P_o	number or amount of capital inputs utilised in the system
t	period of time under which the evaluation of productivity is made

3.2 Productivity measure

Given that productivity is defined as

$$P_t = \frac{QU_o + M_o}{mC_w + Ie_o + N_o + P_ot} \tag{1}$$

Equation (1) reflects the total output of the system (represented as O_t for all symbols in the numerator) divided by the total input of the system (shown by the expression at the denominator). Mathematically, total output $O_t = QU_o + M_o$, labour input $L_t = mC_w$, raw materials input $= Ie_o$, cost of maintaining capital input $= P_ot$. So, total input $= (mC_w + Ie_o + N_o + P_ot)$. The next step in the model formulation is to consider the mathematical model of productivity at the maximum point. Thus, we differentiate the productivity model with respect to the number of goods sold (Equation (2)), the number or amount of raw materials used for processing (Equation (3)), and the period under which the measurement is considered (Equation (4)).

These maximum productivity values are stated below:

$$\frac{\partial P_t}{\partial Q} = \frac{U_o}{mC_w + Ie_o + N_o + P_ot} \tag{2}$$

$$\frac{\partial P_t}{\partial I} = \frac{-e_o(QU_o + M_o)}{(mC_w + Ie_o + N_o + P_ot)^2} \tag{3}$$

$$\frac{\partial P_t}{\partial t} = \frac{-P_o(QU_o + M_o)}{(mC_w + Ie_o + N_o + P_ot)^2} \tag{4}$$

3.3 Profitability measure

We consider details of the profitability measure (P_f) utilised in this work. The total revenue made by the organisation for the measurement period $= QU_o$. The inflation factor is defined as $(1-n)^t$. Earlier in the definition of productivity measure we have defined the raw materials input as Ie_0. This is an important linking component of both profitability and productivity.

Thus, mathematically, we define profitability as:

$$P_f = \frac{QU_0(1-n)^t}{Ie_0} \tag{5}$$

In the development of performance model using Lagrange undetermined multiplier, a number of assumptions are made for computational ease and as a research strategy. The first assumption is that the measurement of productivity and profitability in the organisation is based on the fact that all the m workers receive the same salaries, wages and bonuses for the period considered. The support for this argument is that once the salary of workers increase at the first month of a new year, the same amount is carried over throughout the year. Thus, stability of salaries and wages exists. Another assumption is that the costs it takes to produce goods are the same. This assumption relates to operational costs outside material cost, which could be subjected to rise in price without rise in value of goods. In addition, we assume that the goods are sold at the same unit price. Similar to the analysis carried out on productivity, we need to find out the optimal value of profitability when differentiated with respect to the number of goods sold (Equation (6)), the number or the amount of various materials used for processing (Equation (7)) and the period under which the measurement is considered (Equation (8)). The mathematical expression for Equations (6)–(8) is as stated

$$\frac{\partial P_f}{\partial Q} = \frac{U_0(1-n)^t}{Ie_0} \tag{6}$$

Equation (6) shows that the optimal value of profitability when differentiated with respect to the number of goods sold is directly proportional to the unit selling price of goods and indirectly proportional to the raw material input. It is also obvious that Equation (6) is independent of the number of goods sold, Q.

$$\frac{\partial P_f}{\partial I} = \frac{-QU_0(1-n)^t}{I^2 e_0} \tag{7}$$

This Equation (7) shows that optimal value of profitability when differentiated with respect to amount of raw material fed into the system is a function of number of goods sold, Q, selling price of good and raw material input. This value becomes more negative as raw material input is increased.

$$\frac{\partial P_f}{\partial t} = \frac{QU_0 \ln(1-n)(1-n)^t}{Ie_0} \tag{8}$$

We can determine the optimal value of profitability by differentiating profitability with respect to time t, this gives Equation (8) above. It can be seen that the value of P_f is a function of number of goods sold, Q, unit selling price of goods, U_0, inflation factor n, raw material input Ie_0 and period of time under which the evaluation of productivity is made.

3.4 Application of Lagrange multiplier

In applying Lagrange undetermined multiplier method to the formulations in Equations (2) and (3), the Lagrange factor is introduced with two new equations generated. These equations are labelled Equations (9) and (10).

$$\frac{\partial P_t}{\partial Q}+\frac{\lambda \partial P_f}{\partial Q}=0 \tag{9}$$

$$\frac{\partial P_t}{\partial I}+\frac{\lambda \partial P_f}{\partial I}=0 \tag{10}$$

Now considering Equation (9), we may insert the component values of $\partial P_t / \partial Q$ (obtained from Equation (2) and $\partial P_f / \partial Q$ (obtained from Equation (6)). This is obtained as shown in Equation (11)

$$\frac{\partial P_t}{\partial Q}+\frac{\lambda \partial P_f}{\partial Q}=0:\left(\frac{U_o}{mC_o+Ie_o+N_o+P_o t}\right)+\frac{\lambda U_o(1-n)^t}{Ie_o}=0 \tag{11}$$

From Equation (11), the value of λ will be calculated as shown

$$\lambda=\frac{Ie_o}{\left(mC_r+Ie_o+N_o+P_o t\right)(1-n)^t} \tag{12}$$

We could substitute the values of its various components from Equations (4), (7) and (12) into it and equate the results to zero. This gives us Equation (13).

$$\begin{aligned}\frac{\partial P_t}{\partial I}+\frac{\lambda \partial P_f}{\partial I}=0:&\frac{-e_o\left(QU_o+M_o\right)}{\left(mC_w+Ie_o+N_o+P_o t\right)^2}\\&+\frac{Ie_o QU_o(1-n)^t}{\left(mC_r+Ie_o+N_o+P_o t\right)(1-n)^t I^2 e_o}=0\end{aligned} \tag{13}$$

Equation (13) is very important in that, it may be developed to give different equations in terms of Q, e_o, U_o, m, C_w, P, I, t and m_o. This possibility leads to the emergence of the following equations.

$$Q=\frac{-e_o M_o I}{e_o U_o I-U_o\left(mC_w+Ie_o+N_o+P_o t\right)} \tag{14}$$

Thus, we can now determine the number of goods sold from Equation (14) which was not known before the introduction of the Lagrange factor.

$$e_o=\frac{QU_o mC_w+QU_o N_o+QU_o P_o t}{I\left(QU_o+M_o\right)-QU_o I} \tag{15}$$

Equation (15) expresses the amount of raw material input explicitly in terms of other variables.

$$U_o = \frac{e_o IM_o}{Q(mC_w + Ie_o + N_o + P_o t) - e_o IQ} \tag{16}$$

Equation (16) shows how the unit selling price of goods can be obtained as a function of other variables.

$$m = \frac{e_o I(QU_o + M_o) - QU_o(Ie_o + N_o + P_o t)}{QU_o C_w} \tag{17}$$

Equation (17) expresses in explicitly in terms of other variables, making it possible to determine the number of workers who receive salaries and bonuses.

$$C_w = \frac{e_o I(QU_o + M_o) - QU_o(Ie_o + N_o + P_o t)}{QU_o m} \tag{18}$$

Equation (18) expresses C_w, explicitly in terms of other variables, thus, we can determine directly cost of maintaining an average worker.

$$N_o = \frac{e_o I(QU_o + M_o) - QU_o(mC_w + Ie_o + P_o t)}{QU_o} \tag{19}$$

Equation (19) could be used directly to determine the cost of purchasing miscellaneous materials and services.

$$P_o t = \frac{e_o I(QU_o + M_o) - QU_o(mC_w + Ie_o + P_o t)}{QU_o t} \tag{20}$$

Equation (20) shows how the total amount of capital inputs utilised in system, P_o, over a period of time, t, under which the evaluation of productivity is made, could be obtained.

$$I = \frac{QU_o(mC_w + Ie_o + P_o)}{e_o(QU_o + M_o) - QU_o e_o} \tag{21}$$

Equation (21) could be used to determine directly the number of goods or raw materials fed into production system I.

$$t = \frac{e_o I(QU_o + M_o) - QU_o(mC_w + Ie_o + N_o)}{QU_o P_o} \tag{22}$$

We could determine the period of time under which the evaluation of productivity and profitability are made from Equation (22).

$$M_o = \frac{QU_o(mC_w + Ie_o + N_o + P_o t) - e_o IQU_o}{e_o I} \tag{23}$$

Equation (23) gives the miscellaneous revenue in monetary units (Naira).

4 Case study

In order to verify the working of the model, information from a company engaged in engineering products and services was obtained. Firstly, the dynamics of the system and resources in the organisation are studied and shown in Figures 1–3.

Figure 1 Dynamics of production and PM

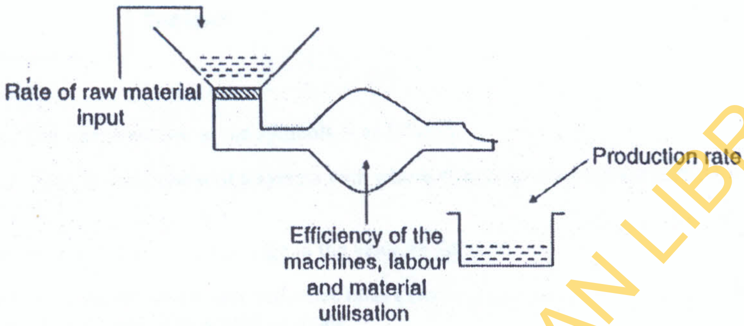
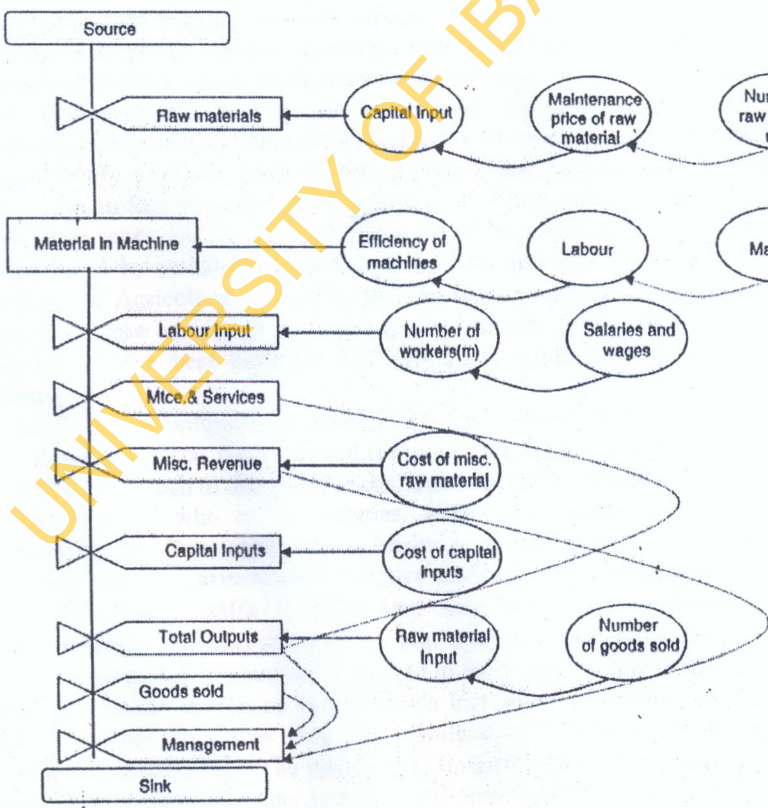


Figure 2 (a) Industrial dynamics symbols depicting dynamics of PM model and (b) interpretation of symbols



(a)

Figure 2 (a) Industrial dynamics symbols depicting dynamics of PM model and (b) interpretation of symbols (continued)

(b)

Note: The interpretation of the symbols is as follows:

Level: a major component of a system with whose changing value we are particularly concerned.

Rate: directly brings about change in the value of the level.

Auxiliary: a factor which may influence rates (That is. may change the value of a rate) or may be influenced by a level or a rate.

Source: starting point of the process while sink is the terminate point of the process.

The organisation engages in seven aspects of products and services: press tools, deep drawing dies, plastic moulds, extrusion dies for collapsible tubes, extrusion dies for aluminium profiles, small equipment/plants and spare parts. Press tools manufactured products are mainly used in the automobile, refrigerator, electrical, building and miscellaneous industries. Deep drawing dies are basically used in hollowware industries. Plastic mould injection involves both injection and blow mould. Extrusion dies for aluminium profiles are required by aluminium smelting industries. The extrusion dies for collapsible tubes are used by aluminium tube manufacturers. Small equipments are mainly used by research organisations such as Institutes of Industrial Research and Institutes of Agriculture. These bodies also require agricultural implements and small general purpose equipment produced by the company under study. Spare parts, which normally require heat treatment and cylindrical grinding are also produced by this company.

In Table 1, information relating to the number of units of goods sold by T.A. Engineering and Tools Limited is displayed. It should be noted that the name above is christened as such to maintain the confidentiality of the identity of the company.

The workers who receive salaries, wages and bonuses from the company are categorised into four: management, senior staff, junior staff (direct) and junior staff (indirect). The management staff comprise of one general management and one technical staff. The senior staffs is segmented into production, engineering, purchasing, sales/marketing, accounts and security. However only three production, one engineering and an account staff are currently engaged in the company. Junior staff (direct) are those doing the transformation of raw materials into finished products, and are categorised under die shop, machine shop and fabrication. The staffs in these sections are 7, 12 and 1, respectively. The junior staffs (indirect) are support staff, including those in maintenance, stores and security/drivers. At present, only one staff is available. In sum, there is a grand total of 28 staff in the organisation.

Figure 3 Block diagram for the optimal performance system model

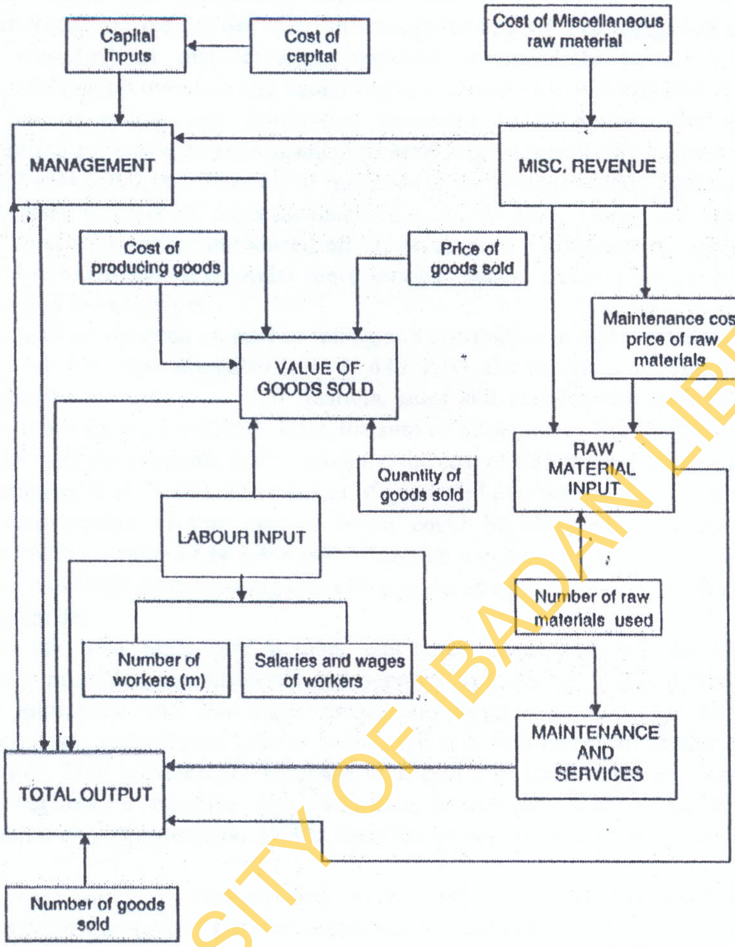


Table 1 Product mix of TA engineering and tools limited

S/N	*Product description*	*Average quantity (units)*	*Value (₦)*
1	Hot extrusion die	240	43,320,000
2	Cold extrusion die	12	6,931,200
3	Die nitriding	126	1,819,440
4	Deep drawing dies	16	5,776,000
5	Press tools	20	5,776,000
6	Jigs and fixtures	12	1,906,080
7	Small equipment	40	2,888,000
8	Small plants	24	3,465,600
9	General trading/spares	36	10,396,800
10	Plastic moulds	30	4,765,200
Grand total			87,044,320

Note: $1 = ₦ 130.

Staff costs, which include salaries and wages, are broadly classified as manufacturing expenses, selling and distribution expenses and office and distribution expenses. These are to capture the salaries of all the categories of staff. For the period considered, salaries classified as manufacturing expenses amounted to ₦ 2,016,000 while wages due to regular overtime and casual workers amounted to ₦ 3,888,000. Salaries and wages due to selling and distribution amounted to ₦ 86,640. For office and administration expenses, salaries resulted to ₦ 693,120. Overall, the salaries and wages of all staff is ₦ 6,700,160. The cost of maintaining the average worker could be obtained from the mean value of all costs for maintaining all the staff. This is obtained from the expense categories earlier introduced all the workers in manufacturing are maintained with ₦ 1,444,000 per year under staff service, which includes expenses on clinic resources and food services.

The expenses incurred on staff in selling and distribution includes sales travelling and transport subsidy. This amounted to ₦ 86,640. Also, the expenses on workers in office and administration relates to staff quarters, rents and maintenance and staff training, which summed up to ₦ 462,080. Thus, the sum of these money is ₦ 1,992,720. Since a total of 28 staff are available in the company, the cost of maintaining the average worker in the company is ₦ 71,169. The number of goods fed into the production system relates to the consumption of unit spares, which could be obtained from manufacturing expenses. It has a value of ₦ 1,444,000. Thus, the number of goods is 700 and the unit cost price is ₦ 9902. In computing the selling price, sales value for the period is obtained as ₦ 47,363,200.

Since the total units sold is 556, unit price then, is ₦ 85,186 The cost of purchasing miscellaneous materials and services includes the amount spent on fuel, oil and lubrication and also light, power and water. This totals to ₦ 1,472,880. The amount of capital inputs utilised in the system is obtained from capital expenditure information. This includes the purchase of a new car, lathe machine, heat treatment furnace, jig boring machine and measuring instruments. The grand total for all these capital expenditures is ₦ 32,490,000. The period of evaluation of performance is one year.

The case study is demonstrated from actual data that verifies the practical significance of the model. The two performance measures whose models are presented are illustrated numerically (i.e. productivity and profitability). However, the focus shall first be made on productivity. Thus, Equations (14)–(23), which express the components of productivity are discussed. Now, utilising Equation (23) to evaluate the miscellaneous revenue, we note that Q = 556, U_o = ₦ 85,186, m = 28, C_o = ₦ 71,169, Ie_o = ₦ 1,444,000, N_o = ₦ 1,472,880, P_o = 32,490,000 and t = 1 year. Thus, M_o = ₦ 1,178,393,352. However, this information could be used to calculate productivity, which is obtained from Equation (1) as 32.77 units. Suppose we are interested in observing the value of productivity if all other parameters are held constant while the miscellaneous revenue is reduced by 50%. The result shows that productivity drops to 17.02 units. Thus, if the unit selling price of goods is reduced by 50%, U_o becomes ₦ 42,593, which productivity is reduced to 32.14 units. Also, if the unit selling price of goods is increased by 50%, P_t increases to 33.41 units. From various variations, a graph could be generated, which shows the trends of performance (Table 2).

Table 2 Percentage changes in productivity (P_t) for different variables

S/No.	*Variable*	*50% increase*	*50% decrease*
1	M_0	48.2	48.1
2	U_0	50	50
3	Ie_0	33	100
4	P_0	96.34	0
5	N_0	0	92.2
6	C_w	0	0
7	Q	0	0

The next series of computations is now made relevant to profitability, represented as P_f. Since the inflation rate varies from 15.0% to 19.4% in the country of location of the company, profitability is affected by these changes (Table 3).

Table 3 Profitability values over a 12-month period of analysis

Month	*Profitability (P_f)*	*Inflation value (n%)*
1	27.28	15.0
2	27.39	16.5
3	26.96	17.8
4	26.73	18.5
5	26.44	19.4
6	26.54	19.4
7	26.54	19.1
8	26.83	19.1
9	27.19	18.2
10	27.52	17.1
11	27.52	16.1
12	27.88	15.1

5 Conclusion

In manufacturing organisations today, there is a great pressure towards achieving international competitiveness in the global market. The outcome of this is a refocus of major business activities towards improving business performance. Therefore, apart from the effort made by managers to improve business performance, it is required that progress in performance should be adequately measured and controlled with quantitative data. The need to measure the performance of a manufacturing organisation at the optimal level is demonstrated in this work. In particular, LaGrange undetermined multiplier is applied in measuring the performance of an organisation. Given the fact that the readers of this paper may struggle with a number of questions, three of these questions readdressed here to justify the current work

1 What are we going to learn from this paper that we do not know now?

2 Why is it worth knowing?

3 How will we know that all conclusions are valid?

There are several lessons to be learnt from this paper. One of the significant lessons is that it is possible to measure productivity at the optimal level such that, any decisions based on such values would be close to the real answer expected from the system.

With the model developed in this work, it is possible to determine the maximum productivity from a given level of profitability. This could be developed in such a way that, graphs are plotted with the variables of profitability and maximum productivity as each of the two axes. Points within this bounded region could give a good understanding of the relationship between profitability and maximum productivity. At a future level, a third axis would be introduced representing any other performance criteria such as quality index. With this, three axes, graphs could be generated that would reveal the holistic nature of PM. With the framework laid out, it is possible to borrow ideas from the APC model of the American productivity center to generate change ratios. The result obtained may be helpful in finding out the effect of changes of any of these three performance criteria on the overall performance of the system. It may be interesting to note that information obtained through this analysis could be useful in generating scenarios that could be useful for performance planning activities. From the simulated experimentation conducted in the early part of this paper, it was pointed out that the application of the model in a real case situation is feasible. This is a way to show that the conclusions made in this work are valid. There are several areas where extensions are sought in future works. One of the areas is the application of various mathematical tools into the existing framework. It may be interesting if mathematicians collaborate with industrial engineers, economists and business managers to introduce the following mathematical tools:

1 theory of the partitions of integers

2 enumeration of set partitions

3 combinations of finite sets

4 cumulative Algebra

5 basic hypergeometric series (q-series).

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